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CLIMATE-CHANGE-RELATED TECHNOLOGY TRANSFER TO CHINA IN THE TRIPS ERA

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The thesis is submitted in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy of the University of Portsmouth.

Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

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Abstract

This thesis attempts to look at the practical impacts that the Agreement on Trade-related Aspects of Intellectual Property Rights has on the international transfer of technology, especially to China, and in relation to climate change technology, which is provided for by international agreements such as the United Nations Framework Convention on Climate Change and the Kyoto Protocol. The author takes the perspective of a developing country, China, focusing on both international and national regulations in order to study the operational situation of the “pull” side of technology transfer. On the one hand, the research addresses the positive and negative effect of the Agreement on Trade-related Aspects of Intellectual Property Rights by looking into the interpretation of its provisions; and on the other hand it examines how individual transactions, or potential transactions, of climate change technology have been affected by intellectual rights and surrounding issues, especially in projects coordinated by the Clean Development Mechanism. The transactions examined are focused upon China, which is a large and rapidly growing developing country, because it possesses certain features that make the transfer of technology both desirable (major climate change and related problems, e.g. severe air pollution) and at times problematic (e.g. its capacity to become a major manufacturer of climate change technology, putting at risk the IP rights of the transferor).

This thesis attempts to look at the outlined subject by employing a social-legal methodology to acquire information through an interview survey and to examine empirical data while discussing literatures and laws. It provides a specific and original angle from which to look at the dynamic of renewable energy technology being transferred to China. This has enabled this research to provide a relatively up-to-date insight into whether intellectual property laws hinder, or are not conductive to, technology transfer as well as the efficiency of mechanisms available under the Kyoto Protocol.

The results of the research show that although the patent data indicates a positive technology growth in China, there are still considerable difficulties in the climate change technology-transfer process. Nevertheless, importing and absorbing such technologies could be crucial to the objective of protecting the global environment. Recognizing this, the Chinese government has played a critical role in promoting technology transfer in a much more effective manner than intellectual property law amendments required by the Agreement on Trade-related Aspects of Intellectual Property Rights. In the future, governments in both the developed and developing world should put effort into establishing a financially practical framework to facilitate technology beyond expediency. The establishment of such should enable developing countries like China to address their need for environmental technologies and to play an active role as a transferor. Given the significant differences in circumstances, and the various needs of nations, reforms towards a more environmental-enabling intellectual property legal system should be conducted in several stages, before any substantial amendments are made to the current international agreements.

Key words: Technology Transfer, Intellectual Property, TRIPS Agreement, UNFCCC, China, Renewable Energy

Word Count: 87971

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Abbreviation

AMSC: American Superconductor

BRIC Brazil, Russia, India and China

CDM The Clean Development Mechanism

CER Certified Emission Reduction

CIS Community Innovation Survey

COP Conference of the Parties

CTE Committee on Trade and the Environment

DAC The Development Assistance Committee

DRC Development and Reform Commission

EST Environmental Sound Technology

EST Environmentally Sound Technology

FDI Foreign Direct Investment

GATS The General Agreement on Trade In Services

GATT General Agreement on Tariffs and Trade

GDP Gross Domestic Product

GEF The Global Environment Facility

GHG Greenhouse Gas

GNI Gross National Income

IBRD The International Bank for Reconstruction and Development

ICTSD The International Centre for Trade and Sustainable Development

IMF The International Monetary Fund

IP Intellectual Property

IPCC The Intergovernmental Panel on Climate Change

IPO Intellectual Property Office

IPR Intellectual Property Right

ITC International Trade Commission

LDC Least Developed Country

LDC Least Developed Country

LVRT Low-Voltage Ride-Through Technology

MEA Multilateral Environmental Agreement

NIEO New International Economic Order

NNPT The Nuclear Non-Proliferation Treaty

ODA Official Development Assistance

OECD The Organisation for Economic Co-Operation and Development

PAE Patent Assertion Entity

PCT The Patent Cooperation Treaty

PDD Project Design Document

R&D Research and Development

SCCF The Special Climate Change Fund

SOE State-Owned Enterprise

TRIPS The Agreement on Trade-Related Aspects of Intellectual Property Rights

TT Technology Transfer/ Transfer of Technology

UNCTAD The United Nations Conference on Trade and Development

UNEP The United Nations Environment Programme

UNFCCC The United Nations Framework Convention on Climate Change

VAT Value-Added Tax

WIPO The World Intellectual Property Organization

WSSD The World Submit on Sustainable Development

WSSD The World Summit on Sustainable Development

WTO The World Trade Organization

Introduction

Climate change is by nature an international environmental problem,[1] and, so it "may well be the biggest and most complex environment-related problem for international cooperation this century and beyond."[2] The influence of mankind has unintentionally become a remarkable force affecting the Earth's climatic system.[3] Such anthropogenic influences are caused by greenhouse gas (GHG) emissions due to energy-use and agricultural activities with "the use of fossil carbon[4] as combustion fuels in all economic sectors: transport, domestic heating, industrial production, electricity generation, and so on"[5] being the biggest factor.

This human-induced problem is beyond the Earth's self-clean ability and is left to be solved through human effort. Technological solutions are therefore seen to be one of the imperative aids in addressing this issue.[6] Accordingly, every relevant major UN General Assembly resolutions for environmental protection include references to technology transfer (TT).[7] As a result, in the context of environmental protection, TT is deemed as a tool to be used to achieve technological, social and economic development in less developed societies under the condition that all states participate in international environmental agreements.[8]

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[1] Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), UN Doc FCCC/CP/1997/7/Add.1, Dec. 10, 1997; 37 ILM 22 (1998) 162.
[2] Benito Müller, 'The Global Climate Change Regime: Taking Stock and Looking Ahead' Fridtjof Nansen Institute (Oslo) for the Yearbook of International Co-Operation on Environment and Development 2002/2003 (London: Earthscan) August 2002 <http://www.oxfordclimatepolicy.org/publications/documents/yiced.pdf> accessed 1 Jul 2017.
[3] Olav Schram Stokke and Oystein B. Thommessen, *Yearbook of International Cooperation on Environment and Development 2002-03*, vol 17 (Routledge 2013) p.27.
[4] E.g. coal, oil and gas.
[5] Müller (n 2).
[6] International Centre for Trade and Sustainable Development ICTSD, 'Climate Change, Technology Transfer and Intellectual Property Rights' Trade and Climate Change Seminar June 18–20, 2008 Copenhagen, Denmark <https://www.iisd.org/pdf/2008/cph_trade_climate_tech_transfer_ipr.pdf> accessed 1 Jul 2017.
[7] Declaration on the Establishment of a New International Economic Order, A/RES/S-6/3201, 1 May 1974.
[8] e.g. United Nations Framework Convention on Climate Change, 1771 UNTS 107; S. Treaty Doc No. 102-38; U.N. Doc. A/AC.237/18 (Part II)/Add.1; 31 ILM 849 (1992), Art 4(1)(h), 4(5); The The Kyoto Protocol, Art 3.14, Art 10.

At the same time, intellectual property rights (IPRs) protection, as a common "legal and policy measure, are potentially both an incentive and an obstacle to TT."[9] "IPRs have been established and conceived as instruments to promote innovation and the dissemination of knowledge."[10] However, if IPRs have an excessive scope or level of protection, they might stifle innovation or make access to knowledge more difficult or costly.[11] Hutchison[12] suggests that minimum standards of IPR protection make technologies prohibitively expensive or contribute to a failure to attract foreign direct investment (FDI). This is probably the case with the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS), which is by far the most comprehensive international agreement governing IP laws and requires each member state to establish a certain level of IP protection.[13]

Therefore, this thesis, while considering climate change as a major theme, the importance and countervailing effect of IPR protection (patents in particular) over climate change TT will be looked at by revisiting substantial literature in this area. By reviewing studies of the definition of TT, climate change TT in particular; differentiated perspectives towards the effect of IP protection in the context of knowledge-diffusion from developed to developing countries; the positive and negative function of TRIPS working together with environmental agreements; and the status quo of climate change TT to China; this thesis will be able to identify gaps in the current literature and endeavours to address some of them. After all, as

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[9] Aaron Cosbey, *Trade and Climate Change: Issues in Perspective* (Final Report and Synthesis of Discussions Trade and Climate Change Seminar, Copenhagen, June 18–20, 2008, 2008).

[10] Ibid.

[11] Sweet and Maxwell, 'Analysis and Debate of Intellectual Property Issues' (2011) 3 The WIPO Journal.

[12] Cameron Hutchison, 'Does TRIPS Facilitate or Impede Climate Change Technology Transfer into Developing Countries?' (2006) 3 University of Ottawa Law & Technology Journal 517, p.530; see also Keith E. Maskus, 'The Role of Intellectual Property Rights in Encouraging Foreign Direct Investment and Technology Transfer' (1998) 9 Duke J Comp & Int'l L 109.

[13] "Under TRIPS, developing countries must adopt minimum standards of protection, meaning 20-year patent terms, and are prohibited from favouring domestic innovation industries. This will not be a good bargain for all states, especially those that cannot afford to license new technologies or are not attracting the FDI that stronger patent laws promise." Hutchison (n 12), p.15.

suggested by the International Centre for Trade and Sustainable Development (ICTSD)[14] in any policy context – including climate change – it is necessary to establish a foundation for finding a balance between the protection of IPRs and the promotion of public objectives such as the TT.

[14] ICTSD (n 6).

Chapter I: Literature review

1.1 Defining technology transfer

Zhao and Reisman[1] observe that there is more than forty years' worth of studies into TT and that the "very definition of TT differs among the various approaches and certainly across the many disciplines addressing this subject."[2] Different disciplines[3] concentrate on the different roles that TT plays: from its economic input to society, to its representation of human creative ability, to its effect on cultural evolution. Also, as well as different disciplinary perspectives, other theorists identify differences in the content of TT. For example, Sahal's[4] description of TT is significant for he observes that "technology must rely on a subjectively determined but specifiable set of processes and products."[5] Roessner defines the concept further as a movement of know-how, of technical knowledge or technology from one organizational setting to another. [6] According to these commentators, TT is a complex combination of transferring both tangibles and intangibles. Any policy governing such activity must take both aspects into consideration.

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[1] L. Zhao and A. Reisman, 'Toward Meta Research on Technology Transfer' (1992) 39 IEEE Transactions on Engineering Management 13.

[2] They observe that economists Kenneth J. Arrow, 'Classificatory Notes on the Production and Transmission of Technological Knowledge' (1969) 59 The American Economic Review 29, 244; Harry G. Johnson, 'The Efficiency and Welfare Implications of the International Corporation' in C Kindleger (ed), International Corporations, vol 35 (Cambridge: CUP,1970 1970); Giovanni Dosi, 'The Nature of the Innovation Process' in Giovanni Dosi and others (eds), Technical Change and Economic Theory, vol 988 (Pinter London 1988) tend to define technology on the basis of the properties of generic knowledge, focusing particularly on variables that relate to production and design. Sociologists (Everett M. Rogers, Diffusion of Innovations (4 edn, The Free Press, New York 2010); Everett M. Rogers and F. Floyd Shoemaker, Communication of Innovations; A Cross-Cultural Approach (The Free Press, New York 1971) tend to link technology transfer to innovation and to view technology, including social technology, as 'a design for instrumental action that reduces the uncertainty of cause–effect relationships involved in achieving a desired outcome'. Anthropologists (George M. Foster, Traditional Cultures: and the Impact of Technological Change (New York & Evanston: Harper & Row. 1962); Elman R. Service, Cultural Evolutionism: Theory in Practice (Holt,Rinehart & Winston of Canada Ltd; First Printing edition 1971).

[3] For example, Feenstra and Judd have adopted an Economics Discipline to address technology's role in productivity change and economic development. Robert C. Feenstra and Kenneth L. Judd, 'Tariffs, Technology Transfer, and Welfare' (1982) 90 Journal of Political Economy 1142; and, Rogers takes a Sociology Discipline to look at TT by making distinctions between innovation and technology as the former is not always technological. The value of TT lies in its contribution to the welfare of society. Rogers (n 2).

[4] Devendra Sahal, 'Alternative Conceptions of Technology' (1981) 10 Research Policy 2.

[5] Sazali Abdul Wahab, Raduan Che Rose and Suzana Idayu Wati Osman, 'Defining the concepts of technology and technology transfer: A literature analysis' (2012) 5 International business research 61.

[6] J.D Roessner, 'Technology Transfer' in C. Hill (ed), *Science and Technology Policy in the US A Time of Change* (Longman, London 2000) p. 1 (Cited by Victoria E. Erosa, 'Technology Policy Implementation Road: Exploring Firms' Technology Readiness in a Mandatory Vertical Diffusion Environment' (2013) 6 Journal of Service Science and Management 20).

In the context of climate change, the Intergovernmental Panel on Climate Change (IPCC) identifies this feature of TT and defined the term as a set of processes covering "the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders."[7] This definition clearly indicates the importance of intangibles other than patent licences, as well as the necessity of hardware transfer. This is especially meaningful for developing countries, as Keller[8] points out, saying that for most of them "foreign sources of technology account for 90 per cent or more of domestic productivity growth." Hence, in many developing countries where "domestic industry is far from the technology frontier, adoption of existing technologies has a higher return than innovation."[9] Domestic economic growth could be considered of less importance from an environmentalist point of view, as a greener way of production, but can be much more expensive than energy-intensive and more polluting approaches. TT should be viewed as a vehicle to encourage parties with different interests to meet in-between by offering either an environmentally friendly manner of economic development, or to bring incentives to promote compromise and collaboration among countries. The Special Report on Methodological and Technological Issues on Technology Transfer[10] defines TT in an even broader way to embrace wider participation. It expands the term 'transfer' to "encompass diffusion of technologies and technology cooperation across and within countries […] and to comprise the process of

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7 IPCC, *Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change* (Bert Metz and others eds, Cambridge University Press 2000).

8 Wolfgang Keller, 'International Technology Diffusion' (2004) 42 Journal of economic literature 752.

9 Calestous Juma and Lee Yee-Cheong, Innovation: Applying Knowledge in Development (UN Millennium Project 2005 ed, Task Force on Science, Technology, and Innovation. United Nations, New York 2005), quoted by Matthew Littleton, 'The TRIPS Agreement and Transfer of Climate-Change-Related Technologies to Developing Countries' (2009) 33 Natural Resources Forum 233.

10 IPCC (n 7).

learning to understand, utilize and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies."[11]

This definition of TT clearly mentions factors other than the purchase and acquisition of equipment. It includes "the transfer of skills and know-how to use, operate, and maintain as well as to understand the technology hardware so that further independent innovation is possible by recipient firms."[12] Not only does it emphasize the techniques directly related to the specific technology that is transferred, but the definition expands to building capacity to enable the recipient to innovate through imitation or reverse engineering. It also includes localised adaptation works and eventually foresees the establishment of independent development abilities. Such a definition represents an environmental discipline trying to include the maximum number of forms of technology that can address climate change mitigation. Although the role that the IPCC plays is merely an international body for assessing the science related to climate change, it does provide policymakers with regular information about options for adaptation and mitigation. It does not tell policymakers what actions to take; it is indeed as a basis for governments at all levels to develop climate-related policies. The TT definition adopted by the IPCC takes less interest in the economic-input function of technology development, but adheres to its role in diminishing climate change influence and maintaining sustainable development. The IPCC advocates environmental discipline and

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[11] Ibid (n 7), quoted by IPCC, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007 (B. Metz and others eds, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA 2007)
[12] Third World Network, 'Climate Change & Technology Transfer: Addressing Intellectual Property Issues' <http://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEM_tec_cfi_ee/7843d4ba5e5e459c99deb4e47b972e83/f7d4f254005e4fb786bd4cf1679e5d1a.pdf> accessed 1 Jul 2017.

encourage countries to value the widespread appliance of technology more than other factors.

1.2 Transfer of green technology

The transfer of environmentally sound technologies (ESTs)[13] is the subject of an extensive literature.[14] Noticeably, an equitable argument has been brought to the debate under the environmental context in support of TT as a tool to achieve social and economic development in less developed countries.[15] Such concerns indicate that "developed countries have already had the opportunity to grow by using practices that caused major environmental degradation."[16] If developing countries do not have an equal chance to go through the same development process, their growth would only be made fair again with financial and technological support from developed countries.[17] In fact, both capital and climate change technology resources are currently unevenly located in a few countries, most of which are developed countries. The Third World Network's report[18] on TT in different sectors of climate change has incorporated several quantitative research projects demonstrating the EST

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[13] United Nations, 'Glossary of Environment Statistics' Studies in Methods, Series F, No 67, United Nations, New York US <https://unstats.un.org/unsd/publication/SeriesF/SeriesF_67E.pdf> accessed 1 Jul 2017: "Environmentally sound technologies are techniques and technologies capable of reducing environmental damage through processes and materials that generate fewer potentially damaging substances, recover such substances from emissions prior to discharge, or utilize and recycle production residues."

[14] e.g. Ernst Worrell and others, 'Carbon Dioxide Emissions from the Global Cement Industry' (2001) 26 Annual Review of Energy and the Environment 303; see also Zili Yang and William D. Nordhaus, 'Magnitude and Direction of Technological Transfers for Mitigating GHG Emissions' (2006) 28 Energy Economics 730 quoted by IPCC, 'Summary for Policymakers' in B. Metz and others (eds), Climate Change 2007: Mitigation Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA 2007).

[15] IPCC, *Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change* (n 7).

[16] Gary C. Bryner, 'Agenda 21: Myth or Reality?' (1999) 157 The Global Environment: Institutions, Law, and Policy 158, quoted by Hari M. Osofsky, 'Defining Sustainable Development after Earth Summit 2002' (2003) 26 Loy LA Int'l & Comp L Rev 111, p.115.

[17] The theories that justify TT from developed to developing countries will not be discussed here but later on in the Chapter of Technology Transfer. See also Section 3.4 in this thesis.

[18] Third World Network (n 12).

ownership structure among countries. The report included Lee and his colleagues' study,[19] which covers six sectors (photovoltaic, wind, carbon capture, concentrating solar power, biomass, and cleaner coal) with the US, Japan, and Germany owning the most climate change technology, followed by emerging economies such as Brazil, China, and India. Nevertheless, developing countries "have no companies or organizations in the top 10 positions in any of the sectors analysed." In the area of renewable energy, according to OECD statistics,[20] the EU,[21] the US, and Japan hold the highest number of climate change patents. These studies have demonstrated the disadvantaged position of developing countries in terms of preserving climate change technologies. Such disadvantage perhaps provides facts that support the need of developing countries for TT. This means that, in order to achieve a global environmental goal in time, pecuniary aid and proactive TT is a prerequisite.

Research by Dechezleprêtre and colleagues[22] has more comprehensively studied climate change TT trends based on data collected from the patent offices of different countries. The targeted technologies covered thirteen climate-mitigation technologies from 1978 to 2008. The authors used a method of calculating the number of technologies invented in country A and then patented in country B. This number is used as an indicator of the amount of technologies transferred from country A to country B. The researchers found that Japan, Germany, and the US together account for 60 per cent of total climate change inventions, while China and Brazil together account for about 10 per cent of total technologies. Such a

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[19] Bernice Lee, Ilian Iliev and Felix Preston, Who Owns Our Low Carbon Future? Intellectual Property and Energy Technologies (A Chatham House Report, September 2009, 2009)

[20] OECD, Compendium of Patent Statistics (2008).

[21] With Germany, Denmark, UK and Spain being the top four patent holders.

[22] Antoine Dechezleprêtre and others, 'Invention and Transfer of Climate Change–Mitigation Technologies: A Global Analysis' (2011) 5 Review of Environmental Economics and Policy 109; Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière, 'The Clean Development Mechanism and the International Diffusion of Technologies: An Empirical Study' (2008) 36 Energy Policy 1273.

result reaffirms an impression of technology being lacking in these developing countries. Furthermore, Dechezleprêtre has illustrated a trend of international transfers in environmental technology, stating that most TTs occurred between developed countries (73 per cent). Transfers from developed countries to developing countries are limited to 22 per cent of all exported technologies, at least before 2008. This also indicates the lack of technology support given from developed countries to developing countries. If global application and the development of climate change technologies is key to stabilizing greenhouse gas emissions, TT should be facilitated both at international and national level. Interestingly, the period studied by Dechezleprêtre et al.'s research[23] happens to be the primary stage of sustainable-development theory becoming prevalent. Despite the global attention given to environmental protection and transferring relevant technologies to developing countries, the vast majority of TTs still occur between developed nations.[24] The authors did not unscramble the paradox that might have explained why most seemingly positive signs (such as the rapid growth of TT to China as well as other emerging economies) did not appear in more recent years.

According to the IPCC Climate Change 2007 – Mitigation of Climate Change,[25] the originator of the transfer, that is the technology holders in developed countries, initially tend to think of TT from a technology supplier-side perspective. A review[26] of the literature written from such a perspective points out that these works tend to focus on the initial choice and acquisition of

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23 Dechezleprêtre and others (n 22).

24 until 2003, the number of climate mitigation tecdhnologies transferred between north and north was 5692 as measured by the number of inventions that are patented in at least two countries. In contrast north to south TT was only 1719 and Sounth to Sount TT was 226. See Dechezleprêtre, Glachant and Ménière, (2008) (n 22).

25 IPCC, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007 (n 11).

26 Brooks, H., 1995: Review of C. Freeman: The economics of hope- essays on technical change, economic growth and the environment. Minerva, 33(2), pp. 199-203. Quoted by ibid (n 11).

technology on a firm-level. Take the Lee et al.[27] and Dechezleprêtre et al.[28] studies, for example where both attempt to use patent data to measure the transfer and diffusion of technologies. The UNEP report states: "while Dechezleprêtre et al. use patents filed in more than one country as an indicator of technology transfer, Lee et al. take patent applications where more than one organization is listed as an owner as an indicator of diffusion."[29] Using patent applications as an indicator of TT is in fact subject to numerous limitations. For example, patent application activity represents the decisions of technology holders, most of whom are located in, and targeted at, a mature marketplace in terms of developed countries. Such TT between developed countries is simpler, because the preconditions are friendlier towards free trade. In contrast, the decision-making process of TTs that involve firms in developing countries are not as straightforward because these TTs are likely to be affected by the policy environment, finance support and technology-absorptive ability of the receiving country.[30] Therefore, they miss the influence of the enabling environment of developing countries on TT from the receivers' perspective. The IPCC has specifically listed barriers to TT, including "lack of information, insufficient human capabilities, lack of capital, high transaction costs, trade and policy barriers, business limitations such as risk aversion, and institutional limitations such as weak intellectual property protection laws and enforcement."[31] Yet the effect of these barriers listed in the technical summary of the IPCC report was not addressed in great detail by the IPCC. The IPCC 2000 report made an example of analysing governmental

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27 Lee, Iliev and Preston (n 19).
28 Dechezleprêtre and others (n 22).
29 UNEP, EPO and ICTSD, *Patents and clean energy: bridging the gap between evidence and policy: Final report* (2010) p.22.
30 IPCC, *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007* (n 11).
31 IPCC, Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change (n 7).

influence by citing an instance of a government patent licence arising out of publicly funded efforts as a part of their industrial policy.[32] As TT varies according to specific context among sectors, more specific studies are required to clarify the role of governments in initiating and facilitating TT. In fact, most barriers listed by the IPCC[33] – ranging from lack of physical supplies, such as capital and equipment, to non-material assistance, such as information, skills, institutional mechanisms and policies – are either partly or mainly due to the environment of the recipient country. [34] Each of the above sectors will at least in the short term continue to be an important driving force in the development of climate change technologies. Thus, we need to exam them in a specific receiving country environment, and further explore its conducive or disabling effect on TT.

1.3 Barriers to TT in relation to IPRs

Another frequently mentioned barrier concerns that of IPR regimes in recipient countries that may have an impact on TT. Both Sherwood[35] and Maskus[36] took the view that technology tends to flow best where conductivity for its transfer is secured by effective IPR systems. They fear that if an invention can be freely and easily gained and copied it will deter the inventors from investing time and money in working on something new and useful. Maskus[37] emphasizes that IP protection gives inventors a sense of safety by assuring a certain control over information in TT. It also secures the rights holders a place in the industry if they are to

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[32] Ibid.
[33] Ibid.
[34] For example, the report has recognised institutional and administrative difficulties exist to develop technology transfer contracts. Such difficulties will incur time and capital cost to contracting parties. In a way, it has increased the threshold of entrance to green technology market. See IPCC, *Climate Change 2001: Mitigation: Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Bert Metz ed, Cambridge University Press 2001).
[35] Robert M. Sherwood, 'Global Prospects for the Role of Intellectual Property in Technology Transfer' (2002) 42 Idea 27.
[36] Keith E. Maskus, 'Transfer of Technology and technological Capacity Building' (2003) ICTSD-UNCTAD Dialogue, 2nd Bellagio Series on Development and Intellectual Property.
[37] Ibid.

exploit the inventions. Not only technology sellers but buyers also need some assurances that they will recover the costs of their investment. According to Sherwood, even though "some technology can be acquired without a willing transfer from its creator," [38] for example through reverse engineering, imitation and "piracy", people can acquire certain technologies they need, such approaches do have distinct limits because the skills gained are less valuable than those received from willing transfers, as the latter tend to offer greater learning for the recipients.[39] Usually this is because of associated transfer of knowledge rather than just the transfer of technology. There is also the very real issue of patent infringement in the above circumstances, which should be taken care of by the imitators. These studies imply that if more effective IPR protection in the recipient country secures willing transfers, in the long term it will not become a barrier to TT but will have a beneficial impact on the country's technology development. Maskus even made a quite conclusive argument pointing out that firms are "more willing to trade, license, and invest in technologies in countries with strong IPR regimes."[40]

Detailed evidence is provided by his joint research together with Reichman[41] where they reviewed a number of studies identifying that "the preponderance of econometric studies suggests that market-mediated flows of technology respond positively to the strengthening of patent laws across countries."[42] However, Smith has found that such trends only appear in

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[38] Sherwood (n 35).
[39] Ibid (n 35).
[40] Carsten Fink and Keith E. Maskus, 'Why We Study Intellectual Property Rights and What We Have Learned' in Carsten Fink and Keith E. Maskus (eds), *Intellectual property and development: Lessons from recent economic research* (A co-publication of the World Bank and Oxford University Press 2005).
[41] Keith E. Maskus and Jerome H. Reichman, 'The Globalization of Private Knowledge Goods and the Privatization of Global Public Goods' (2004) 7 Journal of International Economic Law 279; Pamela J. Smith, 'How do Foreign Patent Rights affect US Exports, Affiliate Sales, and Licenses?' (2001) 55 Journal of International Economics 411.
[42] Maskus and Reichman (n 41) p.289.

patent-sensitive industries[43] in middle-income and large developing countries.[44] This has revealed the limiting effect of strong IP protection on TT, because stronger IP protection will not encourage TT where the receiving country lacks the capacity to adopt the technology. Similarly, Falvey[45] suggests that while stronger IPR protection can ultimately reap rewards in terms of greater domestic innovation and increased technology diffusion in developing countries with sufficient capacity to innovate,[46] it has little impact on innovation and diffusion in those developing countries without such capacity, and may impose additional costs. This has also been argued by Foray,[47] stating that "while it might be debated as a matter of equity[48] that as beneficiaries they should pay, or that being poor they (developing countries) should not be asked to pay, the important fact remains that it would not make much difference from an efficiency standpoint: the world's supply of such innovations would not be much diminished – if at all – by these countries adopting a free riding policy." Nevertheless, the ethical considerations of a free-riding policy and chances of future investment in such jurisdictions shall be considered when a country intends to reform towards a more technology-intensive means of development.

Maskus and Okediji provide a reason for such a trend being seen only in large emerging economics (for example Brazil, Indian, and China): it could be that "the effectiveness of IPRs as incentives to develop ESTs and deploy them in global markets depends on how well the

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43 such as the pharmaceutical industry.

44 Smith (n 41); Keith E. Maskus and Mohan Penubarti, 'How Trade-Related are Intellectual Property Rights?' (1995) 39 Journal of International Economics 227

45 See, R. Falvey, N. Foster and O. Memedović, The Role of Intellectual Property Rights in Technology Transfer and Economic Growth: Theory and Evidence (United Nations Industrial Development Organization, UNIDO 2006)

46 China is such kind of country.

47 Dominique Foray, Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies (ICTSD Intellectual Property and Sustainable Development Series (May 2009), 2009)

48 The equity issue will be discussed in the Technology Transfer Chapter.

innovation policies of industrialized countries currently function and whether developing countries and least developed countries (LDCs) have invested sufficiently in domestic institution-building to facilitate the absorption of new technologies."[49] Economies with low incomes normally have fewer resources invested in the relevant market and therefore are not attractive to technology transferors, regardless of IP protection level available in that country. Although adopting a rather general point of view, Maskus and Okediji[50] have identified the importance of policies and the enabling environment in the developing country working as prerequisite factors towards the actual effect of IP protection. Matkusen and Maskus[51] recognised that with limited technological capacity in some developing countries, their markets do not present a competitive-imitation threat to the transferors. For this reason, even if these poor countries implemented their IP standards in compliance with internationally accepted IP standards (e.g. TRIPS), still they will not encourage additional TT from abroad. Often, even without the threat of competitive imitation, the above research suggests that TT will still not occur because of factors other than the inadequacy of IPR protection in the receiving market. This issue will be explored in this thesis, focusing on a few industry sectors (the renewable energies of wind and biomass in particular).

Traditionally, IP protection is believed to have a positive effect on TT when the receiving country has high incomes and technological capacities: "IPRs become an important factor in

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[49] Keith E. Maskus and Ruth L. Okediji, 'Intellectual Property Rights and International Technology Transfer to Address Climate Change: Risks, Opportunities and Policy Options' ICTSD Programme on IPRs and Sustainable Development Issue Paper No 32 (December 2010) <http://www.ictsd.org/downloads/2011/12/intellectual-property-rights-and-international-technology-transfer-to-adress-climate-change.pdf> accessed 1 Jul 2017.

[50] Ibid.

[51] Keith E. Maskus, Encouraging International Technology Transfer (UNCTAD-ICTSD Project on IPRs and Sustainable Development Issue Paper No. 7 2004) quoted by Maskus and Reichman (n 41).

this regard, even though they are only one of a list of variables that influence ITT."[52] Does this mean that international TT to large developing countries is sufficiently facilitated by the current IP system required under TRIPS? Correa voices his fear that enhanced IPR protection will not effectively promote the development process and will, instead, limit access to technology.[53] Maskus and Reichman[54] also admit the likeliness that stronger global IPRs have placed a limitation on the scope for firms in developing countries to acquire new and mature technologies at manageable costs. For example, "the natural competitive disadvantages of follower countries may become reinforced by a proliferation of legal monopolies and related entry barriers that result from global minimum intellectual property standards. Such external restraints on competition could consign the poorest countries to a quasi-permanent status at the bottom of the technology and growth ladder."[55] This hypothesis about the potential hindering effect of IP protection for firms in developing countries to break into the global market at the forefront of the industry is a valid point in dissecting the actual influence of IPRs. But based on the preponderance of econometric studies, the article failed to confirm the conjecture by providing firm-level evidence.

Existing literature has argued that IPRs could impose costs not only on private firms but also on society. For example, in order to be the first to file, R&D competition between competitors is common and this could cause the wasteful duplication of investment in industry.[56] Still, the

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[52] "Other important factors include effective infrastructure, efficient governance, market size and growth, and proximity to suppliers and demanders." Maskus, Encouraging International Technology Transfer (n 51) quoted by Maskus and Reichman (n 41).
[53] Carlos M. Correa, 'Review of the TRIPS Agreement: Fostering the Transfer of Technology to Developing Countries' TWN Trade & Development Series 13 <http://www.twn.my/title2/t&d/tnd13.pdf> .
[54] Maskus and Reichman (n 41).
[55] Ibid.
[56] K. E. Maskus, 'The Economics Of Intellectual Property Rights And Globalization: Dancing The Dual Distortion' in Intellectual Property Rights in the Global Economy (Institute for International Economics 2000) <http://mattias.ganslandt.info/ipr/maskus_globalization.pdf> .

excessive cost paid for keeping higher standards of IP protection may not be as harmful as public-interest losses. Public concerns such as healthcare, biodiversity and environmental protection could be considered as secondary issues in national and global policymaking, in comparison with the already existing proliferation of exclusive rights granted to private technology owners.[57] If IPR regimes do not sufficiently take into account these public interests it might hinder the use of TT as a means of dealing with climate change. Littleton[58] points out that IPR regimes can in fact become barriers that affect climate change TT on both supplier's and receiver's side. He argues that "technology supply (firms may refuse to transfer without asset protection) or technology demand (one of the domestic policies that can affect technology demand, as mentioned above)."[59] Instead of focusing on the relationship between stronger IP protection and trade/TT flows, the conclusion of this paper provides a way to look at the current IPR regime as a tool that fails its expected role as a climate change TT stimulant. This highlights the shared responsibility of developed and developing countries for "overhauling TRIPS and domestic IPR laws to address climate change, following in the footsteps of public-health exceptions to IPR regulations. Achieving this goal will require simultaneous action inside and outside the WTO."[60] In a nutshell, the empirical evidence from TT, economic growth and IP protection in developing nations indicates that there is no positive correlation among the three.[61] This has provided a basis from which to challenge the

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[57] Maskus and Reichman (n 41).
[58] Littleton (n 9).
[59] Ibid.
[60] Ibid.
[61] K. R. Srinivas, 'Climate Change, Technology Transfer and Intellectual Property Rights' (2009) RIS Discussion Papers No153 45.

importance of patenting as in many emerging economies it is considered as a possible barrier in the clean-TT debate.[62]

Although strengthened IP standards have their pros and cons, no commentators suggest that weak IP protection is the only path to technology growth. Actually there are examples of a now-developed nation being transformed from a less developed economy through technological advances without benefiting from weak IP protection. Countries like Japan[63] and South Korea[64] all underwent a period of policy transformation and therefore achieved corresponding technology development. Although both examples largely occurred before WTO and TRIPS, when global IP regimes were weak and technology diffusion speed and patterns were very different from today, these precedents had at least proved that it is possible to expect an effective environment including an IP system that would guarantee willing transfers, encourage transferors to offer full information needed by recipients, and protect inventors from being infringed by using and exploring the technology. It can be "buttressed by appropriate infrastructures, governance and competition systems in order to be effective".[65] In this case, IPRs can be seen as an instrument aimed at facilitating the transfer of technology. Otherwise, it remains an ornament in terms of international TT promotion in most developing countries.

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62 UNEP, EPO and ICTSD (n 29), suggesting a new patent classification for climate change mitigation technologies" to be adopted.

63 Janusz A. Ordover, 'A Patent System for Both Diffusion and Exclusion' (1991) 5 The Journal of Economic Perspectives 43 quoted by Maskus and Reichman (n 41).

64 Linsu Kim, "Technology transfer and intellectual property rights: lessons from Korea's experience" UNCTAD/ICTSD working paper (2002) quoted by Maskus and Reichman (n 41).

65 Keith E. Maskus, Kamal Saggi and Thitima Puttitanun, 'Patent Rights and International Technology Transfer Through Direct Investment and Licensing' (International Public Goods and Transfer of Technology under a Globalized Intellectual Property Regime, Duke University Law School, April 4-6, 2003).

However, in the context of climate change, we must look into the subtle relationship between IPR protection and TT from a particular perspective. The 2007 Bali Road Map[66] has emphasised the need for appropriate policies regarding green technology development and diffusion, although under conditions of global environmental deterioration, such a debate should be considered case by case in different industry sectors rather than in general terms. This is due to significant differences between industries in terms of technology-absorptive capability. The conflict between the urgency of GHG-mitigation requirement in many developing countries and the fact that these countries are either not able to, or reluctant to, bear all the financial costs associated with acquiring technologies primarily developed in industrialized countries varies between sectors and among countries. For example, the situation in the pharmaceutical industry is different from the renewable energy industry. Moreover, developing countries such as China and Brazil have argued for "the creation of a different IPR regime for climate-friendly technologies in order to encourage diffusion, whereas industrialized countries claim that the incentives provided by existing IPR regimes reinforce diffusion incentives by ensuring patent holders the benefits that result from their inventions."[67] The IPCC, sharing a similar view with the latter, states that "without an IPR law that is effectively enforced, there is little incentive for private companies to share their technology."[68] It would consider the cost of IPR as "usually quite small when compared to the capital investments and risks that are involved." This literature has made the perspective that research takes a crucial factor in reaching any conclusions. A different standpoint (developed

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[66] Participants at the 2007 United Nations Climate Change Conference in Bali developed a road map, known as the Bali Road Map, for negotiating a new climate agreement by the end of 2009.
[67] Dechezleprêtre and others (n 22).
[68] IPCC, Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change (n 7).

or developing, economist or environmentalist view) changes the way a researcher looks at the gravity of each interest: the inviolability of IPRs or the climate change crisis.

In a way, the IPCC provides a solution to the conflict by encouraging developing countries to be flexible in acquiring technologies. For example, they could establish an IP-sharing pool based on contracts made between nominated mechanisms (such as state-owned companies or agents) and private firms, to invest and share technology with them in return for a share of the products produced.[69] Such practice has proven “very successful in the international oil and gas sectors, and could be a model for other energy supply areas”.[70] However, it does not resolve a missing driving force to initiate and maintain such mechanisms. Maskus and Reichman point out a cursory solution to the defect by insisting that it is mainly the responsibility of the developing governments to be “pro-active in ensuring that the net effect of expanded IP protection is to enhance access to technology and to encourage its domestic adaptation and diffusion.” [71] Still, the limitation of the standpoint is that it gives less consideration to the financial and experiential shortage of the developing economies and it is unlikely to actualize without liability being placed on developed countries.

1.4 The TRIPS Agreement

Before the establishment of TRIPS, there was, generally, a significant gap between levels of IP protection in developed and developing countries.[72] But in the 1990s, views towards IP protection changed in some developing countries. This change in standpoint was reflected in

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69 Ibid.
70 Ibid.
71 Sherwood (n 35).
72 Trade-Related Aspects of Intellectual Property Rights (unamended version), Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, signed in Marrakesh, Morocco on 15 April 1994.

the IP regime reform in these countries and the developing governments believed that stronger IP protection would attract TT in different forms, such as FDI.[73] Conforming to this trend, the WTO embodied minimum standards of IP protection in the TRIPS Agreement as part of its trade package. Many developing countries had acceded to these requirements in order to get greater market access to international trade with developed countries. In exchange for developing countries' compliance with higher IP protection, TRIPS requires developed countries to take on a corresponding obligation to facilitate TT to developing countries.[74]

However, at the negotiation stage in reaching TRIPS, the intentions of countries at different development levels varied significantly. Developed countries aimed at creating new rules and principles by craftily bringing claims for a proper place to discuss substantive issues on IPRs. According to Yu,[75] at that time the US lobbied successfully by seizing the opportunity that the economic crises confronting many of the EU member states and Japan. Together with "its successful 'divide and conquer' tactics and aggressive strategies toward the hardliner opposition countries,"[76] many developing countries believed that the negotiations launched by these developed countries were only focusing on counterfeit trade and other such trade-related aspects.

> "By the time Canada proposed to create a new multilateral trade organization in 1990, its proposal, along with the less developed countries' fears of being excluded from such an

[73] IPCC, Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change (n 7).
[74] Cameron Hutchison, 'Does TRIPS Facilitate or Impede Climate Change Technology Transfer into Developing Countries?' (2006) 3 University of Ottawa Law & Technology Journal 517.
[75] Peter K. Yu, 'The Objectives and Principles of the TRIPS Agreement' (2008) 46 Houston Law Review 797.
[76] Jayashree Watal, Intellectual Property Rights in the WTO and Developing Countries (Kluwer Law International 2002) 21, quoted by Yu (n 75).

organization, by the early 1990s, virtually all negotiating parties accepted as inevitable the inclusion of minimum standards for intellectual property protection and enforcement in the GATT framework."[77]

Under the historical formation of the TRIPS Agreement, Peter Drahos evaluates its negotiations using a theory of democratic property rights with a threefold criteria to be met in order to efficiently define property rights: "Firstly, all relevant interests have to be represented in the negotiating process (the condition of representation). Secondly, all those involved in the negotiation must have full information about the consequences of various possible outcomes (the condition of full information). Thirdly, one party must not coerce the others (the condition of non-domination)."[78] And according to the criteria, the study concludes that the TRIPS negotiations did not meet these conditions of democratic bargaining because not all relevant interests were considered in the negotiating process and there was disguised coercion involved. Most importantly, many developing negotiating parties were not aware of the consequences of various possible outcomes of the Agreement. The problem derived from the use of circles of consensus when certain "groups were created within the TRIPS negotiations to move the process towards a final deal."[79] And "it was in these informal groupings that much of the real negotiating was done and where the consensus and agreement that mattered was obtained."[80] Unfortunately the US and Europe were the main force behind most key groups which "allowed them to soak up more information than anyone

[77] Adbulqawi A. Yusuf, 'TRIPS: Background, Principles and General Provisions' in Carlos María Correa and Abdulqawi Yusuf (eds), Intellectual Property and International Trade: The TRIPs Agreement (revised edn, Kluwer Law International 2008), quoted by Yu (n 75).
[78] Peter Drahos, 'Developing Countries and International Intellectual Property Standard-Setting' (2002) 5 The Journal of World Intellectual Property 765.
[79] Ibid.
[80] Ibid.

else about the overall negotiations. Whenever they needed higher levels of secrecy they could reform into a smaller negotiating globule."[81] This gave the TRIPS negotiations doubtful transparency, making the result difficult for less involved countries to predict. Although there is insufficient evidence to prove that developing countries were left incapacitated, Yu[82] has given valuable insights into how these countries are at a disadvantage in negotiations.

Even so, the debate on whether should we have a minimum unified standard of IP protection was effectively ended. What can be counted on now is the operation and amendment of TRIPS. The "purpose of TRIPS is to give adequate and effective protection to IPRs and, in so doing, encourage creativity and innovation, promote the transfer of technology, and protect consumers."[83] Putting aside the effectiveness of the expected TT-promoting function of TRIPS, over time, many developing countries started to feel pressure from some developed countries. As stated by Kleen and Page[84] the US and the EU had been asking for IP protection beyond the minimum standards required by TRIPS. A telling case given by Kleen and Page is "the attempt by the US government and pharmaceutical industry to block the use of parallel imports and compulsory licenses by the South African government to obtain access to cheaper HIV/AIDS drugs."[85]

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[81] Ibid.

[82] Yu (n 75).

[83] See detailed discussion in the IP Chapter. "TRIPS lays down minimum standards for the protection of IPRs as well as procedures and remedies for their enforcement. Failure to enforce such rights encourages trade in counterfeit and pirated goods, thereby damaging the legitimate commercial interests of manufacturers who hold or have acquired these rights." World Bank, Legal Aspects of International Trade (The International Bank for Reconstruction and Development, Proceedings of a World Bank Seminar, 2001).

[84] Peter Kleen and Sheila Page, 'Special and Differential Treatment of Developing Countries in the World Trade Organization' Global Development Studies No 2 <https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/3320.pdf> accessed 1 Jul 17.

[85] See, e.g., Marie Byström and Peter Einarsson, 'TRIPS: Consequences for Developing Countries Implications for Swedish Development Cooperation' Consultancy Report to the Swedish International Development Cooperation Agency, August 2001 <https://www.researchgate.net/publication/253376473_TRIPS_Consequences_for_developing_countries_Implications_for_Swedish_development_cooperation> accessed 1 Jul 17, quoted by Kleen and Page (n 84).

In sum, despite the developed countries' complaints that the implementations of TRIPS in many developing countries are not satisfactory, "developing countries generally feel that the concessions they made during the Uruguay Round with respect to IPRs are not providing them with significant benefits."[86] This is possibly the main reason that developing countries continue to "complain about the high cost of TRIPS and their limited capacity to ensure TRIPS protection."[87] For example, Hoekman et al.[88] in their work on an upper middle-income (levelled by the World Bank) developing country (Jamaica), found that implementing the additional TRIPS rules would cost about six million US Dollars. Correa[89] has studied research work in the area of pharmaceuticals, aimed at identifying the potential effect of TRIPS. One of the studies undertaken in Thailand found that, regarding the patent law reform in and after 1992 according to TRIPS requirement, "there had been no significant increase in transfer of technology or foreign direct investment, and that spending on pharmaceuticals had increased at a higher rate than overall health care spending"[90]. UNCTAD[91] also points out TRIPS's adverse effect on technology diffusion, as it is very likely to affect the conditions for access to and use of technology. For example, imitation and similar activities that used to be patterns of technology acquisition are restricted, thereby making the utility and follow-up innovation of technologies owned by developed countries even more difficult in developing countries. "Strengthened IPRs are also likely to increase the negotiating position of right-holders."[92]

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86 Kleen and Page (n 84).
87 World Bank (n 83).
88 Bernard M. Hoekman, Aaditya Mattoo and Philip English, Development, Trade and the WTO: A Handbook, vol 1 (World Bank Publications 2002), quoted by Kleen and Page (n 84).
89 Carlos M. Correa, 'The TRIPS Agreement and Developing Countries' in Arthur E. Appleton and Michael G. Plummer (eds), The World Trade Organization: Legal, Economic and Political Analysis, vol 2 (Springer Science & Business Media 2007).
90 Siripen Supakankunti and others, 'Impact of the World Trade Organization TRIPS Agreement on the pharmaceutical industry in Thailand' (2001) 79 Bulletin of the World Health Organization 461, quoted By Correa (n 89).
91 Training Tools On The Trips Agreement, UNCTAD/DITC/TNCD/Misc.17, Geneva, January 2002.
92 Ibid.

1.5 The TRIPS and multilateral environmental agreements (MEAs)

The impact of TRIPS TT on developing countries is often reflected indirectly through changes made to national IP law according to requirements of the Agreement. Relatively less empirical literature has focused on the IP law and IP environment in relation to environmental protection than on environmental regulation itself, such as water or air pollution regulation.[93] Many studies related to MEAs make assertions regarding both IP protection and climate change TT. This is due to the fact that MEAs and "declarations are replete with generalized obligations of states to cooperate in transferring ESTs to developing countries."[94] For example, the Principle 9 of the Rio Declaration on Environment and Development encourages cooperation between nations "by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies."[95] Agenda 21 specifically mentions the role of patent protection in EST innovation and transfer. In Chapter 34, the Agenda recognizes the incentive function of patent protection, with such incentives encouraging TT to developing countries.[96] Due to a substantial connection between TT and IP law, researchers and organisations refer to the latter constantly.[97]

However, there is a crucial difference between the philosophies underpinning TRIPS and MEAs. The TRIPS negotiations were launched and manipulated by developed countries. As a

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93 See for example Keith Hawkins, Environment and Enforcement: Regulation and the Social Definition of Pollution (Clarendon Press, New York, NY 1984); Yvonne Brittan, The Impact of Water Pollution Control on Industry : A Case Study of Fifty Dischargers / Yvonne Brittan (Centre for Socio-Legal Studies 1984), quoted by Bettina Lange, 'Empirical Compliance: A Study of Waste Management Regulation in the UK and Germany' (PhD Thesis, University of Warwick 1996).

94 Hutchison (n 74).

95 Annex I Rio Declaration on Environment and Development, United Nations A/CONF.151/26 (Vol. I). See also Declaration of the United Nations Conference on the Human Environment Principles 9, 12 and 20. For example, Principle 20 states that "... environmental technologies should be made available to developing countries on terms which would encourage their wide dissemination without constituting an economic burden on the developing countries." Hutchison (n 74).

96 Rio Declaration chs. 3.4 p.10-11.

97 See for example, Lee G. Branstetter, 'Do Stronger Patents Induce More Local Innovation?' (2004) 7 Journal of International Economic Law 359 and Mark Consilvio, 'The Role of Patents in the International Framework of Clean Technology Transfer: A Discussion of Barriers and Solutions' (2011) 3 Intell Prop Brief 7.

result, the “attempts to harmonize IPR laws have resulted in coerced conformity with the strictest IPR regulations of industrialized countries.”[98] In contrast, the special needs of developing countries are given greater attention in MEAs, while corresponding obligations are imposed according to the enhanced capacities of developed countries. This thesis will highlight one of the most influential MEAs: the United Nations Framework Convention on Climate Change (UNFCCC)[99] includes specific obligations for developed countries to provide financial and other resources to meet the full incremental costs of utilizing EST in developing countries.[100] In Article 4.5, the Convention requires the developed countries to “take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention.”[101]

The favourable standpoint of the UNFCCC is made even clearer in Article 4.7 where the provision states that “The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology.”[102] This provision has given economic and social priority to developing countries, contradicting the previously mentioned view of Maskus’s and Reichman’s claim that it is mainly the responsibility of the developing

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[98] Littleton (n 9).
[99] Declaration of the United Nations Conference on the Human Environment.
[100] Ibid.
[101] Ibid article 4.5
[102] Ibid article 4.7

governments to believe and rely on the "net effect of expanded IP protection is to enhance access to technology and to encourage its domestic adaptation and diffusion." [103]

This highlighting of TT in the provisions of the UNFCCC actually made it more straightforward than in other MEAs; and the Conference of the Parties (COP) of the UNFCCC has been continuously making efforts to improve TT facilitating.[104] Despite these endeavours to encourage TT, the Role of IPRs has remained an issue of disagreement among UNFCCC parties. Latif and others[105] identified the tension from negotiations that began in Bali (2007), and point out that developing countries such as India have argued that "many of the [climate change] technologies that can help it [improve environment protection] and other developing countries achieve a lower carbon growth are out of their reach due to IPRs and prohibitive costs"[106] Behind this divarication are the different views between developed and developing countries.

Except for the above differences between TRIPS and MEAs, TT is likely to be influenced by their regulatory conflicts. For example, the Montreal Protocol on Substances that Deplete the Ozone Layer had set up limitations of production and consumption of specific ozone-depleting substances. Therefore trade with non-parties relating to these controlled substances, and in

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[103] Sherwood (n 35); See also Ahmed Abdel Latif and others, Overcoming the Impasse on Intellectual Property and Climate Change at the UNFCCC: A Way Forward (ICTSD Programme on Innovation, Technology and Intellectual Property November, Policy Brief No 11, 2011).

[104] For example, Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007, FCCC/CP/2007/6/Add.1 (the Bali Action Plan) agreed to at the 13th COP, reaffirmed the centrality of technology development and transfer (Latif and others (n 103)) made it one of the four priority areas to be addressed in discussions aimed at the "full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012". (Paragraph 1(d), the Bali Action Plan); It called for "Enhanced action on technology development and transfer to support action on mitigation and adaptation, including, inter alia, consideration of: (i) Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies (emphasis added)." Ibid (n 103); Later on in 2010, at the Cancun conference, "a new Technology Mechanism for enhancing the transfer of climate-friendly technologies was created. […] The Mechanism is composed of two main bodies: the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN)." Ibid (n 103).

[105] Latif and others (n 103).

[106] Proposals by India for inclusion of additional agenda items in the provisional agenda of the seventeenth session of the Conference of the Parties, FCCC/CP/2011/INF.2/Add.1, 7 October 2011, quoted by Latif and others (n 103).

products that incorporate these substances, is prohibited by the Protocol. Although, later on, such restrictions turned out not to be feasible, the Protocol did advise parties to ban trade in listed substances with non-members when possible.[107] By analogy, any technology that constituted ozone layer depletion would be banned by the Protocol. This is clearly a trade restriction which against WTO objective. "More than seventy-five per cent of the parties to the UNFCCC are also members of the World Trade Organization ("WTO")."[108] Despite the sun-setting of the Kyoto Protocol, the UNFCCC has provided no efficient trade measures so far. While the Kyoto Protocol is more specific in obligating member states, it has not set out specific prohibitions on trade. Thus on the face of it, there is no apparent conflict between the UNFCCC and TRIPS.[109] However, as the climate change crisis develops further, the needs for EST to be transferred to developing countries will grow and the expectations on the TRIPS Agreement to promote and assist TT will be higher. Several other trade-related issues might arise "in the context of energy taxes, trade in services, and subsidies"[110] will probably affect TT as well. Thus, "the treatment of environmental considerations by organs of the WTO[111] raises challenging questions, including that of the relationship between WTO agreements and MEAs."[112] No fundamental conflict between the WTO rules and MEA provisions has been found currently as these questions are unsolved by the existing literature. However, the need

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[107] Simon Walker, 'The TRIPS Agreement: Sustainable Development and the Public Interest' IUCN Environmental Policy and Law Paper No 41 <https://portals.iucn.org/library/efiles/documents/EPLP-041.pdf> accessed 23 Jun 17.

[108] Of the 164 parties that ratified the Kyoto Protocol, 132 (eighty percent) are members of the WTO Committee on Trade and Environment, Matrix on Trade Measures Pursuant to Selected Multilateral Environmental Agreements (WT/CTE/W/160/Rev4, TN/TE/S/5/Rev2, 14 March 2007) (Discussing correlation between WTO members and Kyoto Protocol) p. 32 quoted by Alexander Adam, 'Technology Transfer to Combat Climate Change: Opportunities and Obligations under TRIPS and Kyoto' (2009) 9 J High Tech L 1.

[109] Hutchison (n 74).

[110] World Bank (n 83).

[111] The World Trade Organization (WTO) is the only global international organization dealing with the rules of trade between nations.

[112] Is WTO the appropriate forum to decide questions affecting trade arising under an MEA to which both parties to a dispute are signatories? Is the WTO the only appropriate forum by default? What if only one of them is a signatory to the MEA?

to further clarify the relationship between TRIPS under WTO rules and MEA provisions (UNFCCC in particular) when both affect TT at the same time will matter in the future.[113]

Putting aside the future achievement of full mutual support between MEAs and the WTO that may affect both international and national laws ultimately, some writers "focus on what can be accomplished within the existing IP rules, particularly those provided by TRIPS."[114] But as discussed before, among legal scholars, strong IPR protection has been criticized as a possible impeding factor to technology access; the same result can be inferred with climate change TT. For example, according to Wiener the existing "considerable barriers to the development, deployment and marketability of renewable energy" are largely due to "patent schemes shield proprietary licenses in regions where capital is most aggregated and profits margins are abundant."[115] Many technologies that have "widespread applicability and potentially unimaginable economic and environmental value" are protected by an artificial and non-competitive monopoly through patenting.[116] This will continue deterring new enterprises from starting up renewable energy businesses and costs raised from acquiring these technologies will further affect the regional deployment of such technologies.

On the other hand, Hutchison[117] believes that TRIPS permits "*flexibility* in terms of: what is patentable, and on what basis, the interpretation of claims, permitted exceptions, compulsory

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113 Because, up until now, there are no formal dispute involving a measure under a multilateral environmental agreement has so far been brought to the WTO.

114 E.g. Richard G. Tarasofsky, 'Minimising Conflicts and Enhancing Complementarity between Multilateral Environmental Agreements and WTO Agreements' in Legal Aspects of International Trade (The World Bank 2001) <http://siteresources.worldbank.org/INTLAWJUSTICE/Resources/trade.pdf#page=100> .

115 Jason R. Wiener, 'Sharing Potential and the Potential for Sharing: Open Source Licensing as a Legal and Economic Modality for the Dissemination of Renewable Energy Technology' (2005) 18 Geo Int'l Envtl L Rev 277.

116 Ibid.

117 Hutchison (n 74); Bernard Hoekman, Keith E. Maskus and Kamal Saggi, 'Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options' Research Program on Political and Economic Change Working Paper PEC2004-0003 <http://www.colorado.edu/IBS/pubs/pec/pec2004-0003.pdf> accessed Feburary 2017; see also John Barton and others, 'Integrating Intellectual Property Rights and Development Policy' Report of the Commission on Intellectual Property Rights <http://iprcommission.org/papers/pdfs/final_report/ciprfullfinal.pdf> accessed London September 2002.

licensing."[118] Also, remedying abuses and anti-competitive practices will be useful to developing countries when they feel hampered in getting essential technologies. For example, developing countries could grant compulsory licensing to certain technologies on the basis of pursuing climate mitigation or adaptation. Further, they could interpret environmental TT as grounds for public-interest exception in national patent laws. In cases where inventions are not exploited, or insufficiently exploited, in a country, "measures could be applied to restrain some of the anti-competitive practices feared as potentially impeding the transfer of climate-related technologies to developing countries."[119] If these ideas work as well as they sound, developing countries ought to take advantage of these flexibilities. But it is what happens in practice that is key, where significant shortages of these flexibilities available under TRIPS still exist.

Fortunately, "the 2001 Doha Declaration on TRIPS and Public Health[120] referred to the flexibility afforded by TRIPS to member countries in setting IP protection with respect to pharmaceutical patents."[121] For example, the Declaration reinforced member states' flexibility to determine what constitute urgent circumstances, stating that "each Member has the right to determine what constitutes a national emergency or other circumstances of extreme urgency, it being understood that public-health crises...can represent a national emergency or other circumstances of extreme urgency." It also took the lack of technology-capability concerns into consideration, suggesting that "countries that cannot

[118] Developing countries may implement compulsory licensing provisions to remedy a refusal to deal in situations where the patent has been filed in that country. This will be discussed in detail in the IP chapter later on.
[119] International Centre for Trade and Sustainable Development ICTSD, 'Climate Change, Technology Transfer and Intellectual Property Rights' Trade and Climate Change Seminar June 18–20, 2008 Copenhagen, Denmark <https://www.iisd.org/pdf/2008/cph_trade_climate_tech_transfer_ipr.pdf> accessed 1 Jul 2017.
[120] Declaration on the TRIPS Agreement and Public Health, DOHA WTO MINISTERIAL 2001: TRIPS, WT/MIN(01)/DEC/2, 30 June 2017.
[121] Adam (n 108).

produce pharmaceuticals themselves may import pharmaceuticals made under a compulsory licence according to TRIPS Article 31."[122] Littleton[123] mentioned that such emphases are opening the door to the potential use of these exceptions in the climate change context. The ICTSD[124] therefore suggests that the "experience with the issue of public health"[125] could "become a reference point for the discussion of TRIPS flexibilities, including in the context of the transfer of climate-related technologies,"[126] and such aims seems consistent with the objectives of most MEAs. However, both articles failed to demonstrate the distinctions between different industry sectors and the different applicability of these flexibilities to them. Adam,[127] on the other hand, discusses some differences between ESTs and pharmaceutical products. He had compared the different nature of the problems solved by the technology in question; pointing out that the attention given to pharmaceutical TT is due to the incidence of epidemic "diseases (e.g. HIV/AIDS, malaria, and tuberculosis) in developing countries revealed that a large portion of the world's population lacked access to pharmaceuticals."[128] And because of the mortality factors associated with such diseases, providing drugs and transferring relative technologies to these countries are given more weight during international negotiations. In contrast, even with scientific evidence demonstrating that

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[122] Information and Media Relations Division of the WTO Secretariat, 'TRIPS and Pharmaceutical Patents' WTO OMC Fact Sheet September 2006 <https://www.wto.org/english/tratop_e/trips_e/tripsfactsheet_pharma_2006_e.pdf> .
[123] Littleton (n 9).
[124] ICTSD (n 119).
[125] Several firms have responded such as Merck & Co. announced it would reduce the price of 2 AIDS-controlling drugs in Africa by 40 to 55 per cent, adding to sharp price cuts announced in 2000 (Mark Schoofs and Michael Waldholz, 'Price War Breaks Out Over AIDS Drugs In Africa as Generics Present Challenge' The Wall Street Journal (March 7, 2001) <https://www.wsj.com/articles/SB983915787153550680>). However, even at these prices the drugs may be beyond the reach of most patients. Moreover, drugs developers worry that the availability of far cheaper treatments in poor countries could erode their price-setting poor in rich countries. This erosion could happen directly through unauthorised parallel trade in drugs. Control over patent rights in AIDS treatments is before the WTO in a dispute raised by the US against Brazil in February 2001.
[126] In his speech to the UNFCCC Conference of the Parties in Bali, the Brazilian Foreign Minister proposed that a statement similar to the Doha Declaration on the TRIPS Agreement and Public Health should be considered in the climate change context.
[127] Schoofs and Waldholz, (n 125); Adam (n 108).
[128] Pedro Roffe, Christoph Spennemann and Johanna von Braun, 'From Paris to Doha: The WTO Doha Declaration on the TRIPS Agreement and Public Health' in Pedro Roffe and David Vivas Eugui (eds), Negotiating Health: Intellectual Property and Access to Medicines (Taylor & Francis 2012) 16 quoted by Adam (n 108).

unless properly and timely dealt with, climate change problems will lead to detrimental consequences threatening human life and economic growth in many countries, global warming issues are not considered as equally urgent as public-health emergencies such as the spread of HIV/AIDS.[129] Moreover, pharmaceuticals treating HIV/AIDS "are protected by patents and sold by only a few companies at high prices in developed countries."[130] The case is quite different in the green technology area, where many different companies hold climate change technologies such as green energy technologies, and they are actively offering "their products and services on the open market."[131] Adam has therefore argued that the "WTO's past treatment of the latter sheds little light on its potential treatment of EST products in the future."[132]

Although the reiteration of flexibilities[133] by the Doha Declaration may not be constructive in accelerating climate change TT, in cases where countries refuse to become signatories to MEAs or current MEAs expire, TRIPS is possibly the most appropriate forum to deal with such issues. This will result in calls for measures and adjustments to the TRIPS Agreement to support the post-Kyoto climate regime. But considering the long time that might be needed for accomplishing this, and the many difficulties facing it, this thesis will, meanwhile, focus on

[129] James Shepherd, 'The Future of Technology Transfer Under Multilateral Environmental Agreements' ELR NEWS & ANALYSIS, 37 ELR 10547, July 2007, 10556 <http://elr.info/sites/default/files/articles/37.10547.pdf> quoted by Adam (n 108).
[130] Roffe, Spennemann and Braun 10 (n 12).
[131] "For example, energy efficient appliances indirectly cut GHG emissions by reducing energy consumption. Among its worldwide industry partners the EPA Energy Star website lists twenty-one manufacturers of energy efficient central air conditioning systems, sixteen manufacturers (with 451 products) of geothermal heat pumps, and 152 manufacturers of compact fluorescent light bulbs." 'Certified Products: LIGHT BULBS' (*ENERGYSTAR.GOV*) <https://www.energystar.gov/products/lighting_fans/light_bulbs> . "The EPA lists fourteen developers of fuel cells that had either commercial products or demonstration systems available for performance testing." Combined Heat and Power (CHP) Partnership, 'Catalog of CHP Technologies' (U.S. EPA, March 2015) <https://www.epa.gov/sites/production/files/2015-07/documents/catalog_of_chp_technologies.pdf> .
[132] Adam (n 108).
[133] the Flexibility under TRIPS will be discussed in Chpater V

what can be done during the application of TRIPS and MEAs to enhance implementation and harmony. A detailed discussion of this issue will be included in later chapters.

1.6 TT to developing countries

As a matter of fact, the majority of climate change technology owners are primarily from developed countries.[134] For example, in both the wind and automobile pollution control sectors, major developed countries dominate the ownership of more than 90 per cent of the technology patents.[135] More recent research[136] in the field of agriculture patents concluded with a similar result of 70 per cent.[137] These authors identify the leaders in environmental patenting and prove the generic need for technology transfers to developing countries to occur. Moreover, the IPCC[138] elaborates on problems due to how companies have prevented the exporting of the most advanced technologies in order to progress and retain their own technological advantages.[139] Because accelerating the development of green technologies and promoting their global application are key challenges for stabilizing atmospheric greenhouse gas (GHG) emissions, in order to combat climate change, transferring such technologies "is at the core of current discussions surrounding the post-Kyoto climate regime."[140]

In addition, international TT is particularly relevant in climate change mitigation in developing countries because of its particular importance during the initial stages of development of a

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[134] Third World Network (n 12).
[135] OECD (n 20).
[136] ETC Group, *Gene Giants Stockpile Patents on "Climate-ready" Crops in Bid to become "Biomassters"* (Patent Grab Threatens Biodiversity, Food Sovereignty, Issue #106, October 2010)
[137] See more researches such as Dechezleprêtre and others (n 22).
[138] IPCC, Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change (n 7).
[139] Third World Network (n 12).
[140] Dechezleprêtre and others (n 22).

country's economy. Many developing countries are now in their phase of infrastructure development, and "delays in technology transfer could therefore lead to a lock-in in high-emissions systems for decades to come."[141] For example, in the early years since the founding of a commercial China, the Chinese manufacturing industry has been relying on high-carbon coal-dominated energy supply. According to Fu et al., this is due to China's coal-dominated energy structure, because the country is rich in coal resources but has lack of natural gas, oil and other energy sources. China has therefore become the world's largest coal producer and consumer, which resulted in the infrastructure construction of most enterprises being based on coal-based energy. Therefore, the technical support system in China is accordingly more developed in the high-emission area, which is in fact restricting the development of low-carbon technologies and the applications of those technologies.[142]

But such voices are mostly heard from technology recipients' side. The importance of the transfer of clean technologies would be considered less so from the perspective of developed countries. These countries "are seen more as inventors of clean technologies whereas developing nations are seen as needing those inventions as their energy production increases."[143] This difference in views has led to further discussion as to what degree global warming is a global problem, and of the position that international agreements should take in accepting TT as an important issue. In fact, the UNFCCC parties had discussions on "whether IPRs are an obstacle that impedes effective TT, and if so, what measures should be taken?"[144]

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[141] For example, J. Zou and Y. Xu, Transfer and Development of Technologies: An Important Measure to Response to Climate Change, Environmental Protection (published in Chinese) No. 1 (2005). Quoted by IPCC, Climate Change 2001: Mitigation: Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (n 34).
[142] Y, Fu et.al., "Ways and potential of low-carbon development of Chinese economy" (2008) (published in Chinese) <http://iue.cass.cn/photo/doc/626_20101228143722860.pdf >
[143] Consilvio (n 97).
[144] ICTSD (n 119).

As a forum for combatting the climate change crisis, it is a telling sign that members of the UNFCCC took the position that climate change is a global problem, while negotiations are a kind of game between vested interests and new players. Developing countries like China have argued that "the existing IPR system does not match the increasing needs for accelerating development, transfer, and deployment of ESTs to meet challenges of climate change."[145] "Countries like Cuba, India, Indonesia, Tanzania, and China indicate that patent protection is an obstacle to clean-TT because patents limit a country's access to clean technologies."[146] These claims are probably due to the fact "that technical information is costly to learn and absorb for endogenous commercialization,"[147] according to Maskus. "Technology owners with IPRs may theoretically demand prices that are higher than the marginal cost, or may monopolize markets"[148] because they have the power to manipulate supply demands. The "high concentration of equivalent clean technologies found in a small number of companies"[149] increases the risk of anti-competitive behaviour by developed countries.[150] Based on submissions, in the 2009 United Nations climate treaty negotiations, proposals for weakening IPRs for easier access to green technologies were submitted.[151] Conversely, the US "has expressly opposed any weakening of IPRs related to clean technologies."[152] The divide

145 China, 'China's Views on the Fulfillment of the Bali Action Plan and the Components of the Agreed Outcome to be Adopted by the Conference of the Parties at its 15th Session' in UNFCCC (ed), Ad Hoc Working Group on Long-term Cooperative Action under the Convention 5th Session (AWG-LCA 5), vol FCCC/AWGLCA/2009/MISC.1 (Bonn Climate Change Conference - March 2009, AWG-LCA 5 2009) <http://unfccc.int/resource/docs/2009/awglca5/eng/misc01.pdf> .

146 ICTSD (n 119).

147 Maskus, Encouraging International Technology Transfer (n 51).

148 Ibid.

149 UNEP, EPO and ICTSD (n 29) p.26.

150 Frederick M. Abbott, 'Innovation and Technology Transfer to Address Climate Change: Lessons from the Global Debate on Intellectual Property and Public Health' (2009) ICTSD Programme on IPRs and Sustainable Development Issue Paper No 24.

151 UNFCCC, Ad hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA) Negotiating Text. (FCCC/AWGLCA/2009/8, 2009) (proposing "removing barriers to development and transfer of technologies from developed to developing countries arising from ... intellectual property rights" or exempting least-developed countries "from patent protection of climate-related technologies") quoted by Lisa Larrimore Ouellette, 'Addressing the Green Patent Global Deadlock through Bayh-Dole Reform' (2009) 119 Yale LJ 1727.

152 Ouellette (n 151).

over IPRs has been clearly demonstrated there and has in turn delayed agreement among UNFCCC parties concerning clean-TT.[153] A clear dividing line exists between groups of countries depending on their economic development level and different needs. And they are intending to protect the utmost interests of their citizens.

Taking either perspective blindly – developed or developing –[154] in research is a danger. In fact, it reflects a political perspective rather than a societal perspective, as individual enterprises in most developed countries have experienced a transitional period in history when importing advanced foreign technology, and some developing countries are undergoing the same period. Indeed, it is also possible that there are not just two perspectives. Negotiations at international agreement forums represent the arguments from state level, but firms involved in TT practice may have their own perspectives and it is the transferee firms' perspective that this thesis is looking at. Watal[155] has provided a study, which includes the experience of Indian companies. These firms sought technologies under the Montreal Protocol, in order to transition away from ozone-depleting substances. According to Watal, barriers such as high costs, or the reluctance of proprietors to license, were found within the projects he examined. In most cases, only where the "alternative technology exists, is easily accessible, commercially viable and not covered by IPRs,"[156] did he find that TT was smooth.

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153 Ibid.

154 "Some corporations could engage in patent blocking, a strategy whereby patent owners deter competitors from entering the market because of the costs associated with trying to invent in the neighbourhood of patents." Benjamin K. Sovacool, 'Placing a Glove on the Invisible Hand: How Intellectual Property Rights May Impede Innovation in Energy Research and Development (R& (and) D)' (2008) 18 Alb LJ Sci & Tech 381.

155 Antony Taubman and Jayashree Watal, 'The WTO TRIPS Agreement – A Practical Overview For Climate Change Policymakers' (13 Dec 2010) Intellectual Property Division of the WTO Secretariat <https://www.wto.org/english/tratop_e/trips_e/ta_docs_e/8_3_overviewclimatechange_e.pdf> accessed 30 June 2017

156 *Achieving Objective of Multilateral Environmental Agreements: a Package of Trade Measures and Positive Measures* (Veena Jha and Ulrich Hoffmann eds, United Nations Conference on Trade and Development UNCTAD/ITCD/TED/6 2007)

In other cases, where technologies are "under IPRs, with only a few technology owners,"[157] accessing technologies was comparatively difficult. As inspiring as this study is, it is encumbered by its wide range of subjects and by including many industrial sectors and their status quo in several countries. Watal's study informed the decision of this thesis to focus on the obstacles to TT from a company's perspective. A firm-level perspective helps to demonstrate obstacles that an IP system is placing before TT. Therefore it has enabled this research to provide ideas on what could possibly be a balanced level of IP protection on climate change-related technologies. The thesis endeavours to narrow the target to renewable energy TT to China, considering its increasing market force and being considered by many international private financiers. The bright side of involving such a perspective is not only its precision but also the fact that the tangible nature of energy production and the maturity of many related green technologies "decrease the likelihood of a single blocking patent."[158] "Even in the biofuel sector, where avoiding patented micro-organisms may be difficult, licensing of these patents is likely and royalties would not remain high for long."[159] But "other factors, such as lack of capital and know-how, may be larger impediments to technology transfer."[160]

However, TT in developing countries has different potential to be affected by IPRs. There is a substantial literature[161] on the subtle effect of IP protection on TT to LDCs.[162] With the risk

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[157] Ibid.
[158] Abbott (n 150).
[159] John H. Barton, 'Intellectual Property and Access to Clean Energy Technologies in Developing Countries' (2007) ICTSD Issue Paper No 2.
[160] See Marilyn A. Brown and others, Carbon Lock-In: Barriers To Deploying Climate Change Mitigation Technologies (Engineering Science and Technology Division ORNL/TM-2007/124, 2007) quoted by Consilvio (n 97).
[161] For example, Harvey reports that most patents, especially clean-energy technologies, are not filed in the LDCs. He argues that this is due to small market size and small potential in such countries. (Ian Harvey, 'Intellectual Property Rights: The Catalyst to Deliver Low Carbon Technologies' Breaking the Climate Deadlock, Briefing Paper <https://www.theclimategroup.org/sites/default/files/archive/files/Intellectual-Property-Rights.pdf>) They lack the capacity to

of leaving technology owners vulnerable in the long term in that country, there is not a strong reason for these poor countries to rush to implement their IP standards in compliance with internationally accepted IP standards. Therefore, I assume that the impact of IPRs on TT in LDCs is less obvious than it is in middle-income developing countries. This study therefore opts for the latter part of those[163] specified in mid-income developing countries. On the other hand, situations are quite different in large- or higher-income developing countries. Consilvio's research[164] lists a group of countries with social and business activity in the process of rapid growth and industrialization. He classifies these countries as emerging economies. In comparison with LDCs, these nations have significantly larger quantities of patents filed under IP systems. Maskus[165] Reichman[166] Falvey[167] and other researchers listed in section 1.3 all argued that strengthened IPR protection has a positive impact on TT into a large developing country. A reason for such a dynamic being seen only in large

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copy and breach the patent. Research by Copenhagen Economics suggests that there are almost zero patent filings in clean technology sectors in the least developed countries. (Copenhagen Economics and The IPR Company, *Are IPR a Barrier to the Transfer of Climate Change Technology* (Copenhagen Economics Informed Decisions, 2009)) Additional research conducted by the UN Environment Programme, European Patent Office, and the ICTSD observes that, according to the data collected, "only 0.1 per cent of the 215,000 patent applications for certain clean technologies were filed in LDCs." (EPO and ICTSD UNEP, *Patents and Clean Energy: Bridging the Gap Between Evidence and Policy (Final Report)* (United Nations Environmental Programme, European Patent Office, International Centre for Trade and Sustainable Development, 2010) p.22) If a particular technology is not patented in a country, then companies in that country are free to use these inventions. Although the limited technological capacity in these countries does not present a competitive-imitation threat to the developed country transferors, according to Matkusen and Maskus, it will probably not encourage sufficient TT from abroad. Therefore, according to the existing literature, patents and IP protection are very unlikely to be a barrier in LDCs. Maskus, *Encouraging International Technology Transfer* (n 51).

162 Least developed country (LDC) is the name given to a country "which, according to the United Nations, exhibits the lowest indicators of socioeconomic development, with the lowest Human Development Index ratings of all countries in the world." See Identification of the Least Developed among the Developing Countries, UN Resolution 2768(XXVI) 18 November 1971.

163 Hamid Jafarieh, 'Technology Transfer to Developing Countries: A Quantitative Approach' (PhD thesis, University of Salford, UK 2001); Suerie Moon, 'Meaningful Technology Transfer to the LDCs: A Proposal for a Monitoring Mechanism for TRIPS Article 66.2' (2011) 9 ICTSD Programme on Innovation, Technology and Intellectual Property Policy Brief.

164 Consilvio (n 97). See also *Emerging Economies and the Transformation of International Business: Brazil, Russia, India and China (BRICs)* (Subhash C. Jain ed, Edward Elgar Publishing 2006) p.384.

165 Fink and Maskus (n 40).

166 Maskus and Reichman (n 41); Guifang (Lynn) Yang and Keith E. Maskus, 'Intellectual Property Rights and Licensing: An Econometric Investigation' in Carsten Fink and Keith E. Maskus (eds), *Intellectual property and development: Lessons from recent economic research* (A Co-Publication of the World Bank and Oxford University Press 2005) 111 (n 41), refers to one study which "indicated that US MNEs were less likely to transfer advanced technologies to unaffiliated firms licenses the technology (strong patent laws or invests directly (weak patent laws). Strong patent laws reduce imitation risk, uncertainty and transaction costs involved in technology contracts thereby encouraging licensing relative to trade." Smith 411 (n 41).

167 See Falvey, Foster and Memedović (n 45).

emerging economies could be related to the market size threshold in TT activities. Economies with low incomes normally have less attractive markets.

1.7 TT to China

The seven largest emerging and developing economies by GDP are China, Brazil, Russia, India, Mexico, Indonesia, and Turkey. Among them, China is deemed to be comparatively active in terms of technology absorbing and diffusing. For example, in the research conducted by Lee et al.[168] quantitative data on global patent ownership in several green energy sectors was studied. China was found to be the most popular place for patent filings following the US and Japan. Dechezleprêtre et al [169] also show that China is an emerging country in terms of patent ownership in selected technologies (e.g. solar energy). But the problem remains that the existence of significant quantities of patents in emerging economies does not resolve the issue of whether IP laws regulating these patents is a barrier to clean technology transfer or not.

Over the past few years, "investment in renewable energy has grown rapidly in China, due to venture capital invested in solar power, wind power and bioenergy." [170] As early as 2006, China accounted for 9 per cent of total global renewable investment. China has even "increased its share of global renewable energy investment in 2014 to nearly a third (31%)."[171] Such a large amount of funding was mainly used to develop its domestic wind

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[168] Lee, Iliev and Preston (n 19).
[169] Matthieu Glachant and others, 'Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale: A Study Drawing on Patent Data' (October 29, 2009) Fondazione Eni Enrico Ma ei Working Papers Paper 343 <http://services.bepress.com/feem/paper343> .
[170] Fei Ding and others, 'Green Energy Development and Technology Transfer in China and India' (2012) 19 Journal of International Development and Cooperation 13.
[171] Bloomberg New Energy Finance Fs–Unep, 'Global Trends in Renewable Energy Investment (2015)' Frankfurt School-UNEP Collaborating Centre for Climate & Sustainable Energy Finance, United Nations Environment Programme <http://apps.unep.org/redirect.php?file=/publications/pmtdocuments/-Global_trends_in_renewable_energy_investment_2015-2015 15028nefvisual8-mediumres.pdf.pdf> .

power, methane and dust burying technologies and applications.[172] However, according to evidence presented by Sascha Müller-Kraenner, in comparison with traditional energy supply sources, green energy still accounts for only a small portion of total energy consumption in the energy structure of China.[173] This may be due to a delay in recognizing the importance of sustainable development and implementation strategy in the past. Given the rather early times when the research was conducted, the paper does not recognise that greater importance was attached to sustainable development and the application of renewable energy in China in more recent years. And the lack of awareness of climate change issues has been solved to some extent. It is the IP issues, now and in the future, that may still arise as barriers to the fast adaptation to climate deterioration in China.

Barton[174] takes a rather positive but compelling view of the suspect claims that, even with possible competition issues, IPRs would not become a hindrance as "the availability of other competing technologies and traditional energy sources may only permit IPR holders to demand modest royalties." Indeed, as found by Ockwell et al.[175] there are some areas where IPRs would not be a barrier. For example, although subject to IPRs, the transfer of technologies in the hybrid drive-train sector to China was quite successful because the patent holders have been providing information and training, as well as equipment, for mechanics and engineers: "This passing on of knowledge and skills implies the potential for companies in

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[172] The National Development and Reform Commission of the People's Republic of China (NDRC), "Status of the world's energy consumption and renewable energy development trends" (2006, published in Chinese) available at <http://www.ndrc.gov.cn/nyjt/gjdt/t20061020_89236.htm> quoted by Ding and others (n 170).

[173] Sascha Müller-Kraenner, 'China's and India's Emerging Energy Foreign Policy' Genman Development Institute Discussion Paper 15/2008 <http://edoc.vifapol.de/opus/volltexte/2011/3282/pdf/DP_15.2008.pdf> . See also Xin Zhang and others, 'Analysis on Energy Structure in China under the Low Carbon Economy View' 18 International Journal of Non-linear Science 60.

[174] Barton (n 159).

[175] SPRU and TERI, *UK-India Collaborative Study on the Transfer of Low Carbon Technology: Phase II Final Report* (SPRU (University of Sussex, UK) and TERI (India), 2009)

recipient countries to develop their own technological capabilities."[176] Yet the reality in many other sectors is more complex and not as successful. For example, according to the Energy and Resources Institute's[177] study of local companies in India, China, Indonesia, Malaysia, and Thailand, there are cases where developing country companies terminated negotiations with foreign licensors due to the high royalty fees they required, or because they incurred additional costs buying non-related equipment in order to get access to the desired technology. In Lewis's[178] research, he studied the wind-power industry development strategies in India, China, and Spain. The research found that "developing country manufacturers often have to obtain technology from second- or third-tier wind power companies."[179] This is because leading technology holders are unwilling to license to entities that have the capacity to become competitors in the future. A summary by Mallet, Ockwell et al. is relatively incisive and inspiring – "while consumers in developing countries may not experience specific IPR-related barriers to accessing low-carbon technologies, they may face a cost barrier because of IPRs."[180] This research provided a technology receiver's view to identify difficulties in getting access to the most advanced technologies from their holders in developed countries. But their data needs to be updated for an economy that is at a transition stage. This brings an opportunity for this thesis to complement the research from this angle.

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[176] Ibid.
[177] TERI, *Emerging Asia Contribution on Issues of Technology for Copenhagen* (New Delhi: The Energy and Resources Institute [Project Report No 2008RS09], 2009).
[178] Joanna I. Lewis, *A Comparison of Wind Power Industry Development Strategies in Spain, India and China* (Prepared for the Center for Resource Solutions, Supported by the Energy Foundation, China Sustainable Energy Program, (July 19, 2007), 2007).
[179] Ibid.
[180] SPRU and TERI (n 175).

While many commentators[181] note that IPRs are unlikely to significantly affect access to the pertinent technologies, they could slow down the technology-innovation rate when a developing country is able to develop commercial competitive technologies. Domestic firms may find it extremely difficult to develop indigenous technologies without infringing existing international patents owned by foreign industry leaders, especially when multiple IPRs are related to the development of a single technology. Therefore, it is crucial to the rapidly growing economy of China that more attention is paid to policy development in conjunction with its IP system.[182] In the past few years, according to Ohshita and Ortolano,[183] demonstration projects using cleaner energy technologies assisted by international organizations and developed countries have been raising greater awareness of climate change technologies in China. Accordingly, investment in green industry increased and the decision-making process shifted to a more market-based system. Yet this approach alone was not very successful in diffusing the technologies more widely in the country. Therefore, assistance should start to focus more on policy improvement in China. Such assistance could be associated with the setting of "energy-efficiency standards or enabling an environment of technology diffusion."[184]

However, Bradsher takes a pessimistic view of China's environmental governance, arguing that "the rhetoric about China and green technology seems as simplistic and overheated and

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[181] Fink and Maskus (n 40); Maskus and Reichman (n 41); See Falvey, Foster and Memedović (n 45).
[182] Stephanie Ohshita, 'Chapter 4. Cooperation Mechanisms: A Shift Toward Policy 63 Development Cooperation' in Taishi Sugiyama and Stephanie Ohshita (eds), *Cooperative Climate: Energy Efficiency Action in East Asia* (International Institute for Sustainable Development, Japan
University of San Francisco, United States 2006).
[183] Stephanie B. Ohshita and Leonard Ortolano, 'From Demonstration to Diffusion: The Gap in Japan's Environmental Technology Cooperation with China' (2003) 2 International Journal of Technology Transfer and Commercialisation 351.
[184] IPCC, Climate Change 2007: The Physical Science Basis (Contribution of Working Group I to the Fourth Assessment Report, approved at the 10th Session of Working Group I of Intergovernmental Panel on Climate Change (IPCC), Paris, February 2007, 2007)

that China's push to develop renewables is short-sighted and reductionist."[185] This can be found especially in China's efforts to dominate solar photovoltaic technologies. Bradsher suspects the motivation behind it is that China believes that the "West may someday trade its dependence on oil from the Mideast for a reliance on solar panels, wind turbines and other gear manufactured in China." [186] Not only is the original intention of China's green technology development questioned, but Kennedy [187] argues that China's national government has a native drawback comprising a dense bureaucracy with redundant and overlapping agencies regulating environmental issues. Exceedingly divaricated authority over China's environment, and protectionism in China's domestic green technology industries' trade sector could be a problem in promoting TT flows.[188] For example, the operation of a power station requires several permits and licences, which are issued by different government agencies, including the Ministry of Land and Resources, the Administration of Work Safety, the Administration of Industry and Commerce, the State-Owned Assets Supervision and Administration Commission (SASAC), the Ministry of Environmental Protection, and the National Development and Reform Commission (NDRC). Requirements by these agencies are different and even conflict with each other sometimes. As a result, overlapping authority and the heavy burden it puts on enterprises undermines the effectiveness of governance.[189]

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185 Keith Bradsher, 'China Leading Global Race to Make Clean Energy' *The New York Times, (Jan 30, 2010)* <http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html>

186 Ibid.

187 Robert F. Kennedy Jr., 'The New Arms Race' (*Huffpost, The Blog*, May 25, 2011) <http://www.huffingtonpost.com/robert-%20f-kennedy-jr/the-new-arms-race_b_364211.html> accessed 22 Jun 2017.

188 Even within the National Development and Reform Commission (NDRC), responsibility for energy policies belongs to several different organizations. See Erica S. Downs, 'China's "New" Energy Administration' (2008) 35 China Business Review, Nov-Dec 42.

189 Xin Qiu and Honglin Li, 'Energy Regulation and Legislation in China' (2012) 42 Environmental Law Reporter 10678.

Panagariya referred to China's notorious reputation in IP protection: the country has been accused as being one of the most flagrant violators of IPRs.[190] In fact, the prevailing problem of IPRs infringements in China is with regard to a number of software firms in China that produce and sell pirated software. These technologies are easy to crack and pirate, with low risks and high returns involved, and their market prices are much cheaper. Most consumers have relatively low income in comparison with developed countries and this eventually fostered the forming of a piracy market in the country.[191] Therefore, technologies transferred to this country could be at great risk of infringement and deter investors from exporting technologies to the nation. However, Panagariya's article also pointed out that China is a dramatic example, supporting the hypothesis of low response of FDI to IPRs.[192] This is possibly due to the fact that China offers dramatic returns to foreign investment once it enters the market. FDI has grown significantly in recent years and the country has made great use of the mechanisms under the UNFCCC, such as GEF[193] and CDM, to import TT.[194] These contradicting conclusions indicate an inconclusive effect of such ill-conceived piracy phenomenon has on climate change TT flows to China. More analysis based on data collected

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190 Arvind Panagariya, 'TRIPS and the WTO: An Uneasy Marriage' in Keith Maskus (ed), The WTO, Intellectual Property Rights and the Knowledge Economy (Edward Elgar Publishing 2004).

191 Lina Wang, 'Intellectual Property Protection in China' (2004) 36 The International Information & Library Review 253.

192 Panagariya (n 190).

193 "The Global Environment Facility (GEF) unites 182 countries in partnership with international institutions, civil society organizations (CSOs), and the private sector to address global environmental issues while supporting national sustainable development initiatives. Today the GEF is the largest public funder of projects to improve the global environment." See GEF web page, 'About Us' (*Global Environment Facility*) <http://www.thegef.org/about-us> accessed 15 Jun 2017.

194 "The clean development mechanism (CDM) allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol." See UNFCCC web page, 'Clean Development Mechanism (CDM)' (UNFCCC) <http://cdm.unfccc.int/about/index.html> accessed 2 Jul 2017.

in this research and some recent litigation[195] regarding international green technology infringement will be discussed in later chapters.

1.8 The purpose and contribution of the research

As my goal is to understand the effect of IP law on climate change TT to China, it is inevitable that I will engage with the analysis of TT from different disciplines in terms of economic, legal, political, environmental and social aspects relating to the issue. For example, I will look at how market incentives allocate the capital from investors among the various sectors in TT schemes. This is to clarify the possible impact of market factors on TT flows, and to find out the relationship they have with IP laws. Moreover, to reach the ultimate goal of understanding the ability of IP systems to facilitate climate change TT, which is prominent in addressing global environmental problems, the thesis examines EST transfer to China, which is considered in various MEAs and the TRIPS Agreement. This is also to link TT trend conclusions back to the general picture of international IP systems. Although the aforementioned studies are relatively comprehensive in many areas relating to this research, most of them are either macro studies[196] looking at national or international IP regulations from a general view, or they are based on quantitative data, such as patent filing numbers. Some research has focused on LDCs[197] rather than middle-income countries. This has left a gap for research with a combined view of IP and environmental protection in a middle-income developing country, China, which has apparent advantages in technology absorption capacity and is transiting

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[195] For example, the Patent Law of the People's Republic of China (as amended up to the Decision of December 27, 2008, regarding the Revision of the Patent Law of the People's Republic of China) and the The 13th Five-Year Plan for Environmental Protection.

[196] See more e.g, J. Bradford De Long and Lawrence H. Summers, 'Equipment Investment and Economic Growth' (1991) 106 The Quarterly Journal of Economics 445; Charles I. Jones, 'Economic Growth and the Relative Price of Capital' (1994) 34 Journal of Monetary Economics 359; Jonathan Eaton and Samuel Kortum, 'Trade in Capital Goods' (2001) 45 European Economic Review 1195

[197] for example Jafarieh (n 163); Moon (n 163).

from being a technology receiver to a provider. Moreover, the methodology applied by existing researchers has several shortcomings, including the technology types and perspectives chosen.[198] Many studies on the impact of Chinese IP protection are focused on copyrights,[199] which are less relevant to this research. Some other well-developed literatures are about the transfer of pharmaceutical technologies instead of climate change technologies. While this research is innovative, in that it studies IP and TT in a situation where the recipient country is also a major developer of patented technology, it creates dynamics not necessarily at play in many of the other studies, which focus on recipient countries incapable of developing their own technology to address whatever problems need addressing.

Similarly in the IP research area, because most literature has taken a broader perspective when discussing the Chinese national legal system and policy environment, [200] up until now no research has been done at a firm-level, examining enterprises involved in CDM projects.[201] As a result, there is currently not enough evidence confirming to what degree climate change TT is affected by the TRIPS Agreement in China and what specific measures a sector might take to encourage such flows of technology.[202] Gregory Shaffer has identified that empiricism has not yet infused international law.[203] But according to Dinwoodie it is necessary to tailor IP

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198 See details in the Methodology Chapter.

199 regarding to computer programmes and designs.

200 Joel B. Eisen, 'China's Renewable Energy Law: A Platform for Green Leadership' (2010) 35 Wm & Mary Envtl L & Pol'y Rev 1; And Dong Zhang, '2010 Deep Research Report on China Clean Development Mechanism Industry' 168 Research Group, Nov 16, 2010 <http://www.168report.com/Report/report0177.html> accessed 26 Jun 2017.

201 Petersmann has pointed out that the existing literature provides no theoretical deliberation on any empirical insights in the matter of climate change TT since the implementation of TRIPS. See Ernst-Ulrich Petersmann, 'From Negative to Positive Integration in the WTO. The TRIPs Agreement and the WTO Constitution' in Thomas Cottier and Petros C. Mavroidis (eds), *Intellectual Property: Trade, Competition, and Sustainable Development*, vol World Trade Forum Vol. 3 (University of Michigan Press 2003) p.32. Although Mansfield's study provides some persuasive evidence, it is solely based on the U.S. domestic TT statistics. See Edwin Mansfield, 'Intellectual Property Protection, Direct Investment, and Technology Transfer: Germany, Japan, and the United States' The International Finance Corporation Discussion Paper No 27 (September 1995) <https://elibrary.worldbank.org/doi/pdf/10.1596/0-8213-3442-5> accessed 27 Jul 2017.

202 ICTSD (n 119).

203 This due to two reasons (Gregory Shaffer, 'A New Legal Realism: Method in International Economic Law Scholarship' in C. Picker, I. D. Bunn and D. Arner (eds), International Economic Law: The State and Future of the Discipline (Hart Publishing 2008)): (1) a lack of people trained to conduct the work, (See Thomas S. Ulen, 'A nobel Prize in legal science: theory, empirical

rights to fit the real world,[204] and the empirical method of examining the problem seems to be pragmatic and feasible in this context. Although the studies above have contributed insights into trends in TT and evidence of the influence of IP protection, gaps in the evidence landscape remain. It is therefore the objective of this thesis to take an important step forward by filling in at least some of these gaps in the specific area of transferring renewable energy technologies to China. By identifying theories and collecting data at firm-level this research will provide a closer view of climate change TT in practice.

Work, and the scientific method in the study of law' (2002) Vol. 2002 No.4 U Ill L Rev 875 p.914: "An additional reason that legal scholars have not done much empirical work is that they are not adept in it.") and (2) a perception that empiricism is "less honoured" within the legal academy than traditional doctrinal analysis and normative scholarship. (Lawrence M. Friedman, 'The Law and Society Movement' (1986) 38 Stanford Law Review 763)

[204] Graeme B. Dinwoodie, 'Remarks: 'One Size' Fits All Consolidation and Difference in Intellectual Property Law' in Annette Kur and Vytautas Mizaras (eds), The Structure of Intellectual Property Law (ATRIP Intellectual Property Series) (Edward Elgar Publishing Limited 2011).

Chapter II: Research Methodology

2.1 Aims

This thesis looks at the practical impacts that the TRIPS[1] Agreement has on international TT relating to climate change, which is provided by international agreements (e.g. the Kyoto Protocol[2]). The author takes the perspective of a developing country (China) focusing on both external (international) and internal (national) regulations to study the operational situation of the "pull" side of TT.[3] The research will on one hand address the relationship between TRIPS and UNFCCC, and on the other examine how individual transactions, or potential transactions, of climate change TT have been affected by IP rights and surrounding issues. The transactions examined will focus upon China (which is a developing country) as it possesses certain features that make TT both desirable[4] and at times problematic.[5]

2.2 Research questions

Based on the literature reviewed in the previous chapter, the thesis now turns to look at the research questions and how the answers will be found. As this thesis attempts to look at the practical impacts that the TRIPS[6] Agreement has on international climate change TT, especially to China, in a general environment provided by MEAs (e.g. the Kyoto Protocol[7]), it will focus on the following research question:

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[1] The Trade-Related Aspects of Intellectual Property Rights (unamended version), Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, signed in Marrakesh, Morocco on 15 April 1994.

[2] The Kyoto Protocol sets binding obligations on industrialised countries to reduce emissions of greenhouse gases, Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), UN Doc FCCC/CP/1997/7/Add.1, Dec. 10, 1997; 37 ILM 22 (1998).

[3] the receiving side of TT.

[4] major climate change and related problems, e.g. severe air pollution.

[5] e.g. its capacity to become a major manufacturer of climate change technology, putting at risk the IP rights of the transferor.

[6] The TRIPS Agreement.

[7] The Kyoto Protocol (n 2) sets binding obligations on industrialised countries to reduce emissions of greenhouse gases.

A: What is meant by the concept of transfer technology and what obligations are there under international law for the transfer of technology in relation to climate change issues?

B: How do international agreements, which protect intellectual property rights, relate to green technologies?

C: Is there a conflict between transfer of technology obligations in climate change agreements and the protection of intellectual property rights in TRIPS? If so, how should conflicts between the two be resolved, or how can they be avoided?

D: In practice, does the protection of intellectual property rights (IPRs), or concerns about the protection of such rights, have any impact on the transfer of climate change technology to China?

E: As a consequence of the experience that Chinese entities have had in getting overseas firms to transfer climate change technology, is there a need to change either Chinese domestic or international law? What form should any changes take? Will the upcoming changes under UNFCCC (Post-Kyoto, e.g. the Paris Agreement) alter IP effect on climate change TT in China?

2.3 Methodology

This research adopts a social-legal research methodology, incorporating doctrinal and empirical methods. The doctrinal method will include the analysis of authoritative texts that consist of primary (legal documents) and secondary sources (academic commentary). Such a method is essential for answering research questions A, B and C as it helps identify the international legal context in which climate change technology transfer is conducted and from which challenges arise.

The research then looks at the effects of the current level of IP protection and the IP system enabled by TRIPS on individual enterprises and TT transactions. Kagan notes that "the real meaning of regulatory law can be determined only by observing what occurs 'on the ground.'"[8] Research questions D and E directly respond to Kagan's observation and in answering them, an interview survey was administered to a selected sample of specific Chinese companies from CDM project participators with experience of receiving climate change technology transferred from developed countries. An examination of the dynamic during the TT process in these companies and a study of how China's IP system was amended according to TRIPS shall provide insights into whether IP laws hinder (or are inconducive to) TT in reality, especially when transferring technologies that address the climate change problems that China causes or suffers.

2.3.1 Doctrinal method

This study is designed to try to answer doctrinal questions but is supported by empirical evidence. First, questions A, B and C will be investigated using a traditional legal, doctrinal research method. Doctrine can be defined as "a synthesis of various rules, principles, norms, interpretive guidelines and values. It explains, makes coherent or justifies a segment of the law as part of a larger system of law."[9] Such an approach relies extensively on court judgements or, in this research, the decision of a Dispute Settlement Body and legislations[10] to rectify and clarify the law.[11] For example, in research by Lianos,[12] by reviewing economic

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[8] Robert A. Kagan, 'Editor's Introduction: Understanding Regulatory Enforcement' (1989) 11 Law & Policy 89 p.91.
[9] Terry Hutchinson and Nigel Duncan, 'Defining and Describing What We Do: Doctrinal Legal Research' (2012) 17 Deakin L Rev 83.
[10] The provisions of international agreements.
[11] *Research Methods for Law* (Mike McConville ed, Edinburgh University Press 2007) p.3
[12] Ioannis Lianos, 'A Regulatory Theory of IP: Implications for Competition Law' CLES Working Paper Series, (1/2008) <http://www. ucl. ac. uk/cles/research-paperseries/research-papers/cles-1-2008> accessed Feburary 2017.

theories and property right theories, including justifications for IPRs and decisions from the EU court of justice, he identifies distinct characteristics of IPRs' and their conflicts with competition law. His research was able to look at the "conceptualisation of IP as a form of regulation providing a useful theoretical basis for a better understanding of the interactions between competition law and intellectual property."[13] In this research, a doctrinal method is likewise employed to study the law (e.g. provisions in TRIPS Agreement) and legal concepts in relation to IPRs and TT.

Through a doctrinal study, the thesis includes analysis of texts that consist of primary[14] and secondary sources.[15] This part is essential for it will identify the international and national legal contexts in which climate change TT arises. For example, there are many academic articles about the TRIPS Agreement and the refining of national IP law in accordance with TRIPS. Studying these provides a good reference point to look at how the current IP system was established and its possible effect on climate change TT. Moreover, many efforts made to fight climate change materialize through the implementation of MEAs. The concept of TT is also commonly employed in these MEAs and corresponding obligations for TT in order to cope with climate change are assigned. MEAs including TT provisions such as the UNFCCC[16] will be considered in detail, especially to understand the objectives, principles, functions, mechanisms and efficiency, etc. of these provisions.

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[13] Ibid.
[14] i.e. legal documents.
[15] i.e. commentary on conflicts between MEAs and WTO agreements, including TRIPS.
[16] United Nations Framework Convention on Climate Change, 1771 UNTS 107; S. Treaty Doc No. 102-38; U.N. Doc. A/AC.237/18 (Part II)/Add.1; 31 ILM 849 (1992).

Studying the mechanisms available under MEAs will also help recognize the most possible typical situation of TT practice. In most cases where technology is transferred, IPRs are involved. Thus MEA is an external cut-through to understand how international agreements, which protect IPRs, relate to green TT. To be more specific the research will look at CDM[17] projects in particular, as the mechanism is one of the representatives under the UNFCCC that have helped finance emission reductions and further commit Annex I Parties to obligations including TT aids to reduce emissions. Although this mechanism does not have an explicit TT mandate,[18] it contributes to TT by financing emission-reduction projects using technologies currently not available in the host countries.[19] Therefore, projects taken under CDM are great places to get TT data and information. The research will use the existing literature on these subjects along with the text in relevant international agreements as a starting point from which to identify the context and rules in which climate change TT can occur.

In the context of on-going work on IPRs and climate change, the objective of this thesis is to look at the relationship between IP and the transfer of climate-related technologies and to outline some of the existing and prospective measures, primarily in the TRIPS Agreement that could be considered in support of a post-Kyoto climate regime. If the excessive cost of emission reduction claimed by developing countries (e.g. China) is due to unbalanced IPRs and high standards of IP protection, it requires a prudent review of the system to see whether it is

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[17] The CDM defined in Article 12 of the Protocol (The Kyoto Protocol article 12) "allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets."

[18] Further recognizing that the Kyoto Protocol has not created or bestowed any right, title or entitlement to emissions of any kind on Parties included in Annex I. See Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December, 2005 FCCC/KP/CMP/2005/8/Add.1

[19] Stephen Seres, *Analysis of Technology Transfer in CDM Projects* (Prepared for the UNFCCC Registration & Issuance Unit CDM/SDM, 2008).

possible to reduce TT barriers by adjusting relevant laws. The research will investigate provisions employed by TRIPS relative to international TT and commentaries on how TRIPS could help design an effective and self-interested approach to encourage environmental protection activities.[20] Understanding these issues will help to provide possible resolutions to TT barriers under the current available system and also recognize limitations based on which amendments shall be made. This thesis will try to arrive at a view as to what is the appropriate balance between public interest concerns and the rights of patent holders, based on the observation of large-scale patterns and trends and of the pros and cons of IPRs.[21]

In my study, the doctrinal method is used to identify the more general effect of IP law and explore possibilities to maximize the provisions in favour of climate change mitigation, in particular, to look for better use of the IP system to facilitate green TT to developing countries like China. However, pure doctrinal research is unable to see how these trends formulate and vary among individuals who enact them on the ground. In order to offset the drawback of employing only doctrinal methodology in the research, this thesis also employs a socio-legal method to look at firm-level dynamics for on-the-ground analysis.

2.3.2 Socio-legal method

In the 1960s and 1970s, scholars started "the law and society movement, and pointed to the importance of understanding the gap between 'law in books' and 'law in action', and the

[20] Such study will clarify the norms and function created by TRIPS, for example what are the "flexibility" options under TRIPS and how well did members make use of them? Is it possible to accomplish that goal by providing a compliance record approach as well as an environmental soundness standardizing system to encourage countries' corporation in climate change technology transfer. The Kyoto Protocol (n 2), Chapter 2, for example the clear energy labelling (now mandatory for many goods in the EU), minimum energy standards (as required for some goods in the EU and increasingly in other countries), which overcomes market failures.

[21] available from existing literature.

operation of law in society."[22] The intention is to examine the legal system in terms of whether it actually brings positive effects benefiting public interests. Empirical evidence is often needed to meet this goal.[23] In addition, socio-legal scholars employ a wide range of social science methodologies, such as qualitative research method.[24]

For instance, Dave Cowan and his colleagues employed a socio-legal method "to study the role of adjudication or the decision-making processes within the local authority in influencing the implementation of homelessness law."[25] The study offers not only rich detail on the social world of public administration but also explores the significance of adjudicatory processes on the implementation, which other studies fail to do. The research is done with a threefold method: a doctrinal overview of the history and content of the subject Acts and provisions relevant to a so-called "internal review" approach invoked by homelessness decision-making authorities; quantitative data collected through questionnaire on trend in the seven years since the introduction of internal review;[26] a separate qualitative study uses an existing analytical framework[27] to analyze the "influence of judicial review on homelessness decision-making in order to explore the conditions under which internal review is likely to

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[22] For example, John Henry Schlegel, *American Legal Realism and Empirical Social Science* (University of North Carolina Press 1995); Reza Banakar and Max Travers, *Theory and Method in Socio-Legal Research* (Oxford:Hart Publishing 2005) See in Dave Cowan, Simon Halliday and Caroline Hunter, 'Adjudicating the Implementation of Homelessness Law: The Promise of Socio-Legal Studies' 21 Housing Studies 381.

[23] See in Cowan, Halliday and Hunter (n 22), "the so-called 'gap problem": Z. Bankowski and D. Nelken, 'Discretion as a Social Problem' in M. Adler and S. Asquith (eds), *Discretion and Welfare* (London: Heinemann 1981); "now socio-legal studies has been much more sophisticated in trying to understand the operations of law in society" D. J. Galligan, 'Introduction' in D. J. Galligan (ed), *Socio-Legal Studies in Context: The Oxford Centre Past and Future* (Wiley 1995).

[24] Tracey E. George, 'An Empirical Study of Empirical Legal Scholarship: The Top Law Schools' (2006) 81 Indiana Law Journal 141.

[25] Cowan, Halliday and Hunter (n 22).

[26] "There was an absolute increase in the extent to which local authorities were exposed to the process. How many decisions were changed as a result of internal review in the six-month period? How many appeals to the County Court were made in the six-month period?) The quantitative data also reveals that many local authorities believe that internal review has had a positive 'impact' on the quality of first instance decision making." Ibid, (n 22).

[27] "This framework posits that internal review will have greater influence over decision making (1) where initial decision makers receive more information about the legal requirements of decision making in light of internal review; (2) where the initial decision makers are more conscientious about applying that legal knowledge to their routine tasks; (3) where they have greater competence in understanding and applying legal knowledge; and, finally, (4) where law's strength in the decision-making environment is greater." Ibid (n 22).

have most influence on the implementation of homelessness law."[28] The qualitative study is based on a case study conducted in Southfield Council[29] and interview data collected from the Brisford authority.[30] This study is one eligible example demonstrating how data is collected to examine how a legal institution operated and whether legal reform achieved its intended outcomes, including what were the real motivating factors and thereby providing recommendation on future policy and legal reform.

The structure of my research questions are similar to Cowan's study but in a different area that looks at the effectiveness of the international agreements that specifically regulate IP issues, in particular the effect that current levels of IP protection and the IP system have on individual enterprises and TT transactions. Therefore, the research employs a similar method as Cowan in his study. My research takes a mixed method approach, in that empirical legal scholarship is complementary to the previously mentioned doctrinal research. Both methodologies are used simultaneously[31] to examine issues to be address in the thesis.

The study is undertaken in the context of China being the workshop of the world. The fear of the industrial growth of China and the associated problem of the country being a major economic competitor could also be factors influencing whether overseas firms provide TT to the country. These have been reflected in the "one-size-fit-all" international IP regime, which is possible in crippling developing countries, such as China, from acquiring climate change technologies. Dinwoodie was successful making an argument for tailoring IP rights to fit the

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[28] Ibid.
[29] "that an organisational anxiety over anti-social behaviour sat in tension with legality as an influence over decision making on the ground" ibid.
[30] Brisford's commitment to legality was countered by its commitment to "efficiency".
[31] J. Baldwin and G. Davis, 'Empirical Research in Law' in P. Cane and M. Tushnet (eds), *The Oxford Handbook of Legal Studies* (Oxford University Press 2003) p.881.

real world.[32] He argues that although the international legal system has tended to favour national autonomy and keeping internationally mandated levels of protection low; seeking to establish a unitary body of IP law on “certain issues” will benefit not only current rights holders but also future users. But to make sure that climate change TT is counted as a “certain issue” that is dealt with primarily under the IP system, we have to first confirm the hypothesis that insufficient climate change TT is to do with the current IP protection system and can be affected by IP law amendments. This requires acquiring data available not only from: international organizations’ web pages (e.g. Project Design Document from the CDM web page)[33]; the Chinese government (Chinese national year books)[34]; institutions (such as the China CDM information centre[35]); but also, importantly, individual experiences gathered from professionals and employees in the industry. The lack of international facilities in developing countries – both materially and intellectually – needs to be expressed clearly and convincingly, especially at this point when there are already some theorists arguing that enough favours are given to technology-receiving countries and insufficient attention to the rights of IP owners. A socio-legal methodology will provide direct evidence of the influence of IP law on climate change TT practice, thus making it the most feasible way to confirm my hypothesis. However, the contention here is that these two dimensions should be seen not as being mutually exclusive but as each having value that cannot be neglected. This thesis has

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[32] Graeme B. Dinwoodie, ‘Remarks: ‘One Size’ Fits All Consolidation and Difference in Intellectual Property Law’ in Annette Kur and Vytautas Mizaras (eds), *The Structure of Intellectual Property Law (ATRIP Intellectual Property Series)* (Edward Elgar Publishing Limited 2011).
[33] ‘CDM Project Search’ (*UNFCCC website*) <http://cdm.unfccc.int/Projects/projsearch.html> accessed 12 Jul 2017.
[34] ‘Annual Data’ (*National Bureau of Statistics of China*) <http://www.stats.gov.cn/english/statisticaldata/AnnualData/> accessed 9 Jun 2017.
[35] ‘Clean Development Mechanism in China’ (*CDM in China Website*) <http://cdm-en.ccchina.gov.cn> accessed 6 Aug 2017.

indeed offers a socio-legal analysis of the effect of IP on TT to China, specifically in the context of global climate change.

To be more specific, the empirical part of my research examines how Chinese IP law altered according to TRIPS requirements and how it works in international TT practice, including which laws will be involved and how will they influence TT; how and to what extent patent law influences "the actions, attitudes, and expectations of officials and non-officials;"[36] how the relevant policies and procedures, and the way they are applied, affect green industry business. Moreover, in this study, regulation and its enforcement are treated as social processes. Therefore, what might be regarded as hindrance of TT resides not simply in the legal rules but in social behaviour, for example how the way that people value application of green technologies and how IP is respected in a country might affect industry at large. As a successful TT is accomplished via a series of human judgements, emphasis is therefore given to legal procedures and government requirements for they are essentially stimulus in a firm's decision-making. This is an attempt to find out how strongly TT decisions are dependent on IP law and in turn answer the ultimate question of how effective the law is supposed to be and how it works in reality. A few examples had illustrated the kinds of issues investigated and their breadth.[37] Through an empirical method, my research examines patents and know-how; the common treatment of various subject matters within environment protection

[36] D.J. Galligan, 'Legal Theory and Empirical Research' in Peter Cane and Herbert Kritzer (eds), *The Oxford Handbook of Empirical Legal Research* (OUP Oxford 2010) p.978.
[37] Why victims of accidents failed to pursue remedies for damages in the courts. Donald Renshaw Harris, *Compensation and support for illness and injury* (Oxford University Press 1984); How court decisions affect the actions of those to whom they are directed. Bryant G. Garth and Austin Sarat, 'Justice and power in law and society research: On the contested careers of core concepts' in Bryant G. Garth and Austin Sarat (eds), *Justice and Power in Sociolegal Studies* (American Bar Foundation. 1998); Why the ranchers of Shasta county ignored the law and adopted their own social rules. Robert C. Ellickson, *Order Without Law: How Neighbors Settle Disputes* (Cambridge: Harvard University Press 1991)

regimes; and international IP laws across borders. Such an approach to looking at the problem seems to be pragmatic and feasible.

2.3.3 Empirical method

The behavioural impact of law can be studied both for its own sake as well as for insights into the general relationship between law and behaviour. But any behavioural change induced by law also has implications for environmental and economic conditions in the world at large.[38] Existing empirical research has examined the causal connection between law and changes in industrial outcomes and economics costs. Ultimately, this connection should matter greatly to anyone interested in improving the design of a law and its enforcement. The subject matter of this research is strongly related to the ratification of the TRIPS Agreement among countries. This is an international agreement administered by the WTO that "sets down minimum standards for many forms of IP regulation as applied to nationals of other WTO members."[39] The Agreement also specifies "enforcement procedures, remedies, and dispute resolution procedures."[40] Under TRIPS any national law aims at IPR protection and enforcement shall meet the principles and objectives set by the Agreement. Empirical methodologies will be providing valuable information for making policy choices and offering an opportunity to examine the effect of an international law. One of the disadvantages of using empiricism to explore an international law is that it appears not to be well adopted by most lawyers.[41] Still, many are adept at supporting "normative arguments from inferences in

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[38] *The Oxford Handbook of Legal Studies* (P. Cane and M. V. Tushnet eds, Oxford University Press 2003).
[39] See TRIPS Art. 1(3)
[40] See TRIPS Art. 1(3)
[41] Andrew Hurrell, 'Conclusion: International Law and the Changing Constitution of International Society' in Michael Byers (ed), The Role of Law in International Politics: Essays in International Relations and International Law (reprint edn, Oxford University Press 2001); Also Abbott suggests "the critical questions that international relations theory would posit involve: How exactly does law affect people's behaviour? How, if at all, do legal rules differ from other norms? What conditions determine the effectiveness

existing empirical social science literature."[42] Given the considerable number of existing quantitative[43] and qualitative[44] researches, the empirical method has been widely accepted.

Joel Trachtman points out that "lawyers are generally good at […] describing what courts and legislatures have done."[45] David Bederman even suggests that international law scholarship has "become lazy" and is "no longer sufficiently empirical."[46] However, employing empirical methods in the legal researches creates opportunities to provide an important counter-narrative. Such scholarship brings researchers closer to the facts rather than logics, thus making policy makers able to see the effect of law in practice and become more nuanced in their future decisions. Even empiricism may not be suitable to study every issue concerning international law, it may be better for some than others. Cases as complex as climate change TT could be studied more explicitly under such methods and this is also why an empirical

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of international legal rules? What explains variations in legalization and compliance?" Kenneth W. Abbott, 'Commentaries on Kenneth W. Abbott, Modern International Relations Theory: A Prospectus for International Lawyers 14 YALE J. Int'l L. 335 (1989)' (2000) 25 Yale J Int'l L 273.

42 See in Susan D. Franck, 'Empiricism and International Law: Insights for Investment Treaty Dispute Resolution' (2007) 48 Va J Int'l L 767: "Empirical political scientists are right that many international law scholars have traditionally been overly sanguine in simply assuming the efficacy of international law and then busying themselves with textual analyses of the international law instruments themselves." Laura A. Dickinson, 'Toward a "New" New Haven School of International Law?' (2007) 32 Yale J Int'l L 547; "Social science in general has already contributed a great deal of useful theory describing and explaining the two-way causal relations between rules and behaviour, but much more remains to be done in applying this work to the theory and empirical study of international problems." Benedict Kingsbury, 'The Concept of Compliance as a Function of Competing Conceptions of International Law' (1997) 19 Mich J Int'l L 345; referring to social science literature to argue empirical research demonstrates shortcomings in a theoretical framework, Peter L. Lindseth, 'Democratic Legitimacy and the Administrative Character of Supranationalism: The Example of the European Community' (1999) 99 Columbia Law Review 628; Anne-Marie Slaughter, *A New World Order* (Princeton University Press 2004).

43 See in Franck (n 42): "quantifying and statistically analyzing variables that affect the probability of legislative repeal of judicial statutory interpretation" Robert D. Cooter and Tom Ginsburg, 'Comparative Judicial Discretion: An Empirical Test of Economic Models' (1996) 16 International Review of Law and Economics 295; "empirically analyzing human rights treaties" John King Gamble, Charlotte Ku and Chris Strayer, 'Human-Centric International Law: A Model and a Search for Empirical Indicators' (2005) 14 Tul J Int'l & Comp L 61; "empirically analyzing dispute resolution processes at the WTO" Andrew Guzman and Beth A. Simmons, 'To Settle or Empanel? An Empirical Analysis of Litigation and Settlement at the World Trade Organization' (2002) 31 The Journal of Legal Studies S205.

44 See in Franck (n 42): "gathering empirical literature related to international human rights law" Laura Dickinson, International Law and Society: Empirical Approaches to Human Rights (Ashgate Publishing Company 2007); "using the South African Constitution as an instructive case study" Heinz Klug, 'Constitution-Making, Democracy and the Civilizing or Irreconcilable Conflict: What Might We Learn from the South African Miracle' 25 Wis Int'l LJ 269; "conducting interviews with officials and using them to tell three transnational law stories" Janet Koven Levit, 'A Bottom-Up Approach to International Lawmaking: The Tale of Three Trade Finance Instruments' (2005) 30 Yale J Int'l L 125.

45 "There is no agreement on the theory and methodology of international law. This lack of consensus challenges the very legitimacy of international law as an academic field." Joel P. Trachtman, 'International Economic Law Research: A Taxonomy' in Colin Picker, Isabella D. Bunn and Douglas Arner (eds), *International Economic Law: The State and Future of the Discipline* (Bloomsbury Publishing 2008), quoted by Franck (n 42).

46 See in Franck (n 42): David J. Bederman, 'Constructivism, Positivism, and Empiricism in International Law' (2000) 89 Geo LJ 469, reviewing Anthony C. Arend, *Legal Rules and International Society* (Oxford University Press on Demand 1999).

method has been selected for this research. The increasing interest in how TRIPS and relevant domestic laws function: whether they achieve their goals, and at what cost[47] will be better addressed with such method.

2.3.4 Qualitative way of analysis

As already suggested in the previous texts, law can affect the performance of individual business operations. In the environmental law area,[48] qualitative studies become a possible way of assessing the effect of environmental laws on the environment. Interviews enable researchers to get access to people's experiences and perceptions. "Individual interviews are used extensively by qualitative researchers examining legal phenomena and perceptions of law and the legal profession."[49] Enforcement style may vary both internationally and across different agencies and sectors within an individual country.[50] Therefore, it is crucial to select a narrow environment or a specific subject to simplify analytical conditions. Many prefer to report the "day-to-day activities of regulators and the regulated by using techniques of participant observation."[51] For example, Keith Hawkins[52] uses this empirical method of research to study the relationship between social behaviour and enforcement of regulation by reporting in the arena of control of pollution discharged directly to watercourses. The

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[47] See for example Matthew Littleton, 'The TRIPS Agreement and Transfer of Climate-Change-Related Technologies to Developing Countries' (2009) 33 Natural Resources Forum 233; Peter M. Gerhart, 'Reflections: Beyond Compliance Theory--TRIPS as a Substantive Issue' (2000) 32 Case W Res J Int'l L 357; Yoshifumi Fukunaga, 'Enforcing TRIPS: Challenges of Adjudicating Minimum Standards Agreements' (2008) 23 Berkeley Technology Law Journal 867.

[48] *The Oxford Handbook of Empirical Legal Research* (Peter Cane and Herbert Kritzer eds, OUP Oxford 2010).

[49] See for example: Hilary Sommerlad, 'Researching and Theorizing the Processes of Professional Identity Formation' (2007) 34 Journal of Law and Society 190; Margaret Thornton, *Dissonance and Distrust: Women in the Legal Profession* (Oxford University Press 1997); *See, e.g. William W. Burke-White, 'Complementarity in Practice: The International Criminal Court as Part of a System of Multi-level Global Governance in the Democratic Republic of Congo' (2005) 18 Leiden Journal of International Law 557 (n 44).*

[50] Marco Verweij, 'Why Is the River Rhine Cleaner than the Great Lakes (Despite Looser Regulation)?' (2000) 34 Law & Society Review 1007;Peter J. May and Søren Winter, 'Regulatory Enforcement and Compliance: Examining Danish Agro-Environmental Policy' (1999) 18 Journal of Policy Analysis and Management 625.

[51] , *The Oxford Handbook of Empirical Legal Research* (n 48).

[52] Keith Hawkins, *Environment and Enforcement: Regulation and the Social Definition of Pollution* (Clarendon Press, New York, NY 1984).

researcher's field work was carried out in two selected regional water authorities who had experiences in pollution control when the targeted environmental legislation was awaiting implementation, and they were still actively engaged in developing and refining their administrative practice. To learn how field staff did their job, Hawkins acquired consent to accompany them during their daily work. Data was then collected by extensive participation, observation and casual conversation in 36 field officers' routine work.

Lange demonstrates a more social-scientific method of assessing law. Her thesis deals with the concept of legal compliance in the waste management industry, with regulators of the day-to-day life of handling waste, which describes the relationship between rules and social practices. Her main argument is that "the concept of formal compliance has shortcomings and therefore needed to be complemented with a concept of empirical compliance."[53] People's daily practice changes their understanding of legal concepts, therefore "formal concepts of law which are based on formal legal rules have to be modified in order to understand empirical compliance."[54] For this, enforcement officers' and regulated companies' understanding of the definitions is important. In order to establish an empirical concept of law, Lange adopts "a social-construction approach by exploring how actors in the field establish and manipulate the various normative constraints under which they work."[55] Thus she recruited staff on the lowest level of the organizations involved, and observation and participant observed their everyday work during participation.

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[53] Bettina Lange, 'Empirical Compliance: A Study of Waste Management Regulation in the UK and Germany' (PhD Thesis, University of Warwick 1996).
[54] Ibid.
[55] Ibid.

These researchers have all proved in some area that empirical method and qualitative analysis is an option for assessing the relationship between law and performance. But their discussions during observation are usually very loosely structured to preserve as natural and informal a setting as possible. This is to avoid even the hint of a contrived formal interview.[56] This thesis is, on the other hand, based on people's experience of TT during past projects, thus, it is not possible to go back in time and discover their behaviour by observation. Although the technique is less beneficial to the topic of this research as compared to direct observation of each TT process, people's choice of individuals/agencies is worth looking at to construct the sampling method used in this thesis. "Regulation must operate in the real world, and in the real world regulation is only one of many interrelated factors that affect a business firm's behaviour."[57] It is assumed that the more closely people experienced the TT process (a typical TT process includes patent register, staff training, innovation and investment) then the more valuable their opinions are in a company's design or use of TT in future. Moreover, identity/position of participants will influence the interpretation of the TT and IPR laws in different Chinese companies and further affect compliance of legal requirements. There are well-developed theoretical arguments[58] as to why the effectiveness of legal systems should be a determinant of FDI,[59] though with little convincing empirical evidence. And as for how

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56 Leonard Schatzman and Anselm Leonard Strauss, *Field Research: Strategies for a Natural Sociology* (Prentice Hall 1973) 71.

57 Timothy F. Malloy and Peter Sinsheimer, 'Innovation, Regulation and the Selection Environment' (2004) 57 Rutgers L Rev 183.

58 "This assistance is based upon the argument that investors are attracted to States which have effective legal systems; that an effective legal system is one which implements laws efficiently and predictably; and that reform of an inefficient and unpredictable (i.e. ineffective) legal system can help a State to attract FDI." Amanda Perry, 'Effective Legal Systems and Foreign Direct Investment: In Search of the Evidence' (2000) 49 International and Comparative Law Quarterly 779.

59 "One commentator argued that Sri Lanka's failure to attract FDI 'can only be explained' by the 'relative conduciveness (sic) of the investment climate,' which is made unattractive by a lack of certainty, transparency and stability." Premachandra Athukorala, 'Foreign Direct Investment and Manufacturing for Export in a New Exporting Country: The Case of Sri Lanka' (1995) 18 World Economy 543, pp 544-548; in addition, "the former general counsel of the World Bank argued in 1995 that a legal and regulatory framework ... is a fundamental element in the stability and flexibility needed for the investment environment." Ibrahim F. I. Shihata, *The World Bank in a Changing World: Selected Essays and Lectures*, vol 2 (Martinus Nijhoff Publishers 1995) 234; the 1997 World Development Report concludes that "perhaps the worst damage that a State can do to its prospects of investment is to cultivate an air of uncertainty." World Bank, *World Development Report 1997: The State in a Changing World* (1997) 43; and the

people's reaction is an essential part of the effectiveness of a legal system, it would be feasible to investigate impressions of IP law among practitioners, which might continuously affect, from a receiver's perspective, on-going and potential TT.

2.3.5 Research using similar methods

There are studies that have successfully demonstrated the function of the empirical-qualitative method. For example, Malloy and Sinsheimer's research[60] adopted interviews to collect data from people who worked in the dry-cleaning industry.[61] And through interviewing informants selected from key categories of people relying on a model of the "professional cleaning" system constructed, researchers were able to capture a full range of views among practitioners in the profession. Data was then used to identify the barriers to the diffusion of wet-cleaning technology, and to identify the way that policy tool might affect these barriers. Mann[62] also used interview data to conduct his research, assessing whether patent law deters small software firms from innovating. Specific questions were designed to identify the perception that firms have of patent law and whether the law discourages them

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Foreign Investment Advisory Service (FIAS) of the World Bank Group argues that ineffective legal systems "increase the withdrawal of investors who may have made a preliminary decision to commit to a country. (Foreign Investment Advisory Service (FIAS), Administrative Barriers at <http://www.fias.net/services/barriers.htm> on 31 August 1999.)" quoted by Perry (n 58).

[60] Malloy and Sinsheimer *(n 57)*.

[61] See in ibid *(n 57):* The study focused on a small set of selected socio-economic factors that affect the innovative behaviour of business firms. The "selection environment" consists of the regulatory obligations and prohibitions that relate to a firm's everyday business. This is worth studying for it gives a specific lens to look at subject and it is more feasible. A firm's technology choices are certainly influenced by the selected factors. The selected factors also included the "mechanisms by which information about the innovation flows to potential adopters; the attributes of the innovation and its value to the potential adopters (i.e. the benefits and costs of adoption) Richard R. Nelson and Sidney G. Winter, *An Evolutionary Theory of Economic Change* (Harvard Business School Press, Cambridge 1982); and the strength of pre-existing routines and behaviours exhibited by relevant individuals and organizations." For a broader discussion on "a range of technical, economic and institutional relationships that influence the decision of whether to adopt new technology," look at R. Kemp, *Environmental Policy and Technical Change: A Comparison of the Technological Impact of Policy Instruments* (Edward Elgar 1997) p.275-77.

[62] Ronald J. Mann, 'Do Patents Facilitate Financing in the Software Industry' 83 Tex L Rev 961.

in competition. This literature[63] has tested the use of interview technique in investigating the role of regulations and their effect on companies' behaviour.

Some researchers have used interviews to study CDM projects in China. In Pei-Fei Chang's study[64] of the major driving forces behind China's wind energy policy change,[65] data was collected from "interviews with senior officials in the NDRC, large state-owned enterprises (SOEs), and other influential public and private actors in the Chinese wind energy sector."[66] These are mostly people who have a general overview of the reform of Chinese wind policy and the role that central government is playing. The study concluded with the direct impact that Chinese energy regulation has on the renewable energy sector[67] and the importance of CDM[68] in achieving China's considerable strategic targets. Interviews provided information about governmental organization changes, successful examples of wind projects, and barriers created by current policy.[69] Although Pei-Fei's research had only 20 informants' participation[70] and all interviews were conducted off-the-record and maintained confidentially as unofficial transcripts, it showed that access was conditional but possible.

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[63] Jessica M. Silbey, 'Harvesting Intellectual Property: Inspired Beginnings and'Work-Makes-Work,'Two Stages in the Creative Processes of Artists and Innovators' (2011) 86 Notre Dame Law Review 2091.

[64] Pei-Fei Chang and Hans Bruyninckx, 'Wind Energy in China: From Ad hoc Projects to Strategic Policy' (2011) 1 Renewable Energy L & Pol'y Rev 17.

[65] Including Chinese law that governs energy sector as well as international cooperation such as the CDM.

[66] Chang and Bruyninckx (n 64).

[67] Without the Renewable Energy Law (2005) and its Amendment 2009 Chinese energy policy would likely still focus on coal-fired energy, while environmental pollution would be worse and market investments in renewable energy would not be stimulated, Renewable Energy Law of P.R.C. (promulgated by the Standing Commission. National People's Congress, Feb. 28, 2005, effective Jan. 1, 2006).

[68] without the CDM as a baseline, renewable energy projects would likely not be economically competitive.

[69] For example the interview data indicated that "without the CDM as a baseline, renewable energy projects would likely not be economically competitive, (e.g. high costs prevent wind power development from being competitive with conventional power generation (e.g., coal-based or hydro). If wind power projects are developed as CDM projects, their initial CO 2 reduction can be traded to UNFCCC Annex I countries (as emission reduction credits). That increases the revenue of wind power generation.) and the internal rate of return (IRR) would be lower (5 %) than the benchmark price (the lowest acceptable price set by the National Development and Reform Committee). In contrast, with the CDM, the IRR can be larger (25 %) than the benchmark (bolstered by revenue transferred from the expected CO2 emission reduction), making it economically feasible." Interviews done by Pei-Fei with a central organization in Beijing (2 June 2009) see footnote 66.

[70] Interviews with central government officials and SOE employees revealed information on internal rate of return (IRR) difference due to introduction of CDM in practice, such data illustrating how much the CDM contributes to profits for renewable energy development would not be gather in any other currently available resources (neither the CDM nor the government requires

Bo Wang[71] considered TT in CDM projects in China, focusing on the way foreign TT is promoted or hindered by the economic sector, such as the incentives created by Certified Emission Reductions (CERs), transaction costs, relative policies in the host country and the role of CDM participants. The study invited "more than 20" interviewees[72] and most of them attributed the inefficiency in TT or CDM projects to lack of incentives. But the author also learned in his interviews that "half of them believed participating in TT was an effective tool for securing CER contracts; they called it a trend in the CDM market."[73] The relatively small number of respondents participating in the above Chinese research identifies potential difficulties in getting access to interviewees in that country, which had affected my research as well. Wang did not explain any difficulties in accessing participants but he did indicate using non-official ways to approach interviewees. Such a choice is understandable, as also found in this research, for that Chinese participants lack experience in cooperating with non-governmental researchers. And they are afraid of the risk of blemishing their personal reputation if they reveal anything improper during interviews. Insufficient motivation to cooperate in academic research is another possible reason to cause difficulties in data collecting. Christmann-Budian Fan[74] shows that research projects in China are well conducted only in certain subject areas constrained by national policy plans and political stakeholders. A "top-down" pattern is common from initiation to implementation of researches. Every

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enterprises to submit document in relation to the effect of CDM) unless the government initiates research specifically on this factor. Although the study shows the wind power project operation pattern change in China, it remained at a rather broad level of viewing the industry sector. This is due to the sensitive economic and political context of its research topic and the status of interviewees.

[71] Bo Wang, 'Can CDM Bring Technology Transfer to China?—An Empirical Study of Technology Transfer in China's CDM Projects' (2010) 38 Energy Policy 2572.

[72] Such as carbon traders, CDM project consultants, etc. According to his language I assume it indicates that he had engaged less than 30 respondents in the research.

[73] Wang (n 71).

[74] Cheng Fan, Stephanie Christmann-Budian and Sarah Seus, *Evaluation and Innovation Cooperation between the EU and China.* (Study for the European Commission DG RTD by Fraunhofer ISI, 2014)

Five-Year-Plan points out several priority areas in which researches are promoted and funded by the government.[75] Research that falls outside the priority areas would face comparatively more difficulties in progressing, including access to funds, resources and participants. Various other hindering factors could be found in conducting non-official research in China. For example, the undervaluing of research, the low respect for research ethics in the country (sparking participants' fear of the risks of technology and information-leakages), the lack of effective and efficient administration for the implementation of research on both the researcher and the participant sides, and so on.

2.4 Research design

2.4.1 Qualitative research data collection

In order to identify how relevant legal provisions are in applying to a community, and how useful a legal framework is as a foundation for encouraging climate change TT, the doctrinal study is supported by data collected from TT cases completed already. It was the initial intention of this research to review TT agreements between Chinese and foreign companies but this proved impossible as all companies refused access on the grounds of commercial confidentiality. Consequently, I tried to get an understanding of what the content of these documents were in the interviews I undertook. And each interview was long enough for the participants to relax and for me to find out what goes on behind the scenes. More preparation work was done beforehand, including the analysis of documentation either publically available (e.g. CDM[76]) or to which access had been gained, and a pilot interview with one

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[75] The Medium- and Long-Term Program for Science and Technology Development's overall role in current Chinese research development strategies is unique because it still constitutes the dominant basis for all detailed periodical, sectoral and institutional sub-plans, programs, funding schemes, priority setting etc. Ibid.

[76] 'Clean Development Mechanism (CDM)' (*UNFCCC*) <http://cdm.unfccc.int/about/index.html> accessed 2 Jul 2017.

company involved in the TT project was not smooth-going but helped modify in what questions should be asked and in what way they should be asked in subsequent interviews.

The existing literature on the subject focuses mostly at a general level on the nature and effects of environmental policy and IP law.[77] Most writers proceed by identifying IP protection obligations that fall within the TRIPS clauses.[78] Some focus on assessing the economic factors that explain the current pattern of emission in trade.[79] Other studies focus upon national policy and international frameworks and have not addressed practical issues or gathered information about individual TT agreements.[80] Such approach is better in examining the nature of IP regime and the framework of international mechanisms. However, it has two major disadvantages in evaluating the effects of IP law. First, the quality of the research depends entirely on the legitimate nature of "IP protection". The global environmental crisis has become an obvious challenge in the last few decades and climate change technology is

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[77] Jiahua Pan, Jonathan Phillips and Ying Chen, 'China's Balance of Emissions Embodied in Trade: Approaches to Measurement and Allocating International Responsibility' (2008) 24 Oxford Review of Economic Policy 354 edited; See also Bin Shui and Robert C. Harriss, 'The Role of CO2 Embodiment in US–China Trade' (2006) 34 Energy Policy 4063; Tao Wang and Jim Watson, 'Who Owns China's Carbon Emissions' (2007) 23 Tyndall Briefing Note.

[78] see Keith E. Maskus and Jerome H. Reichman, 'The Globalization of Private Knowledge Goods and the Privatization of Global Public Goods' in Keith E. Maskus and Jerome H. Reichman (eds), Maskus and Reichman, International Public Goods and Transfer of Technology under a Globalized Intellectual Property Regime (Cambridge University Press 2005) for articles on TRIPS and TT); Some authors are sceptical about the positive role of TRIPS in facilitating TT, e.g., Carlos M. Correa, 'Can the TRIPS Agreement Foster Technology Transfer to Developing Countries?' (2005) International Public Goods and Transfer of Technology under a Globalized Intellectual Property Regime, Cambridge University Press, Cambridge 227. It is argued that "TRIPS may impede the transfer of environmentally sound technologies (ESTS) to developing countries." Alexander Adam, 'Technology Transfer to Combat Climate Change: Opportunities and Obligations under TRIPS and Kyoto' (2009) 9 J High Tech L 1. Cameron Hutchison points out "that countries can take advantage of the flexibilities of TRIPS." Cameron Hutchison, 'Does TRIPS Facilitate or Impede Climate Change Technology Transfer into Developing Countries?' (2006) 3 University of Ottawa Law & Technology Journal 517. On the other hand, "while IPR is a hurdle in TT to developing countries, it can be overcome by various means." Cecily Anne O'Regan, 'Is Intellectual Property a Hurdle for Transferring Technology to Developing Countries-If so, How High or a Hurdle' (2009) 1 Hastings Sci & Tech LJ 1. This footnote was quoted by Krishna Ravi Srinivas, 'Role of Open Innovafion Models and IPR in Technology Transfer in the Context of Climate Change Mifigafion' Diffusion of renewable energy technologies <http://environmentportal.in/files/file/DiffusionRenewableEnergyTechnologies.pdf#page=163> .

[79] Tim Laing and others, 'Assessing the Effectiveness of the EU Emissions Trading System' Centre for Climate Change Economics and Policy Working Paper No 126, Grantham Research Institute on Climate Change and the Environment Working Paper No 106 (2013) <http://www.academia.edu/download/31211123/WP106-effectiveness-eu-emissions-trading-system.pdf> accessed 23 Aug 2017; Pan, Phillips and Chen (n 77); Tim Everett and others, 'Economic Growth and the Environment' Defra Evidence and Analysis Series Paper 2 (March 2010) <https://mpra.ub.uni-muenchen.de/23585/1/MPRA_paper_23585.pdf> .

[80] Joel B. Eisen, 'China's Renewable Energy Law: A Platform for Green Leadership' (2010) 35 Wm & Mary Envtl L & Pol'y Rev 1; Dong Zhang, '2009 Deep Research Report on China Clean Development Mechanism Industry' 168 Research Group, Sep 30, 2009
<https://www.slideshare.net/168report/2009-deep-research-report-on-china-clean-development-mechanism-cdm-industry-5576375> accessed 26 Jun 2017.

the key for dealing with the issue. IP related to climate change technologies forms a comparatively new type of IP and it is questionable whether it should be treated commonly under the general principle of IP protection designed for earlier times. In other words, any rule that is designed for regulating green-techs could be treated differently from patents that have no direct contribution to environmental protection, as an exception or granted special privileges. Thus, issues relating to ESTs must be discussed in a special context, which shall be understood better through the economic environment as well as companies' green TT behaviour. Secondly, by far, the best general picture of the TT process and its environment can be generated from economic data reported from outside of the green industry.[81] Such literature is indeed making drawing comprehensive conclusions from all relevant factors.[82] However, these kinds of empirical results lack focus on the effects of IP law in particular. This research recognizes the importance of this particular angle, as such effects are critical in directing firms to make the choice of joining environmental projects or making use of their IPRs.[83] In other words, there is conjecture on the possible effects that laws could have on companies' behaviour, but lack of research to identify people's real understanding and struggle with IP law, out of which they make decisions. Therefore, by listening to real people in practice, this research will testify to the contribution made by previous literatures in order to revisit the legality, rationality and feasibility of the law.

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[81] Jill Chopyak and Peter Levesque, 'Public Participation in Science and Technology Decision Making: Trends for the Future' (2002) 24 Technology in Society 155; Howard Rush, John Bessant and Mike Hobday, 'Assessing the Technological Capabilities of Firms: Developing a Policy Tool' (2007) 37 R&D Management 221; Robert McDonald and George Teather, 'Science and Technology Evaluation Practices in the Government of Canada' in OECD (ed), *Policy Evaluation in Innovation and Technology: Towards Best Practices* (Organisation for Economic Co-operation and Development 1997).

[82] including technical capacity, decision-making ability and governmental policy efficiency.

[83] i.e. file patent application for independent developed technologies, protect competitive advantages by preventing IP infringement.

Accordingly, I take firms in China as the subject matter of the research for that "the country is currently the world's biggest emitter of GHGs"[84] and a large amount of CDM funding flows into the country each year. This study has selected eight Chinese projects and the researcher has attempted to get access to people experienced in the climate change TT process. By interviewing the participants, the researcher had them provide oral information on a variety of issues.[85] Valuable data was collected by asking pre-provided and extemporaneous questions and gave the research interesting insights into the dynamics of TT processed in these companies. According to scholars,[86] the TT contracts sometimes include restricting clauses and other limitations to fulfil strategic purpose of the transferor. Although I intended to find direct evidence within transaction contracts demonstrating the uneven distribution of bargaining power between transferor and transferee that could have been affected by the IP laws, I was only able to gather circumstantial evidence. Fortunately, it is enough to imply the need for assistance for Chinese companies in respect to contract bargaining and minimizing the abuse of IPRs in TT. Such information is not currently available from the existing literature, especially data that reveals individual employees and officers' understanding and feelings about IP regulation on green-tech. Although in this research only the receiver-half of the TT chain is studied, it is possible to deduce some actions that reflect the considerations of transferors.

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[84] John Vidal and David Adam, 'China Overtakes US as World's Biggest CO2 Emitter' (*The Guardian*, 19 June 2007) <https://www.theguardian.com/environment/2007/jun/19/china.usnews> accessed 14 Aug 2017

[85] for example on what kind of technology is actually transferred, in what form is it transferred, the price and quality of those technologies, what procedures the TT had gone through, and were there any clauses that would hinder future TT to China or impede following replication and innovation. See detail in Appendix I.

[86] Ashish Arora, Andrea Fosfuri and Alfonso Gambardella, *Markets for Technology: The Economics of Innovation and Corporate Strategy* (MIT Press 2004); Nagesh Kumar, *Globalization, Foreign Direct Investment and Technology Transfers: Impacts on and Prospects for Developing Countries* (Routledge 2003).

2.4.2 Population

In getting close to a better understanding of the effect of IP under TRIPS requirements on international green TT flows, the primary focus is on firms that have engaged in CDM or GEF projects.[87] Several related considerations support this choice. Some scholars[88] have showed great confidence in these mechanisms because they are innovative instruments providing platforms for achieving committed reduction goals. The research thus approached informants from those entities involved with CDM projects for interviews.

The research is intended to target companies that have participated in CDM projects so that we can investigate TT in practice. Up until the 19th of December 2012, 4,971 CDM projects were hosted in China. 980 projects already have CER Issuance,[89] which means that more than 980 Chinese firms have experiences with CDM. Eight of these companies' CDM projects were selected for study and each of them was launched between 2006 and 2012.[90] Firstly, eight companies will be analyzed in-depth, including the real process and dynamic between transferors and transferees as well as understanding the expectations pertaining to IP and TT from company staff. We expect data obtained from these sources to be much more useful than that obtained from a broader type of survey. Therefore, the research only involves a

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[87] Although GEF is a mechanism with equal importance, it does not have as many projects as CDM has in China. Moreover, after further research into these projects, it was discovered that most GEF projects are less straightforward for the purpose of this research, as each GEF project usually involves more than one host company, and in most cases they are located in different provinces. That means that one project is operating simultaneously in different provinces with different political conditions. The experience of individuals may vary due to this policy difference, making our analysis difficult. Although a cross-province project might offer a more comprehensive view (i.e. considering the complexity caused by schemes being undertaken in different provinces), it creates greater practical difficulties in obtaining information for the researcher. Conducting research with companies outside of Shandong requires a wider social network and much more funding (e.g. for travel expenses), which is rather impractical. Consequently, the research will use data collected from CDM projects in Shandong alone.

[88] Zhang (n 80).

[89] "It is important for a project to get CER issuance, The clean development mechanism (*CDM)* allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol." 'What is the CDM' (*UNFCCC website*) <http://cdm.unfccc.int/about/index.html> accessed 25th Sep 2012; for more detail see chapter IV discussion on the CDM mechanism.

[90] According to Project Design Documents (PDD) available from UNFCCC website

limited number of companies and carefully selected interviewees who were willing to cooperate with their time and patience. All of them are located in Shandong Province as it is geographically easier for gaining access to relevant individuals. Secondly, the researcher secured approval from the provincial DRC[91] to launch the research,[92] and such approval enabled the author to get access to the interviewees. Thirdly, the province ranks first among other Chinese provinces in the production of a variety of products and it is one of the richer provinces of China. Shandong is one of the biggest industrial areas[93] in China and it is quite actively involved in emission reduction activities, including CDM projects.[94] Structurally, energy consumption in Shandong Province is dominated by energy-intensive heavy industries.[95] That means that it has great potential in emission reduction activities and enough data about absorbing energy technology available. The eight firms were approached and three of them directly gave their consent to participate in the research. The researcher then used government contacts to gain access to and successfully persuaded the rest to participate. All eight companies claimed in Project Design Documents (PDDs) that they have participated in CDM projects involved with international TT.

Pathways for TT vary according to sectors, types technology, how mature is that technology and political environment of the receiver-country. Given this variety and complexity, the

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[91] The National Development and Reform Commission of the People's Republic of China (NDRC), is a macroeconomic management agency under the Chinese State Council. It has great planning control over the Chinese economy on almost every important industry sector. The provincial development and reform commission reports to the provincial government as well as the national DRC. By gathering local statistics and studying provincial economy, it helps the national DRC formulating policies regarding China's economic system. It is virtually one of the most important departments of government.

[92] This approval letter can be used at a recommendation reference when approaching the firms as the provincial government as strong power over those firms and public authority equipped the researcher with a proof of good faith and reliability.

[93] Shandong Statistics Bureau, *Shandong Statistics Yearbook* (Beijing: Chinese Statistics Press 2009 and 2010).

[94] By 2008, ADB's energy sector had given to China "non-lending support of about $50 million has evolved from tariff reforms, sector restructuring, establishment of the electricity regulator, and mainstreaming environment evaluation, to innovative technologies and mechanisms in energy efficiency and renewable energy, and to capacity building for CDM." Allan Zhang, ESD China Limited and People's Republic of China Shanghai, *PRC: Energy Efficiency and Emission Reduction Project in Shandong Province* (Technical Assistance Consultant's Report TA 7295, Asian Development Bank, 19 April 2011).

[95] See ibid

research involves the study of eight projects, and they can be roughly divided into sub-categories: wind power and biomass (there is only one project related to fluoride chemical decomposition). Generally, according to a UNFCCC report,[96] factors such as agriculture, Hydrofluorocarbons (HFC)[97] and wind energy are more likely to involve TT in projects. Conversely, biomass,[98] […] and transport projects are less likely to involve TT.[99] For example, in the wind sector, about 18 GW of installed capacity is seen in 2011. This has indicated an opportunity for wind power manufacturers to expand globally. Despite most wind facilities being locally built and credited as a local industry, in practice, production relies mostly on technology transferred from Western countries. An illustrative example is technology transferred in manufacturing bearings: a prevailing problem for wind turbine manufacturers is the production of quality bearings – the wheels at the back of the turbine that enable it to turn. This patented technology is still controlled by foreign investors.[100] But wind power projects are still considered as "easy projects" because the technology transferred largely falls into a form of equipment selling. The declining rate of TT for the most common project type (wind project) in China also indicates a TT "beyond the individual CDM projects that allows later projects to rely more on local knowledge and equipment."[101] While

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[96] Stephen Seres, Erik Haites and Kevin Murphy, 'Analysis of Technology Transfer in CDM Projects: An Update' (2009) 37 Energy Policy 4919

[97] "Hydrofluorocarbons, commonly used in refrigerators and air conditioning systems, could add 0.5C to global temperatures by the end of the century." Oliver Milman, '100 countries push to phase out potentially disastrous greenhouse gas' (*The Guardian*, 22nd September, 2016) <https://www.theguardian.com/environment/2016/sep/22/100-countries-phase-out-hydrofluorocarbons-greenhouse-gas> accessed December 2016.

[98] "Biomass is biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material. Biomass-derived energy holds the promise of reducing carbon dioxide emissions, a significant contributor to global warming, as carbon dioxide acts as a "greenhouse" gas by trapping heat absorbed by the earth from the sun. Although the burning of biomass energy releases as much carbon dioxide as fossil fuels, biomass burning does not release "new carbon" into the atmosphere while burning fossil fuels does." NREL, 'Biomass Energy Basics' (*NREL*) <http://www.nrel.gov/learning/re_biomass.html> accessed 2017-June-15.

[99] Seres (n 19).

[100] Key players include those from Denmark, Germany, the Netherlands, Spain, and the US.

[101] Seres (n 19).

more wind projects established, a declining rates of TT starts to show over time, yet biomass showed no such trend. This suggests that modern biomass technology in China remains immature and has to depend on international transaction or technologies derived abroad.[102] For this reason, I included biomass projects as a comparative group to the study in wind projects. A rapid growth in biomass energy sector is also discovered due to favourable policies.[103] This indicated that the selected types of industry were not hindered by economic policy resistance. Therefore, having them as the subject of selected projects will enable us to exclude barriers created by a restraining policy environment.[104]

2.4.3 Sampling

The informants (samples) of this research include people from all relevant key categories[105] of the recipient party of the TT. As the study concerns the views of technology transferees towards the current IP system in China, the sample includes a range of technicians, lawyers, company managers, and decision-makers outside of the transferee company (e.g. local government officials) in order to capture a full range of views among a recipient enterprise. A similar approach has been employed successfully in other socio-legal researches.[106] There is an obvious model in the Texas research for this approach, and it has worked for analyzing the effect that patent laws have on small software firms' behaviour.[107] That research studied the role of IP in the software industry. Relying on interviews that Mann conducted, and on

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102 Li Jingjing and others, 'Biomass Energy in China and Its Potential' (2001) 5 Energy for Sustainable Development 66.
103 Detail of these policies will be discussed in Chapter VI.
104 More detail will be seen in Chapter. VI.
105 , *The Oxford Handbook of Empirical Legal Research* (n 48) p.934.
106 For example, if the research concerns the views of legal professionals, the sample may include a certain number of judges, a certain number of advocates, and a certain number of transactional lawyers in order to capture a full range of views among legal professionals. Perhaps the best-known contemporary example of how qualitative social scientific research may have practical organizational applications is the analysis on five qualitative studies of apprenticeships. Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge University Press 1991).
107 Mann (n 62).

publicly available information, he showed that "the development of young firms in the software industry is not significantly constrained by large patent portfolios in the hands of incumbent firms."[108] Malloy and Sinsheimer's[109] research similarly gathered information through a series of semi-structured interviews to collect data from equipment vendors, professional cleaners, and government officials in relation to the local energy industry. Opinions from these three types of interviewees comprise a comprehensive view of the impact that patent laws in Los Angeles have on the innovation activities of firms. The survey specifically assessed the attitudes of dry-cleaners towards technology choice affected by the law.[110]

My research selects four different categories of people respectively: from Chinese firms' technology department, legal department (or external lawyer), managerial department, and local government. I approached at least two persons from departments of each targeted firm and one from the local government to participate in interviews.[111] This is to ensure that there is feedback from most important individuals involved in the TT process.[112] Employees from the technology department will be expert in assessing, implementing and, they are beneficial as interviewees due to their knowledge and information directly gained from their technical practices. Lawyers are clearer with licences, limitations and restrictions contend in TT contracts and preparing legal documents in project application. People from managerial

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108 Ibid.

109 Malloy and Sinsheimer (n 57).

110 "Topics covered in the survey included: experience as a professional cleaner, familiarity of different garment care technologies, knowledge of professional wet cleaning, factors influencing a decision to purchase professional wet clean equipment, and interest in programs which would reduce the cost of purchasing wet clean equipment." Ibid *(n 57).*

111 In case there is no legal department in the company.

112 namely assessment, transfer contract, implementation, evaluation and adjustment, and replication. See Charikleia Karakosta, Haris Doukas and John Psarras, 'Technology transfer through climate change: Setting a sustainable energy pattern' (2010) 14 Renewable and Sustainable Energy Reviews 1546.

positions are more experienced with difficulties in agreement bargaining and administrative procedures in preparation for TT, and they have decisive power over selecting appropriate technology and over replication of the technology absorbed afterwards. Interviewees from local government undoubtedly have a broader view of the development of the industry in the local area, and their opinions are especially crucial regarding starting up a project and offering favourable policies to attract TT. Analysis of the views from different departments will give a comprehensive understanding of the TT process and a realistic view of the role that IP law played at the firm level. According to the bottom-up[113] operating model of CDM, most projects are initiated by the private sector. So any factor that would influence individual firms' in their TT action will ultimately result in a declining TT trend at large. In other words, each one of the practitioners in the field will be part of an enterprise's motivations, fears and strategy. And all of them are accountable for a potentially successful project. This has given strong grounds for conducting an in-depth study of individual enterprises.

In addition, the researcher also employs a snowball sampling technique,[114] meaning that she began with some participants recruited in the first place; in particular, interviewees from the firms identified. She then asked them to provide, if agreed, details of someone else whom they consider to be a good participant for the purposes of the study. The nominated person would be classified within one of the aforementioned groups, or placed in an additional reference class.[115] The benefit of this kind of sampling method enables the researcher to get

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[113] Kevin A. Baumert, 'The Clean Development Mechanism: Understanding Additionality' The Clean Development Mechanism Draft Working Paper <https://www.scribd.com/document/249159556/CDM-Understanding-Additionality> accessed 21 Aug 2017

[114] Patton describes this as "purposeful sampling" (2002:45). See Jan E. Trost, 'Statistically Nonrepresentative Stratified Sampling: A Sampling Technique for Qualitative Studies' (1986) 9 Qualitative Sociology 54.

[115] For example if the nominated person is from domestic "like-technology" providers they have considered, lawyers they employed during the project or institutions/government department they have contacted to get approvals.

access to technical experts, outside consultants and business partners who also had detailed experience in the TT process. And in that way she built up a slightly larger but more comprehensive sample of participants. The weakness of this approach is that it contains many uncertainties, not only in regard to the number of interviewees but also due to confidentiality issues.[116] This is due to the fact that most of the nominated interviewees specialize in fields directly related to a company's trade secrets or a governmental department's confidential works. Fortunately, at the end of field work the researcher managed to seek out two other key people that were likely to provide richer sources of information or data based on the recommendations of people interviewed.

Although eight is not a large sample in comparison with thousands of climate change TT projects established under or outside CDM, Shandong is a representative province in terms of not only size and population but also its level of development in both revenue and technology. For example, the selected samples included the very first biomass electricity generation TT project and also those ones that are still in the middle of the process. The interviewees are very representative samples of practitioners in the Chinese biomass industry in terms of their experience and knowledge. Their views are down-to-earth, authentic and valuable.

2.4.4 Interviews

A company's technology absorption[117] and its response to regulations and policies intended to shape the TT behaviour. Moreover, technology choice is also influenced by practitioners in

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[116] for that it shall not against a nominated person's will to be referred to or accessed by interviewers.
[117] Technology absorption describes the ability to understand, deploy and improve upon the imported technology. Sanjaya Lall, *Learning to Industrialize: The Acquisition of Technological Capability by India* (Springer 1987).

the industry;[118] by the firm's internal structure;[119] and its intention in attracting TT.[120] Thus, any law reform seeking to encourage climate change TT in a given industry sector must fully understand the process of TT in practice and how each relative actors affects it. Policy and regulation designed without this understanding will often fail to produce the outcome it seeks in the first place.[121]

"Interviews, of course, hold no monopoly over interpretive practice. Nor are they the only occasions when subjects and their opinions, emotions, and reports are socially constructed. [...] but interviews expressly put *whats* and *hows* of interpretive practice to work."[122] Qualitative interviewing is better at providing the opportunity to "collect and rigorously examine narrative accounts of social worlds."[123] Many socio-legal studies thus rely on interviews and/or documentary evidence.[124] However, any effort to address the relation between IP and TT must proceed with modest goals. It is not plausible to expect impeccable evidence comprehensively enough to determine whether strengthened IP protection cause a higher TT rate in an industry to an absolute level. Thus, my goal is only to provide a richer understanding of the possible effects that current IP protection under the requirement of TRIPS might have on climate change TT. Using this mixed methodology, I can only rely on what

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[118] Such as suppliers, customers, and competitors; and by external social and legal factors like patent registration polices, project application procedures, industry standards and environmental protection requirement.

[119] Such as internal research and development funding policies.

[120] Imitation or concerns about the climate.

[121] Malloy and Sinsheimer (n 57).

[122] James A. Holstein and Jaber F. Gubrium, 'The Active Interview' in David Silverman (ed), *Qualitative Research: Theory, Method and Practice* (Sage 2004).

[123] Jean M. Converse and Howard Schuman, *Conversations at Random* (Wiley 1974).

[124] analysis ("White Collar Crime" studies, see for example Peter Cleary Yeager, *The Limits of Law: The Public Regulation of Private Pollution* (Cambridge University Press 1993); Joseph F. DiMento, *Environmental Law and American Business: Dilemmas of Compliance* (Springer Science & Business Media 1986); Diane Vaughan, *Controlling Unlawful Organizational Behavior: Social Structure and Corporate Misconduct* (University of Chicago Press 1985); Arieh A. Ullmann, *Industrie und Umweltschutz: Implementation von Umweltschutzgesetzen in deutschen Unternehmen* (Campus WZB 1982); Marshall B. Clinard and others, *Illegal Corporate Behavior* (US Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice 1979); Renate Mayntz and Eberhard Bohne, *Vollzugsprobleme der Umweltpolitik: empir. Unters. d. Implementation von Gesetzen im Bereich d. Luftreinhaltung ud Gewässerschutzes*, vol 4 (Kohlhammer 1978); quoted by Lange, (n 53).

we should expect from the law and interpretations that are consistent with limited accessible events "on the ground." I cannot hope to provide a definitive account of the effects of IP law on TT.[125] Although the number of 30 interviews conducted by this research seems to be small in comparison with the size of the population, they are practitioners with strong representation in the industry. An intensive interview “permits an in-depth exploration of a particular topic with a person who has had the relevant experiences.”[126] In accordance with this research, informants are gathered from a group of selected companies actively running businesses in the green energy sector and, based on their experiences, the interviewees provide in-depth insights on the status quo of TT to Chinese wind and biomass energy generation. A sample is adequate as it is precisely selected for studying small-scale research projects.[127] Precedents can be found in some of the reviewed studies, which have involved only 20 to 60 interviewees.[128] Therefore, I primarily assume that 30 informants will provide enough data to be analyzed. This is not because the number has credibility because it was statistically significant, given the size of the population, but because it would provide in-depth information contributing to a deep understanding of IP influence over TT. The data from interviews are generally rich in quality, and can be studied by identifying the phenomenon and bringing it to life through the interpretative skills of the researcher.[129]

In the first stage of sampling, I intended to invite at least three informants from each company, ideal one from the three different departments of a company and one from the

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[125] Texas law review

[126] Kathy Charmaz, *Constructing Grounded Theory* (Sage 2014) quoted by Liana Müller, *Theoretical and Practical Challenges using Qualitative Interviews as Data Gathering* (2013).

[127] A good guide for small-scale research

[128] For example, Mann (n 62); Chang and Bruyninckx (n 64); Wang (n 71); Fan, Christmann-Budian and Seus (n 74).

[129] Consumer Correspondent, Susan Quilliam and Shelley Mehigan, ‘Faculty Awards’ (2008) 34 Journal of Family Planning and Reproductive Health Care 206.

local government. In fact, eight identified firms had provided at only 28 interviewees, for four of them have no legal department or a person in charge of CDM project available for interview. In stage two of sampling, two more interviewees were nominated with one working for a well-known consultant company in the industry – the Electric Power Design Institute, and another working in the R&D department of a world leading wind turbine manufacturer. Each interview was intended to take one hour with fewer than seven broad questions to eliminate the sense of tension that comes with being interviewed; these were followed by proper open-ended questions to promote discussion with the interviewees. It took significantly longer time (than the interviews) to transcribe the interviews for subsequent analysis.

As long as rich information is gathered and it sufficiently reflects the effect that IP law has on climate change TT, the rather small number of interviewees should not be a big issue for conducting the research. In addition, the choice of sample is based on practical issues such as cost, which justify choosing Shandong Province (the researcher's home province) as the site of the sample. And as the "push" side of the transaction will not be addressed in this study, it was not necessary to interview transferor companies.

2.4.5 Access

This research sought access initially through e-invitation letters sent[130] to the identified companies, and the responses turned out to be unsatisfactory. The use of emails proved to be highly unproductive and no companies committed to the project by email. Therefore, I decided to use personal contacts to get in touch with the companies. Only three companies

[130] In the late August 2012

were interested in participating in the first place. I then also made use of third parties, in particular I approached the Shandong Provincial DRC to get approval and a recommendation letter to promote my research. An approval letter was issued[131] and a scanned version is available to be printed. This provided a positive impetus for pursuing access to the remaining five companies, and nominated people, as the commission plays is an important authority in both industry and local government. Later on, I contacted the selected companies tentatively in person, to give them confidence in the research and show my good will. This included a travelling to China in the second year of the PhD programme.

Nevertheless, difficulties occurred when getting access to interviewees. The very first interviewee was a manager from a biomass energy station. A local governmental officer introduced the research and me to the manager. Although an invitation letter explaining my purpose, along with a consent form and a list of interview questions were sent to him a week before the pilot interview, the interviewee showed great hesitation in answering questions straightforwardly. It is a known fact that before an interview, some interviewees may be unwilling to cooperate with researchers: it may be hard to fix an agreed time; or people may be slow to reply; there may be a fear of authorities and anxiety about potential commercial confidentiality issues. And this is why a confidentiality agreement was provided for the interviewee beforehand. But the actual result of the first meeting turned out to be surprisingly disappointing. For example, my expectation was to have access to the contract signed during the TT project, and to be able to ask questions about the details of the business (such as profits and rates of return on investment), but instead the interviewee did not give

[131] The letter is dated as 3rd December 2012

me permission to look at the agreement nor did he answer the questions directly. This is a challenge for all qualitative research. It requires the researcher to be "a master of dramaturgy" and he or she "should be able to create the right atmosphere for the interview".[132] In my case, although I planned ahead and chose the interviewee's office as the best place to make him feel comfortable, according to the interviewee, he and his colleagues were "not used to signing official documents which seem fearful." Therefore, this access approach was revised after the pilot interview. Printed paperwork was then presented during interviews rather than before. Only after the interviewer explained the aims and methods of the research and the rights of the participants orally, a consent form was casually and politely handed to the interviewees for signature. And after interviews when the interviewee knew for sure that any information released was appropriate they were allowed to check the consent forms again. I did not repeat my request for access to the TT agreement but used questions to get information about contractual limitations. Such revisions proved to be significantly helpful for the remaining interviews and there was no subsequent hesitation like that in the pilot interview.

During four months of preparation and practical work conducted by the researcher in China, all eight companies she intended to target were visited, and 30 people in total were interviewed. Such a number included interviews with individuals who work for the company (including technical directors, plant managers, CDM project managers and in-house lawyers); people who directly influence decision-making within the company (government officer in relation to energy industry); as well as those who could provide background information to

[132] Tove Thagaard, Systematikk og innlevelse: en innføring i kvalitativ metode, vol 2 (Fagbokforlaget Bergen 2003) quoted by Müller (n 126).

the use of TT and IPR issues in China.[133] The number of interviews actually undertaken was fewer than expected. This is due to the fact that some people did not nominate potential interviewees outside their company. For example, most companies have no independent legal department and they claimed to have had no involvement with any IP disputes so far, so they were not able to refer us to a lawyer helping them with their contract.

2.4.6 Semi-structured interviews

Semi-structured interviews "in which the interviewer sets up a general structure by deciding in advance the ground to be covered and the main questions to be asked"[134] will be used in this research. The questions asked are open-ended rather than closed, with a core of standard questions that may be expanded upon to explore a given response in greater depth during the interviews. It means that extemporaneous questions can be added to standard questions at any time when some interesting or unexpected topics show up during interviews. The need for extemporaneous questions reflects the fact that the interviewer does not know what information the interviewees will possess and what they may reveal. Extemporaneously formulated questions are to discover more crucial information based on interviewees' voluntary elaborations. However, their benefits could be outweighed by two major disadvantages. "First, data from the follow-up questions are difficult to interpret because different participants are asked different questions."[135] It is made difficult to compare or generalize common issues from answers responding to different questions. "Second, even the answers for the standard questions are difficult to interpret because the standard questions

[133] These individuals include two engineers from the provincial electric power design institute and one expert from a transnational engineering corporation.

[134] Eric Drever, *Using Semi-Structured Interviews in Small-Scale Research. A Teacher's Guide* (ERIC 1995).

[135] Mark L. Mitchell and Janina M. Jolley, *Research Design Explained* (Cengage Learning 2012) p.302.

were not asked in the same standard way to all participants the interviewer may affect what participants say in response to the standard questions."[136] Thus, it is important to carefully decide which answers to probe and how to probe them by designing proper questions. Regardless of the disadvantages, "a semi-structured qualitative interview is more like a 'guided conversation' with a purpose. Themes are explored using open-ended questions to elicit a response from the interviewee in their own words."[137] The loose way of structuring interview questions enables the interviewer to divert from any comment made by the interviewee for more details at each time.[138] Semi-structured interviews are used in this research for a number of reasons. First, it is difficult to get information to ascertain what to ask at a preliminary stage in terms of IP-related procedures and TT contract negotiation because such information is considered to be confidential by companies. Therefore, semi-structured pilot interviews or discussions may provide some ideas for other questions that could be used in later interviews. Second, from the data collected from the follow-up questions, the researcher should get inspiration that will help in conducting the theory. A third reason is that experiences vary among interviewees according to their different company positions. This is meaningful to identify the different perceptions of each type of interviewee, based on the way they provide information. This is also the reason why some questions are asked in one set of questions and others are not in particular interviews.[139] Therefore, the same semi-structured standard interview questions will not be used for each

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[136] Ibid.

[137] Michael Quinn Patton, *Qualitative Evaluation and Research Methods* (SAGE Publications, inc 1990) p.295.

[138] Nicky Britten, 'Qualitative Research: Qualitative Interviews in Medical Research' (1995) 311 BMJ 251; See also Edwin van Teijlingen and Karen Forrest, 'The range of qualitative research methods in family planning and reproductive health care' (2004) 30 Journal of Family Planning and Reproductive Health Care 171.

[139] Teijlingen and Forrest (n 138)

type of interviewee.[140] This is due to the fact that not all interviewees understand IP issues or understand them in the same way, especially technicians. Their perception of IP law may depend on second-hand experience (e.g. the responses of their manager). Certain questions are designed to identify levels of understanding.[141]

Mechanisms under international regulatory framework for enforcing environmental standards are of equal importance with environmental legislation in the climate change TT context, first-hand experience from practitioners provides more convincing data in understanding the rationality of current legislation and the efficiency of available mechanisms. The responses from the interviewees are likely to show that IP does affect TT in an indirect way, and to identify how influential this is in the factors that determine firms' engagement with the TT process. One of the aims of including firm-level study in my research is therefore to demonstrate the distinctive problems and special opportunities that practitioners and implementers are likely to encounter in dealing with climate change TT.

2.4.7 Data recording and analysis

All interviews were tape recorded[142] with the consent of the participant because this is the best way to keep the original data. This mission was successful at the end of the day. Notes were taken during interviews for the convenience of coding work in subsequent analysis. A high level of confidentiality was maintained throughout the collection, handling and analysis of data. The trust of the interviewees was gained by promising them anonymity and the right to review and correct the transcript. A confidential agreement signed by both interviewer and

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[140] See details in Appendix I.
[141] Ibid.
[142] Phone interviews will be done with the speaker phone switched on, and recorded by another recording machine.

interviewee required that unless otherwise agreed the interviewee's identity would be concealed by an alias. Only a general title and the name of the CDM project will be mentioned when referring to any specific interviewees. A copy of the interview transcript was delivered to each interviewee for his or her information and they were able to correct the information they gave and be reassured that it was ready to be authorized to the researcher for academic use. This improved integration and authentication of the data and avoided misunderstandings between the researcher and the participant over ethical concerns. In fact, none of the interviewees corrected anything sent to them from which I understand as an approve of the contents.

After an agreed transcript has been made, analysis was undertaken in the form of systematically grouping and summarizing the descriptions of experiences.[143] Primary data were input to NVivo 10 and the code categorized into different themes.[144]

As this socio-legal research is based on interviews, it is highly dependent on an understanding of the interviewees' cultural backgrounds and ways of expression to get relatively valid data.

> The human element of qualitative inquiry is both is strength and weakness – its strength is fully using human insight and experience, its weakness is being so heavily dependent on the researcher's skill, training, intellect, discipline, and creativity. The researcher is the instrument of qualitative inquiry, so the quality of the research depends heavily on the qualities of that human being.[145]

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143 Jaber F. Gubrium and James A. Holstein, *The New Language of Qualitative Method* (Oxford University Press on Demand 1997) ch.2.

144 Dee detail in Appendix I.

145 M. Q. Patton, *Paradigms and Pragmatism in Fetterman, DM (ed.): Qualitative Approaches to Evaluation in Education: The Silent Scientific Revolution* (New York: Praeger 1988) p. 89-115.

Therefore, I checked closely whether each statement follows reasonable logic based on what was found in previous interviews and carefully dealt with flaws in the evidence and how conclusions were reached. This was to check the authentication of the data and to try and avoid any bias from interviewees. Comparisons will be made of the same issues from the point of view of different interviewees and scholars to try to minimize effect of different conclusions on analyzing.

2.4.8 Problems

The success of a research based on interview method is depended on the premise and authentic answer of interviewees. This is unlikely because most participants are to some degree scared of *formal* interviews.[146] Thus, the interview situation is to some extent "unreal" and words should often not be taken as solid proof. International political sensitivities may have inhibited access to data. For example, it was challenging to get the authentic opinion from a government officer on the approach employed to the encouragement of technology duplication (including illegal duplications). A government officer would never reveal information such as weak IP implementation is acquiescently approved to stimulate endogenous independent technology development. This is one of the difficulties of accessing officials for interviews. Some people in certain positions,[147] especially in state-owned enterprises, tended to take a political standpoint rather than provide neutral opinions, due to the fear of losing their jobs. Moreover, obtaining candid answers on business sensitive issues was relatively difficult. Some interviewees were suspected of bias in taking a

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[146] Juha Laurila, 'Promoting Research Access and Informant Rapport in Corporate Settings: Notes from Research on a Crisis Company' 13 Scandinavian Journal of Management 407; Andrea Fontana and Anastasia H. Prokos, *The Interview: From Formal to Postmodern* (Left Coast Press 2007).

[147] E.g. communist party secretaries of state-owned enterprises.

"company line" and avoiding releasing any business secrets. Some interviewees may have provided the answers that they believed the interviewer wanted to hear, rather than the most accurate answer. Beyond these issues, there were different understandings of the meaning of basic definitions, such as the meaning and source of IP law. Misunderstandings between interviewer and interviewee also created problems. This was mostly settled by asking follow-up questions to clarify any points made during the semi-structured interviews and further clarified by sending transcripts back to interviewees for correction. Other difficulties derived from time management and lack of funding (i.e. delays in conducting field work). In dealing with these difficulties, the researcher tried to make herself seem less official or ambitious to the interviewees, showing her well-developed knowledge of the subject and providing ethical assurance, declaring that the data was only for academic use, and by promising anonymity to respondents. A personal visit of the interviewer back in China helped to develop relationships with the companies and had a positive impact on promoting the research.

In the following chapters of this thesis, I will identify the special features of international climate change TT in Chapter III. Chapter IV will examine how TT is promoted within international environmental agreements; Chapter V will revisit how IP theory and regulation could affect TT under the current international IP system (TRIPS Agreement); and Chapter VI will provide empirical findings in regard to climate change TT to China.

Chapter III: Overview of Technology Transfer

3.1 Introduction

Most environmental concerns are multifaceted problems “requiring highly integrated answers, which will undoubtedly require substantial measures implemented within multiple sectors and at many different levels.”[1] For example, developing countries with different needs from developed countries might find it difficult to deal with climate change problems without external help. The use of TT is in fact a positive aid to help developing countries in a way they need. Many developing countries are ex-colonies (though not China), which were used to enjoying technologies provided by the colonizers. Now, when there arises the need to get developing countries to agree to MEAs, TT is required instead. Especially after the historic moment of finalizing the 1972[2] Stockholm Declaration and alongside the establishment of the New International Economic Order (NIEO),[3] TT has been gradually accepted worldwide as an important tool. It is widely used among environmental agreements to help environmental protection, enhance international cooperation and accelerate technological development not only within developed nations but also in many less developed countries. Accordingly, many MEAs are ratified with the developed countries taking most responsibility for climate change in the first place and look forward to gain more developing countries’ participation in the future using TT as a tool to get them involved.

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1 Duncan A. French, ‘Managing Global Change for Sustainable Development: Technology, Community and Multilateral Environmental Agreements’ (2007) 7 International Environmental Agreements: Politics, Law and Economics 209.

2 Decolonization largely took place before this. It was only the Portuguese and a few British colonies in the Caribbean and Middle East which gained independence thereafter.

3 The NIEO focused on “restructuring of the world's economy to permit greater participation by and benefits to developing countries.” Declaration on the Establishment of a New International Economic Order, A/RES/S-6/3201, 1 May 1974.

TT is mainly about enabling a receiving country to use new technology in manufacturing. It is a process consisting of acquiring and learning knowledge and methods; about skills training and transferring facilities among companies, governments, universities and other institutions. However, studying TT in the climate change context is more complex, as the problem is caused by many "interactions among physical, biological, political, social, cultural and economic factors."[4] The highly interconnected nature of the issue cannot be handled with only one-dimensional political solutions. Just as it is clearly incorrect to categorize climate change TT as purely commercial or environmental, "appropriate responses must equally be premised on a broader range of considerations."[5] Given the subject of this thesis, it is especially important to look at TT as a concept with its meaning and development history clarified. Different attitudes towards TT and climate change must also be considered, along with measures related to TT available for countries and organizations encountering the climate change crisis.

3.2 Background of technology transfer

For a long time, technology has been considered important to the modern development of any economy. Adam Smith was one of the first to look at manufacturing technology systematically.[6] His work has provided the foundation for analyzing the development of economies. Smith did not examine technology and innovation as an individual issue but "the relevance of his reading of the creative human nature and how it affects social and economic

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4 French (n 1).
5 Ibid.
6 As early as in 1776. Kwangsu Kim, 'Adam Smith's Theory of Economic History and Economic Development' (2009) 16 The European Journal of the History of Economic Thought 41.

processes has endured."[7] Smith pointed out that the "underlying forces of the growth of technology and productivity had been inducing economic development." [8] Later, *technological determinism theory* was coined. It presumes that a society's technology is so decisive for it is a driving force of the development in social and cultural aspects of a society. The first major elaboration of technological determinism was provided by Karl Marx who elaborated his theory based upon the idea that technology advancement is the primary influences on the structure of social relations, "and that social relations and cultural practices ultimately revolve around the technological and economic base of a society."[9] His view has been embedded in the contemporary understanding, which claims "fast-changing technologies alter human lives in a positive way."[10] These studies were looking at technology from a country's economic and social development point of view. Schumpeter adopts an evolutionary version of economics, which differs from Marx and claims that a monopoly over property as well as technology is essential for short-term purpose.[11]

The rich literature on technological change has pointed out the vital role that technology plays in productivity change and economic development, and therefore provides a very important justification for TT.[12] As technology is key to development, it explains to some extent why

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[7] Iqbal Z. Quadir, 'Adam Smith, Economic Development, and the Global Spread of Cell Phones' (2013) 157 Proceedings of the American Philosophical Society 67.
[8] A. Smith, *The Wealth of Nations: An Inquiry into the Nature and Causes of the Wealth of Nations.* (R. H. Campbell and A. S. Skinner eds, Oxford: Clarendon Press 1976).
[9] Bruce Bimber, 'Karl Marx and the Three Faces of Technological Determinism' (1990) 20 Social Studies of Science 333.
[10] Gerald Allan Cohen, *Karl Marx's Theory of History: A Defence* (Oxford: Clarendon Press 2000).
[11] "technological innovation often creates temporary monopolies, allowing abnormal profits that would soon be competed away by rivals and imitators, these temporary monopolies were necessary to provide the incentive for firms to develop new products and processes for the whole of society." Joseph Schumpeter, 'The Instability of Capitalism' (1928) 38 The Economic Journal 361.
[12] F. H. Hahn and R. C. O. Matthews, 'The Theory of Economic Growth: A Survey' (1964) 74 The Economic Journal 779; Edwin Mansfield, *The Economics of Technological Change* (Longmans 1969); Edward Fulton Denison, *Accounting for United States Economic Growth, 1929-1969* (Brookings Institution 1974); Nathan Rosenberg, 'The Impact of Technological Innovation: A Historical View' in Ralph Landau and Nathan Rosenberg (eds), *The Positive Sum Strategy: Harnessing Technology for Economic Growth* (reprint edn, National Academy Press 1986) p.17.

countries long for access to new technologies either through domestic independent innovation or through international transfer.

3.2.1 Technology transfer in colonial times

Most of history countries have sought to protect knowledge of their technologies because knowledge is seen as power (both military and economic).[13] However, international TT is not a new activity. Historically, according to Daniel Headrick,[14] especially after the Industrial Revolution, TT actually accelerated the receiver country's productivity and in turn benefited the transferor nations, which were the colonizers at the time. Some technologies served the interests of the native populations: public health services, railways and irrigations systems. These technologies received official approval when transferred into the colony, but only within the narrow limitations of tightened colonial budgets. Nevertheless, when a new technology[15] was introduced into a colony, experts from western countries would came along work on equipment settings and help with operation, and sometimes pass their jobs on to their heirs. This established a long-term and comprehensive TT pattern with generations of skilled persons working as trainers and living examples of trades, etc. in the colonial countries. This meant that not only equipment but also know-how was transferred successfully. Nonetheless, such TT formed between colonizer and the colonized bred the risk of crippling the receiver countries' independent technology-development capability.[16]

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13 Sergio C. Trindade and others, 'Section 1.3 Background in Charpter 1 Managing Technological Change in Support of the Climate Change Convention' in Bert Metz and others (eds), *Methodological and Technological Issues in Technology Transfer* (Cambridge University Press 2000).

14 "The Europeans who ruled the colonies were in an ambiguous position. They represented a conquering civilization which obtained its power from ingenious innovations, and they certainly shared the Western love of new devices and the urge to proselytize their techno-mania among the 'backward races' of the world." Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940* (Oxford University Press 1990).

15 it could be either new process or new sets of equipment.

16 Headrick (n 14).

From the Industrial Revolution onwards,[17] many Asian and African colonies "saw Western technology as their key to power and prosperity and they sought more machinery and knowledge than the Europeans offered them locally."[18] However, those TTs that might have led to the growth of import-substitution industries[19] (e.g. textiles, natural colourants, rubber, metal machinery parts, and so on) were generally viewed with suspicion within transferor countries. Once they lost support from Western countries these businesses became unable to compete, and had to adjust their production and operation in an independent way by providing inferior goods. For instance, after the independence of sub-Saharan Africa, factories in the country started to produce cheaper textiles, which was a step backwards from its colonial time because "they began to make thinner clothing instead of finer materials."[20] At the same time they made best use of their comparative advantage in having cheaper labour. Thus, they competed with European manufactures in a way that "challenged the authority of the colonial regimes."[21]

Even under the best of circumstances, when technologies were accessible, importing technology could have been hazardous. For example, small businesses like the Chinese tin mines of Malaya could not afford to keep up with the rising cost of Western machines. Tin was the most important trade in Malaya and the ownership of the industry was "shared primarily between the British and the Chinese."[22] Before the First World War, merely a

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[17] In the period from about 1760 to sometime between 1820

[18] Suvobrata Sarkar, 'Technological Momentum: Bengal in the Nineteenth Century' (2010) 37 Indian Historical Review 89.

[19] Ibid.

[20] Ana Paula F. Mendes, Mário A. Bertella and Rudolph F. A. P. Teixeira, 'Industrialization in Sub-Saharan Africa and Import Substitution Policy' Rev Econ Polit vol34 no1 São Paulo Jan/Mar 2014 <http://www.scielo.br/pdf/rep/v34n1/v34n1a08.pdf> accessed 2 Mar 2017.

[21] "Many colonial officials would have gave them a harsh time to development domestic industry as they were from the English gentry and the French petite bourgeoisie, which had lost ground and assets to industrialists." Headrick (n 14).

[22] Cheah Boon Kheng, *Red Star Over Malaya: Resistance and Social Conflict During and after the Japanese Occupation, 1941-1946* (NUS Press 2012).

quarter of global tin production was under control of Britain companies.[23] But after the war, British share increased steeply as a result of introducing colossal dredging machine among mines. Even more so, "towards the end of the last century the British began breaking in on the monopoly of tin by the Chinese and the trend had been increasingly toward British control."[24] Therefore, "the hand-worked open-cast Chinese mines were unable to compete with the British dredges. Under the spur of competition the Chinese made considerable advances in selling their mines but they lacked capital for the installation of dredges."[25] After all, entrepreneurs with both business skills and capital were rare, and those who understood Western machines were rarer.[26] In fact, international TT at the time was initially used as an approach to maximize colonial benefits.[27] This could explain why technology given to colonies had restrictions attached. Gradually, the role of TT changed, but the *advantage difference* between technology owners and manufacturers remained and the flow of technology that originated in colonial times continues.

3.2.2 Technology transfer in the postcolonial era

After World War II and until the 1970s – a time of decolonization – "most developing countries in Latin America and Africa, as well as some countries in Asia (like India and Thailand), depended heavily on agricultural production to support their economies."[28] The debate on TT between colonizer and colonial has shifted to TT from developed countries to

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[23] Ibid.

[24] 'TED Case Studies: Tin Mining In Malaysia - Present And Future' (14 Dec 2012) <http://archive.is/syKM#selection-11.0-11.61> accessed 20 Aug 2017.

[25] Ibid.

[26] Otto Ullrich, 'Technology' in Wolfgang Sachs (ed), *The Development Dictionary: A Guide to Knowledge as Power* (2 edn, Zed Books Ltd. 2010) p.275: A short paper discussing the relationships between technology and production. He then relates the topic to colonialism and neocolonialism.

[27] See John Weiler, 'Colonial Connections: Royal Engineers and Building Technology Transfer in the Nineteenth Century' (1996) 12 Construction History 3.

[28] Martín Piñeiro, 'Agricultural Technology Transfer to Developing Countries and the Public Sector' Science and Development Network Policy Briefs, Jan 2007 <http://library.wur.nl/WebQuery/file/cogem/cogem_t477e4c16_001.pdf> .

developing countries. The topic, therefore, finds its roots in the call for development needs of the newly independent nations in the later era of decolonization.[29] These countries realized that technological advance was critical to a country's development. As food scarcity was a key issue to many less developed countries, lots of development activities were aimed at modernizing the agricultural sector in these countries.[30] During this period, most TT from developed countries focused on transferring agricultural technologies to developing countries.[31] But since the late 1970s, technologies "have become embodied in physical products, like farm machinery or agrochemicals, exponential growth in such industries."[32] Such change in trend has "led to a rapid expansion of private firms that create, manufacture and sell technology."[33] And so the role of the public sector diminished. More recently, from a time in the mid-1990s, globalization has resulted in more production of consumer goods in developing countries (Indonesia, Malaysia, and Thailand). These East Asian economies have benefited from a strategy of absorbing imported technology to increase their export growth since then.[34]

In the 1960s, the international community had to discuss the issue of TT in this postcolonial era for the first time:

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[29] Jérôme de Meeûs and Alain Strowel, 'Climate Change and the Debate around Green Technology Transfer and Patent Rules: History, Prospect and Unresolved Issues' 3 WIPOJ 178.

[30] Piñeiro (n 28).

[31] "However, such activities relied on public institutions and universities since many of the agricultural technologies and much of the knowledge being created had little market value. Physical products were not being produced, and those technologies were considered 'public goods', which anyone could use without diminishing the value. Examples include improved seeding rates, pasture management or crop rotation practices." Nádia Solange Schmidt Bassi and others, 'Controversies about the Process of Technology Transfer from Public Research Institutions in Brazil: The Case of the Brazilian Agricultural Research Corporation - Embrapa.' (2014) 9 J Technol Manag Innov 2014, Volume 9, Issue 3 182

[32] Ibid.

[33] Ibid.

[34] Carl Dahlman, 'Technology, Globalization, and International Competitiveness: Challenges for Developing Countries' in United Nations. Department of Economic and Social Affairs (ed), *Industrial Development for the 21st Century: Sustainable Development Perspectives* (United Nations Publications 2007).

TT was first tabled as an international issue in 1961, with a request to the United Nations Secretary General by some developing countries that studies be commissioned to ascertain the role of international treaties in promoting IPRs protection in developing countries.[35]

In the first session of the UNCTAD in 1964, the meeting defined technology as "systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service", which "does not extend to the transactions involving the mere sale or mere lease of goods"[36] This definition clearly identifies that "the knowledge that goes into the creation and provision of the product or service" is the essence that constitutes technology, and excludes foods that are a finished product or service from the ambit of technology.[37] Accordingly, it described the input and output of technologies among countries as TT and provided a way for understanding TT which was not the physical transfer from one place to another.

The UN made its first prominent use of TT under its Article IV 2 of the 1968 Nuclear Non-Proliferation Treaty (NNPT).[38] Even so, the main purpose of the treaty was to prevent the spread of nuclear weapons and relative technology. TT was only employed as an incentive

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[35] Padmashree Gehl Sampath and Pedro Roffe, 'Unpacking the International Technology Transfer Debate: Fifty Years and Beyond' ICTSD Programme on Innovation, Technology and Intellectual Property Issue Paper No 36 <http://www.ictsd.org/downloads/2012/11/unpacking-the-international-technology-transfer-debate-fifty-years-and-beyond.pdf> accessed 17 Jul 2017.

[36] Draft International Code of Conduct on the Transfer of Technology as at the close of the 6th session of the Conference on 5 June 1985, TD/CODE TOT/47, Geneva : UN, 20 June 1985. ch.1, para.1.2.

[37] UNCTAD, 'Transfer of Technology' UNCTAD Issue Paper Series UNCTAD/ITE/IIT/28, New York and Geneva, 2001 <http://unctad.org/en/docs/psiteiitd28.en.pdf> accessed 2 Sep 2017

[38] "All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. Parties to the Treaty in a position to do so shall also co-operate in contributing alone or together with other States or international organizations to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapon States Party to the Treaty, with due consideration for the needs of the developing areas of the world." UNODA, 'Treaty on the Non-Proliferation of Nuclear Weapons (NPT)' (*United Nations Office for Disarmament Affairs*) <https://www.un.org/disarmament/wmd/nuclear/npt/text> accessed 2 Sep 2017.

for developing countries to participate in the international regime. In the 1980s, discussions and deliberations over TT reached a peak with the UNCTAD negotiations on an International Code of Conduct on TT.[39] Although efforts made by the Code did not make much difference, TT has become a essential topic in a variety of international forums.[40] In fact, developing countries were 'bought off' by TT provisions to sign particular treaties, especially MEAs. For instance, the General Agreement on Trade in Services (GATS)[41] and the TRIPS Agreements both refer to TT in provisions.[42] The Montreal Protocol[43] and the Kyoto Protocol[44] are more clearly include TT for environmental protection objectives.

3.3 Defining of technology transfer

3.3.1 Technology transfer from different perspectives

It is widely recognized that TT from developed countries to developing countries has "an important impact on the pattern of trade and relative incomes across countries."[45] Positive descriptions of TT can be found in comparatively early literature on the topic.[46] According to Zhoa and Reisman,[47] the definition of TT differs substantially among disciplines.[48] TT has

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39 See detail discussion of the Code in Section 3.7

40 Sampath and Roffe (n 35).

41 The GATS contains an obligation in Article 4 para 2: "developed countries to establish contact points to facilitate the access of developing country members' service suppliers to information related to their respective markets concerning the availability of services technology." General Agreement on Trade in Services, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1B, 1869 U.N.T.S. 183, 33 I.L.M. 1167 (1994).

42 See for example, TRIPS article 7 and article 66.2

43 Montreal Protocol on Substances that Deplete the Ozone Layer, TD/CODE TOT/47, Geneva : UN, 20 June 1985. Article 10A

44 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), UN Doc FCCC/CP/1997/7/Add.1, Dec. 10, 1997; 37 ILM 22 (1998), article 10, 11 and 12.

45 Robert C. Feenstra and Kenneth L. Judd, 'Tariffs, Technology Transfer, and Welfare' (1982) 90 Journal of Political Economy 1142.

46 Gaetan Verhoosel, 'Beyond the Unsustainable Rhetoric of Sustainable Development: Transferring Environmentally Sound Technologies' (1998) 11 Geo Int'l Envtl L Rev 49.

47 L. Zhao and A. Reisman, 'Toward Meta Research on Technology Transfer' (1992) 39 IEEE Transactions on Engineering Management 13 p.14.

48 They observe that economists such as the Kenneth J. Arrow, 'Classificatory Notes on the Production and Transmission of Technological Knowledge' (1969) 59 The American Economic Review 29; Harry G. Johnson, 'The Efficiency and Welfare Implications of the International Corporation' in C Kindleger (ed), *International Corporations*, vol 35 (Cambridge: CUP,1970 1970); Giovanni Dosi, 'The Nature of the Innovation Process' in Giovanni Dosi and others (eds), *Technical Change and Economic Theory*, vol 988 (Pinter London 1988), tend to define technology as part of the society's IP therefore focuses are made on factors that matter to production and design.

been used by many firms to improve their competitive advantage.[49] By introducing mature technology from the external (another country) and innovating with and upon it, latecomers are able to erode the "competitive advantage of the well-entrenched firms and propel themselves to the forefront."[50] Thus it has been a great equalizer of the market and has been "used as a strategy for enhancing the competitive position of an entire industry, a region and, indeed, of an entire nation."[51] Also, it has then been a tool in improving "economic progress, social development, improvements in quality of life, and even of culture and of value systems."[52] In order to clarify the systematization and complexity of TT, studies on the subject have attracted increasing interest in academia. In the respective literatures, TT has been studied from many lens: "economists, sociologists, anthropologists, engineers, and both behavioural and quantitative management theorists."[53] These scholars provided a variety of definition of TT attributing to the different approaches and disciplines adopted.[54]

In this thesis, TT is looked at through a social-legal lens by identifying the responsibility to provide technologies as the legal obligation of more developed countries. And at the same time, TT is recognized as a need for human society to improve the natural environment of the planet.

Sociologists (such as Everett M. Rogers, *Diffusion of Innovations* (4 edn, The Free Press, New York 2010); Everett M. Rogers and F. Floyd Shoemaker, *Communication of Innovations; A Cross-Cultural Approach* (The Free Press, New York 1971)) tend to link TT to innovation activities which is considered as a type of social behaviour.
Anthropologists (such as George M. Foster, *Traditional Cultures: and the Impact of Technological Change* (New York & Evanston: Harper & Row. 1962); Elman R. Service, *Cultural Evolutionism: Theory in Practice* (Holt,Rinehart & Winston of Canada Ltd; First Printing edition 1971); Robert S. Merrill, 'The Role of Technology in Cultural Evolution' (1972) 19 Social Biology 240) tend to view TT broadly within the cultural environment and focus on how TT will affected when the cultural context changes; See also literature review chapter.

49 C. Christopher Baughn and Richard N. Osborne, 'Strategies for Successful Technological Development' (1989) 14 The Journal of Technology Transfer 5.

50 Michael E. Porter, 'Technology and Competitive Advantage' (1985) 5 Journal of business strategy 60.

51 Arnold Reisman, 'Technology Transfer: A Taxonomic View' (1989) 14 The Journal of Technology Transfer 31.

52 N. Mohan Reddy and Liming Zhao, 'International Technology Transfer: A Review' (1990) 19 Research Policy 285.

53 Zhao and Reisman (n 47).

54 Ibid (n 47); A discussion of TT definitions across disciplines, see Appendix II.

3.3.2 Contents of technology transfer

According to Rubens Ricupero and Carlos Correa:

> There are two relevant categories of knowledge that are essential for economic progress and competitiveness. The first consists of knowledge embodied in machines and equipment that makes it possible to control sophisticated processes for producing goods and services and marketing them at a profit. The other category, to some extent still elusive, consists of tacit knowledge, that is, knowledge embodied in the organizational routines and collective expertise or skills of specific production, management, research and development and marketing. It is the first type of knowledge that people generally have in mind when discussing today's knowledge-intensive economy and the transfer and diffusion of technology. However, as knowledge becomes a more decisive factor, and a more critical commodity, its acquisition and diffusion will require that the two aspects of knowledge be considered as an integral part of knowledge transfer. This makes the process of TT more than ever a continuous and uninterrupted learning process.[55]

Generally speaking, successful TT consists of both tangible and intangible aspects. Sahal's description of TT is significant among the literature as he observes that "technology [as the object of TT] must rely on a subjectively determined but specifiable set of processes and products."[56] Roessner, in his overview of TT, points out the specific importance of "the

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[55] Rubens Ricupero and Carlos Correa, 'Preface' in Surendra J. Patel, Pedro Roffe and Abdulqawi A. Yusef (eds), International Technology Transfer: The Origin and Aftermath of the United Nations Negotiations on a Draft Code of Conduct (The Hague: Kluwer Law International 2001). This broad definition of "technology transfer" draws inspiration from the IPCC vision on TT unanimously recognized by the international community: Technology Transfer is "a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations and research/education institutions" IPCC, 'Summary for Policymakers' in Bert Metz and others (eds), *Methodological and Technological Issues in Technology Transfer: A Special Report of IPCC Working Group III* (Cambridge University Press 2000).

[56] Devendra Sahal, 'Alternative Conceptions of Technology' (1981) 10 Research Policy 2.

movement of know-how, technical knowledge, or technology from one organizational setting to another."[57] This further articulates the *specified process* that Sahal has put forward by identifying the particular contents of the processes. A research on TT simply focusing on the final product is not sufficient. TT "is not merely the product that is transferred but also knowledge of its use and application."[58] In that case, a successful TT should always be considered alongside "obtaining certain result, resolving certain problems, completing certain tasks using particular skills, employing knowledge and exploiting assets."[59] If missing any of the factors above, it would have failed the very comprehensive process of TT. Yet, in real practice, it is usually easier to access the tangible type of knowledge/technologies, with the intangible category remaining less available to developing countries. This is because on one hand investment in capital such as machinery and equipment is the most traditional way of investing that provides instant result in increased productivity in developing countries; and on the other, it is the less risky approach to get direct returns from investment as increases in physical capital, employment, and usage of advanced machinery and equipment often bear fruit.[60]

The transfer of environmental sound technologies (ESTs)[61] has been raised in more recent years, and is the subject of an extensive literature.[62] Similarly, this looks at TT from all the

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[57] J.D Roessner, 'Technology Transfer' in C. Hill (ed), *Science and Technology Policy in the US A Time of Change* (Longman, London 2000) p.1.
[58] Barry Bozeman, 'Technology Transfer and Public Policy: A Review of Research and Theory' (2000) 29 Research Policy 627
[59] Ping Lan and Stephen Young, 'International Technology Transfer Examined at Technology Component Level: A Case Study in China' (1996) 16 Technovation 277.
[60] Alper Sönmez, *Multinational Companies, Knowledge and Technology Transfer* (Springer, Cham 2013).
[61] United Nations, 'Glossary of Environment Statistics' Studies in Methods, Series F, No 67, United Nations, New York US <https://unstats.un.org/unsd/publication/SeriesF/SeriesF_67E.pdf> accessed 1 Jul 2017: "Environmentally sound technologies are techniques and technologies capable of reducing environmental damage through processes and materials that generate fewer potentially damaging substances, recover such substances from emissions prior to discharge, or utilize and recycle production residues."
[62] E.g. Ernst Worrell and others, 'Carbon Dioxide Emissions from the Global Cement Industry' (2001) 26 Annual Review of Energy and the Environment 303; see also Zili Yang and William D. Nordhaus, 'Magnitude and Direction of Technological Transfers for Mitigating GHG Emissions' (2006) 28 Energy Economics 730.

different perspectives mentioned earlier, but discussions revolve around technology that benefits environmental protection and TT for the purpose of climate change mitigation.[63] Indeed, successful TT should involve a technology transferor that makes its technology applicable to a transferee under certain processes reaching technical achievement. Such achievement is depending on the utilization of certain information, knowledge and experience relating to all aspects of production (i.e. processes, materials and operation management). This definition is broad enough to include patents, technical secrets (know-how) and ancillary support needed for application of the technology.[64]

It has been argued that TT is a tool that helps to achieve social and economic development in less developed societies under the condition that all states participate in international cooperation.[65] But we also need to understand that the TT process is a two-way interactive process.[66] The economies in some large developing countries are now growing rapidly and these countries are experiencing a transition period from being pure receiver to becoming a provider. This can change traditional views in which TT was seen as a means of ensuring equity between developed and developing countries.

3.4 Fairness, equity and cooperation

The legitimacy of international ESTT aid roots in "multilateral obligations and state commitments" which are therefore important "because the private sector does not have

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[63] See detail discussion on EST in Chapter IV

[64] Including almost everything supporting means ranging from computer software, integrated circuit layouts and new varieties of plants, etc.

[65] IPCC, *Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change* (Bert Metz and others eds, Cambridge University Press 2000) p.131.

[66] developing countries will be benefited from technology development while developed country which provides the technology in the transfer gains royalties or equipment sales. See UNEP-IETC, Technology Transfer: The Seven 'C's for the Successful Transfer and Uptake of Environmentally Sound Technologies (Osaka, Japan: The UNEP International Environmental Technology Centre, January 2004).

automatic incentives to TT to developing countries."[67] One of the main viewpoints taken to justify such a commitment to MEAs of developed countries is a concern about fairness stating that "developed countries have already had the opportunity to grow by using practices that caused major environmental degradation. If developing countries cannot go through that same process, their growth would be unfairly impaired."[68] Therefore, in consideration of an equal development opportunity among all nations, developed countries should take some action to ensure less developed countries do not achieve growth in a manner that leads to pollution. Such an obligation applies not only to environmental damage that has been caused but also extends to preventing more damage being caused. Moreover, the emissions in the past gave the developed nations a chance to gain wealth earlier that can be used for compensation today. Virtually every country agrees that economic growth in developing countries "cannot take place with the same disregard for the environment as did economic growth in the now-developed countries."[69] But they fear that environmental protections will slow down the economies of developing states. While developing nations advocate their sincerity to a more sustainable and environmentally friendly way of development, in fact some developing countries are not substantially using environmentally friendly measures. As indicated by their actions these developing countries are either unable to afford, or decide not to, employ green productivity because the majority of their funds go towards building their economy in energy-intensive ways. For example, "in 2014, a UN Intergovernmental Committee of Experts estimated the total cost of the Sustainable Development Goals to be

[67] Sampath and Roffe (n 35).
[68] Gary C. Bryner, 'Agenda 21: Myth or Reality?' (1999) 157 The Global Environment: Institutions, Law, and Policy 158.
[69] Patrick Doherty, 'The Transfer of Environmentally Sustainable Technologies to Asia' (1995) 4 Review of European Community & International Environmental Law 33.

trillions of dollars a year";[70] on the other hand "some 550 million people are still living on less than $1.25 a day, most of them in sub-Saharan Africa."[71] Yet mid-income developing countries (such as China) are in a better position, so their unwillingness in taking environmental action is not due to poverty in the main. While the ex-Premier of China, Wen Jiabao, stated that "China will take a more active part in pushing forward international cooperation on sustainable development,"[72] more people from private sector view the responsibility to achieve sustainable development in a subtle way by emphasizing that "developing countries, which are experiencing a key period of transition and development, usually prioritize development but still value sustainability."[73] Companies in these countries are simply disinclined to switch to greener production notwithstanding that their emission volume is increasing. For example, in 2016 the Chinese Ministry of Environmental Protection visited 1,019 steel companies across the country and found that "173 firms had broken the rules [in environmental protection laws], with 62 firms involved in illegal construction and 35 exceeding state emission limits."[74] All in all, such reluctance is due to expense that damps the zest of firms. Until these firms in developing countries have enough economic incentives made available to them, it seems unlikely that they will continue engage with non-environmentally friendly production.

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70 United Nations, Report of the Intergovernmental Committee of Experts on Sustainable Development Financing (United Nations General Assembly Sixty-ninth session, UN Doc A/69/315, 15 August 2014).

71 Romilly Greenhill and others, *Financing the Future: How International Public Finance Should Fund a Global Social Compact to Eradicate Poverty* (Overseas Development Institute (ODI) Reports, April 2015)

72 Lan Lan and Jize Qin, 'Rio 'Reflects Efforts of Developing Nations'' *China Daily* (2012-06-22) <http://www.chinadaily.com.cn/china/2012-06/22/content_15518010.htm>

73 As said by Chi Fulin, the president of China Institute for Reform and Development, during his speech at the Rio+20 conference.

74 This proves that industry does not want to comply with the costs of being environmentally friendly. See China Environmental News according to the ministry's official publication.

A second standpoint represents the idea of the “polluter pays”. In 2009, Prime Minister Meles Zalawi of Ethiopia spoke on behalf of many African nations claimed that the developed countries such as the US and the UK are responsible for most historic global emissions.[75] These developed countries should therefore compensate developing nations for the damage they have caused in history attributing to the global climate change. This argument emphasized the historical responsibility of developed countries for their GHG emissions. Such voices raise the basic question of who should pay for environmental damages. As much as most developing countries view climate change as a considerable issue, they also believe that efforts on mitigation should start in the developed countries that are responsible for the majority amount of emissions in history. The ecological footprints thesis allows the historical justice argument to be made: as damage caused will endure into the future with negative impacts for the whole of the global community, a nation shall pay for its contributions to environmental damage in the past. Such a concept was circulated well before the Rio conference[76] and further established by William Rees[77] and others.[78]

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[75] Quote from *Development Challenges in a Post-crisis World:* (Claudia Sepúlveda, Ann Harrison and Justin Yifu Lin eds, World Bank Publications 2013); “See, for instance, Meles Zenawi, ‘Climate Change will Hit Africa Hardest’ (*TheGuardian*, 28 November 2009) <https://www.theguardian.com/commentisfree/cif-green/2009/nov/28/africa-climate-change> accessed 11 Jul 2017 or http://www.bloomberg.com/apps/news?pid=newsarchive&sid=agSY4tVL.oOw. Similar views are expressed by Blaise Compaoré of Burkina Faso, http://www.afrik.com/article17747.html. For additional quotes from heads of state, see http://www.unep.org/climateneutral/Resources/Quotes/tabid/362/Default.aspx, http://allafrica.com/stories/201009201379.html, http://www.ethjournal.com/index.php?option=com_content&view=article&id=2155:ethiopia-pushes-for-more-financing-to-mitigate-and-adopt-climate-change&catid=13:headlines&Itemid=19,Brazil, The World Bank, ‘Low Carbon Growth in Brazil’ (*The World Bank*, June 17, 2010) <http://www.worldbank.org/en/news/press-release/2010/06/17/low-carbon-growth-brazil> and ‘Copenhagen Accord Not Legally Binding: Basic Countries’ (*Hindustan Times*, Jan 25, 2010) <http://sustainabilityoutlook.in/news/copenhagen-accord-not-legally-binding-basic-countries-2389> accessed 15 Sep 2017

[76] David William Pearce, Anil Markandya and Edward Barbier, *Blueprint for a Green Economy*, vol 1 (Earthscan 1989).

[77] William E. Rees, ‘Ecological Footprints and Appropriated Carrying Capacity: What Urban Economics Leaves Out’ (1992) 4 Environment and Urbanization 121.

[78] Mathis Wackernagel, ‘Ecological Footprint and Appropriated Carrying Capacity: A Tool for Planning Toward Sustainability’ (PhD, School of Community and Regional Planning, University of British Columbia 1994); Wackernagel, Mathis, 1991. "Land Use: Measuring a Community's Appropriated Carrying Capacity as an Indicator for Sustainability"; and "Using Appropriated Carrying Capacity as an Indicator, Measuring the Sustainability of a Community." Report I & II to the UBC Task Force on Healthy and Sustainable Communities, Vancouver; William Safire, ‘Footprint’ *The New York Times Magazine* (Feb. 17, 2008) On Language <http://www.nytimes.com/2008/02/17/magazine/17wwln-safire-t.html> ; Mathis Wackernagel and William Rees, Our Ecological Footprint: Reducing Human Impact on the Earth (New Society Publishers 1998).

There are also two important factors among the many that cause environmental problems: population and consumption. Populations of developed countries are stable, but the per capita consumption is relatively high. On the other hand, "developing countries have low per capita consumption but rapidly expanding populations."[79] There is a clear division between developed and developing countries over the question of which factor is the main force causes environmental problems. The idea that all countries should reduce their emissions by similar percentages clearly favours the countries that have more per capita emissions and green-tech capability today and therefore is not acceptable for most developing countries. Large emitters do not necessarily have higher energy consumption per capita. Some developing countries with large populations and ranking world's top subtotal energy consumption could fall in the low consumption per capita category. Therefore, they would surely favour an argument that lower consumption per capita countries deserve donation from higher consumption per capita countries, for the density of energy and resource provided to the later would have had brought the standard of living in those countries higher. For example, China in 2005 emitted 7,225.4 megatons making its emissions the highest in the world. However, its GHG emission per capita was only 5.5 tons (almost five times lower than the U.S.). Thus, less developed countries are more likely to prefer a model in which emissions allowances are distributed according to the level of per capita emissions.[80]

Another argument involving equity is not based upon the historic benefits of emissions which led to climate change but on the possible adverse effects. For example, Hsiang and colleagues

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[79] Michael Jacobs, 'Sustainable Development as a Contested Concept' in Andrew Dobson (ed), *Fairness and Futurity: Essays on Environmental Sustainability and Social Justice* (Oxford University Press 1999) p.33.

[80] "The obvious result would be massive financial transfers from countries with actual per capita emissions above this allocated level, to countries with actual per capita emissions below it." Cédric Philibert, 'How Could Emissions Trading Benefit Developing Countries' (2000) 28 Energy Policy 947.

identify that "for rich countries an additional degree of warming results in little effect, but for poor countries the same change leads to very significant costs in the form of reduced economic growth and increased costs of military and other conflicts."[81] This is pointing to the heterogeneous between countries. Some countries are rich in oil and coal recourses,[82] some are low-lying lands at low-latitudes in risk of inundation.[83] From a climate change perspective, such differences are meaningful in assessing damages referred as vulnerable sectors (agriculture, coastal zones, human mortality, and natural ecosystems).[84] The current situation is that there exists a higher vulnerability to climate change for developing countries than for developed countries; hence climate change risks are different across countries. Some developing countries have more to lose if they are unable to cope with the effects[85] while others are more concerned about the costs of international agreements that "will limit their markets for fossil fuel or hamper their perceived chances of development."[86] Finally, the causes of environmental degradation and lack of local R & D improvement are most significantly caused by financial factors occurring in developing countries.[87] As a result,

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[81] Solomon M. Hsiang, Kyle C. Meng and Mark A. Cane, 'Civil Conflicts are Associated with the Global Climate' (2011) 476 Nature 438.

[82] For example, China, India and Africa

[83] Subtropical arid and semi-arid regions will likely experience less precipitation than high latitude places. Over wet tropical regions, extreme precipitation events will very likely be more intense and more frequent in a warmer world. See IPCC Working Group III Technical Support Unit, *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems (SR2)* (SR2 Scoping Meeting, Dublin, February 2017, 2017).

[84] *Climate Change 1995: Economic and Social Dimensions of Climate Change* (James P. Bruce, Hoesung Lee and Erik F. Haites eds, Cambridge, UK: Cambridge University Press 1996).

[85] For example, "East Africa can expect to experience increased short rains, while west Africa should expect heavier monsoons. Burma, Bangladesh and India can expect stronger cyclones; elsewhere in southern Asia, heavier summer rains are anticipated. Indonesia may receive less rainfall between July and October." IPCC Working Group III Technical Support Unit (n 83).

[86] Thomas Sterner, 'Climate Change & Developing Countries: Considerations for Rio+20' Resources for the Future Issue 180 Spring/Summer 2012, (Jun 8, 2012) <http://www.rff.org/research/publications/climate-change-developing-countries-considerations-rio20> accessed 14 Jul 2017

[87] United Nations, The Road from Johannesburg: World Submit on Sustainable Development: What was Achieved and the Way Forward (2003) quoted by Hari M. Osofsky, 'Defining Sustainable Development after Earth Summit 2002' (2003) 26 Loy LA Int'l & Comp L Rev 111.

without any incentives, reaching consensus in negotiating international environment protection and corresponding obligations among developing countries is very difficult.

This phenomenon has led some to believe erroneously that developing countries[88] have no interest in contributing to the mitigation of climate change. Such misunderstanding might have based on views of developing countries on the distribution of the burden to combat climate change. In fact, such views do not necessarily proof non-interest overall. A developing country that rejects MEA proposals for equal reductions in emissions could have valued the issue no less than other countries. The 'growth economies' of developing countries are unwilling to accede to the request of developed countries to slow their economic growth in order to solve the planet's environmental problems because such problems are seen by these developing countries as primarily the result of years of unrestrained economic growth in developed countries.[89] If more advanced technologies are made cheap and available so they can produce energy in a less polluting way, economically these countries may then be more willing and able to reduce emissions.

All in all, climate change is inherently a global issue and the risk is globally distributed. Accordingly responsibility for addressing the problem should be shared by all countries.[90] To be successful in addressing climate change, we cannot ignore issues of fairness, equity, and environment protection. In fact, some developing countries have been initiating actions in

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[88] There were apparently different 'blocs' within the Rio / UNFCCC negotiations in the developing world including the BRICS, the Association of Island States, Least Developing Countries. During the creation of G77 (the group of developing countries) the division of interests between developing countries in the UNFCC negotiations are noted by a substantial literature. See for example Adil Najam, Saleemul Huq and Youba Sokona, 'Climate negotiations beyond Kyoto: developing countries concerns and interests' (2003) 3 Climate Policy 221; See also *NGO diplomacy: the influence of nongovernmental organizations in international environmental negotiations* (Michele Merrill Betsill and Elisabeth Corell eds, Mit Press 2008).

[89] Doherty (n 69).

[90] Henry D. Jacoby and others, 'CO2 Emissions Limits: Economic Adjustments and the Distribution of Burdens' (1997) 18 The Energy Journal 31.

dealing with the climate change crisis.[91] More positive and active attitudes towards climate change are reflected in decision- and policy-making in these countries.[92] As a reflection of this, the Kyoto Protocol has been ratified by 192 parties and states that:

> developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, and places a heavier burden on developed nations under the principle of "common but differentiated responsibilities."[93]

Challenges remain for developing countries because those that are most vulnerable in climate change are also the ones lack environmentally friendly technologies and human resource in green production area. Unfortunately these countries are less able in making their voice accountable in international negotiations as well. From a fair philosophy, assistance should be made available to these countries regarding knowledge and finance. Based on these reasons, it falls to the developed countries to take the greater burden and TT is a key pillar in impelling global environmental protection. Moreover, utilizing resources is imperative to economic development and, as such, it should not be allowed to cripple developing countries with burdensome emissions-cutting requirements. This is why

> there is generally a high degree of ambition and political support for green growth across the developing world, but only where it can lead to poverty reduction, higher social

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[91] "Quite a few development programs motivated by national and local economic goals (in developing countries) are also good for climate, such as energy efficiency or sustainable water resource management. A lot of countries have energy efficiency programs which are not driven by climate change considerations, but by concerns about energy security." World Bank, *Development and Climate Change: A Strategic Framework for the World Bank Group* (Completion Report FY09–11, World Bank Washington DC 2012).

[92] G. E. Skorov and otnosheniĭ Institut mirovoĭ ėkonomiki i mezhdunarodnykh, *Science, Technology, and Economic Growth in Developing Countries* (G. E. Skorov ed, Pergamon Press 1978).

[93] Environmental Protection Agency, 'The Kyoto Protocol' <http://www.epa.ie/climate/thekyotoprotocol/> accessed May 2017.

welfare and job creation. In addition, it must support the structural transformation of the economy to achieve higher productivity and more value added.[94]

Thus, the transfer of new technologies needs to allow developing countries to continue using resource and developing economies in a more environmentally sound manner[95] that is meaningful both for their national welfare and the world's future in the long term.

3.5 Defining developing countries

TT aid can be seen as a possible way of paying back less developed countries for what has been taken from them or as an incentive to gain their participation in international agreements. Such views became popular among decolonized countries in the 1950s and 1960s. With the fading of the old colonial powers, and in the initial discussion of TT in NIEO, it was an attempt by the ex-colonies to get some payback from their former colonial masters. From the 1970s onwards the issue has been how global environmental problems can be dealt with in a way that does not overly burden developing countries. Therefore, the differing viewpoints of countries are no longer divided between the colonizer and the colonized but the developed and developing countries. Together with the growth of the idea of "sustainable development,"[96] the question of technology distribution triggered further debates. One of the difficult questions is how to separate countries into different categories because, according to some less developed countries, the poor group (developing countries) deserves payback or assistance from the richer one (developed countries).

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94 OECD, *Green Growth and Developing Countries* (Consultation Draft, June 2012, 2012).

95 Lorelyn Hall, 'Technology Tranfers under the United Nations Framework Convention on Climate Change' (2005-2006) 17 Colo J Int'l Envtl L & Pol'y 59.

96 Marina V. Cazorla and Michael A. Toman, 'International Equity and Climate Change Policy' in Michael A. Toman (ed), *Climate change economics and policy: An RFF anthology* (Resource for the Future Washington, DC 2001).

Nations in the world are in different stages of economic and technological development but there is no absolute way to classify them. Generally speaking, developing countries are countries that have not reached a high degree of industrialization and keep a medium to low standard of living within their population. But to further define the concept, various definitions of 'developing countries' are available for countries to classify themselves because the most recognized international organizations (such as the WTO) did not give any specific definitions of "developed" and "developing" countries, meaning that member states can announce themselves as "developed" or "developing" countries. This has provided a chance for countries to classify themselves according to different variables to meet their specific needs. Even so, there are some frequently used classifications. For example, some institutions produce lists of "developed countries" which can be used as a counter concept to "developing countries".[97] There is yet a unified convention for determining developed and developing countries thus the UN list has to be designed mostly according to trade practice.[98] Many other institutions have made lists that are referred to occasionally when discussing developed countries. For example, the 34 members of OECD are often considered as a group of developed countries[99] and the International Monetary Fund (IMF) lists 35 "advanced economies" which can also be seen as developed countries.[100]. The 66 "high income

[97] E.g. The International Monetary Fund (IMF); The OECD; The World Bank

[98] "In common practice, Japan in Asia, Canada and the United States in northern America, Australia and New Zealand in Oceania and Europe are considered developed regions or areas. In international trade statistics, the Southern African Customs Union is also treated as developed region and Israel as a developed country; countries emerging from the former Yugoslavia are treated as developing countries; and countries of Eastern Europe and the former Union of Soviet Socialist Republics countries in Europe are not included under either developed or developing regions" Statistics Division United Nations, 'Standard Country or Area Codes for Statistical Use (M49)' (*United Nations*) <https://unstats.un.org/unsd/methodology/m49/> accessed 22 Aug 2017.

[99] Economic and Social Research Institute (ESRI) and Government of Japan Cabinet Office, 'Minutes of Forum #26: Global Strategy Series 2 - Japan as It Should Be (Outline)' (*ESRI Economic Policy Forum*, December 2006) <http://www.esri.go.jp/en/workshop/forum/minute/minute26-e.html> accessed 2013-07-12.

[100] IMF Advanced Economies List. I. M. F. Research, *World Economic Outlook, October 2012: Coping with High Debt and Sluggish Growth* (International Monetary Fund 2012) p.180; I. M. F. Research, *World Economic Outlook, April 2011: Tensions from the Two-Speed Recovery: Unemployment, Commodities, and Capital Flows* (International Monetary Fund 2011) p.165.

countries" classified by the World Bank are also helpful in understanding developed country from a gross national income (GNI) per capita aspect.[101]

The OECD Development Assistance Committee (DAC) has established a list of official development assistance (ODA) Recipients. Countries included in the list can be considered in some way as developing countries. This list consists of "all low- and middle-income countries based on GNI per capita as published by the World Bank, with the exception of G8 members, EU members, and countries with a firm date for entry into the EU."[102] The list also includes all of the least developed countries (LDCs) as defined by the UN.[103] The list of ODA recipients is designed to identify countries and economies that are eligible to receive resource flows originating in donor countries.[104] The OECD claims that for a country to be considered as qualifying for the developing country list, decisions have to be agreed by the ODA between the governments of 22 OECD member countries. While the OECD definition holds a lot of weight among classification sets, most of its member states are richer or better-developed nations. This definition clearly takes economic development or income variables to be more important than other factors in defining "developing".

The World Bank employs analytical income categories[105] based on the Bank's operational lending categories. The definition is provided for operational and analytical purposes, and the

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[101]World Bank DataBank, 'World Bank List of Economies ' (*World Bank*, July 2016) <http://siteresources.worldbank.org/DATASTATISTICS/Resources/CLASS.XLS> .

[102] ESRC, 'GCRF Strategic Networks call 2016 Frequently asked questions' Economic and Social Research Council updated 24 June 2016 <http://www.esrc.ac.uk/files/funding/funding-opportunities/gcrf-strategic-networks-call-2016-faqs/> accessed Feburary 2017.

[103] The list of LDCs includes: African, Asian and Island LDCs. "The list is reviewed every three years by the United Nations Economic and Social Council (ECOSOC), in the light of recommendations by the Committee for Development Policy (CDP). The following three criteria were used by the CDP in the latest review of the list, in March 2012." UNCTAD, *The Least Developed Countries Report 2012* (United Nations Conference on Trade and Development, UNCTAD/LDC/2012, 2012)

[104] 'DAC List of ODA Recipients' (*OECD website*, 1st Janurary 2015) <http://www.oecd.org/dac/stats/daclist.htm> accessed Feburary 2017

[105] According to the World Bank classification, China ($4,382-International Monetary Fund; $4,393-World Bank), with its 2010 GDP (nominal) per capita, is an upper middle income country; In 2010, 391000 patent has been granted ranking second of the

main criterion for classifying economies is GNI per capita. Three categories were created based on countries' GNI per capita: low income, middle income (subdivided into lower middle and upper middle), and high income. The low-income and middle-income countries are sometimes referred to as developing economies.[106] The intention of using these terms is merely for convenience "not to imply that all economies in the group are experiencing similar development or that other economies have reached a preferred or final stage of development."[107] Such classification by GNI does not necessarily reflect a country's development level, but it does affect the countries' eligibility in getting loans from the International Bank for Reconstruction and Development (IBRD). While among institutions, GNI per capita is often used to identify a country's development status. And the most important, GNI per capita, does not reflect real welfare levels of the society, which requires a focus on the importance of public health, degree of civilization, environmental conditions, and the social and cultural needs of citizens. This is particularly important when "developing country" is employed as a concept in agreements dealing with environmental issues.[108]

Classification by income establishes a conventional (and probably the most common) means of understanding the phrase "developing country", yet it does not necessarily reflect ever aspect of development status. Different classification of nations can be found in numerous theoretical systems that in fact have diverse orientations. There are theories of

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world.

[106] "Economies are divided according to 2012 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, $1,035 or less; lower middle income, $1,036–$4,085; upper middle income, $4,086–$12,615; and high income, $12,616 or more." World Bank, 'World Bank Country and Lending Groups' (*The World Bank Website*) <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519> accessed 7 Jul 2017

[107] *Global Economic Prospects: Realizing the Development Promise of the Doha Agenda* (The International Bank for Reconstruction and Development and The World Bank, 2004)

[108] See for example: The Kyoto Protocol Article 2 (3) and Article 3 (14).

decolonization,[109] anti-imperialism,[110] liberation theology,[111] political economy[112] and Marxism.[113] However, these theories cannot be simply applied to development classifications. Take political economy as an example: studies on political economy mainly focus on a country's production and trade. Therefore, employing such a theory might classify countries that have large export volumes like China as developed countries. However, when considering the excessive labour resources and the labour-intensive means of production in the country, it becomes problematic. Another important factor that indicates level of development in a country is changes in different sectors attributing to the development. Some researchers emphasize the increased awareness and knowledge of investment in human capital (education, health, etc.) as indictor of identifying development status. For example, Schultz's research[114] into economic development, with particular consideration of the problems of developing countries, discovered that well educated farmers can be more productive than the under-educated ones. Mohammed Tamim,[115] concludes that developing countries are in the transition phase from a traditional way of living to the modern way of living ever since the Industrial Revolution in the nineteenth century; They are developing in different aspects such as social, economic, demographic, cultural transition, etc. and the importance of education levels in relation to development is highlighted.

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[109] David Fieldhouse, *The West and the Third World: trade, colonialism, dependence and development* (Wiley-Blackwell 1999).
[110] John Gallagher and Ronald Robinson, 'The Imperialism of Free Trade' (1953) 6 The Economic History Review 1.
[111] Eddy Muskus, 'Liberation Theology: Its Origins And Early Development' in Rev Dr Eryl Davies MA BD (ed), *Foundations: A Journal of Evangelical Theology* (British Evangelical Council 2015)
[112] Erik Gartzke and Dominic Rohner, 'The Political Economy of Imperialism, Decolonization and Development' (2011) 41 British Journal of Political Science 525.
[113] Immanuel Wallerstein, *The Capitalist World-Economy*, vol 2 (Cambridge University Press 1979).
[114] Theodore W. Schultz, *The Economic Value of Education* (Columbia University Press 1963).
[115] Mohammed Tamim, *Le Spectre du Tiers-monde: L'éducation Pour le Développement* (Editions L'Harmattan 2002).

Relatively recently, a set of new measurements was included in a UN Development Programme's Human Development Report: the Human Development Index.[116] This is a fresh means of measuring well-being, including "life expectancy, literacy, education, standards of living, and quality of life for countries worldwide."[117] This is useful to measure the impact of economic policies on quality of life. The Index was established to shift the focus on "human well-being rather than popular income-centric measures like GDP per capita."[118] Four categories were developed to divide countries according to human development: very high human development, high human development, medium human development and low human development.[119] The later three categories are considered to be developing groups and the "very high human development" represents developed countries in some way. Interestingly, 32 countries[120] classified as high income by the World Bank, such as Russia, fall outside the very high Human Development list. This is attributed to the human well-being perspective taken by the Index.

In the context of TT, indicators to be used when defining developing countries could be further differentiated from the aforementioned ways of interpreting. For example, when the Montreal Protocol deals with parties' application to be listed as a developing country

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116 United Nations, *2013 Human Development Report* (United Nations Development Programme 2013, 2013).

117 Golam Kibira, 'Mining: Friend or Foe? Economic, Environmental and Social Impacts- An Overview' Science & Technology Article 35, 13 March 2013 <http://www.sydneybashi-bangla.com/Articles/GolamKibria_Mining_Friend%20or%20Foe.%20Economic_Environmental%20and%20Social%20impacts_An%20overview_11%20March%202013%20%5Bsent%5D.pdf> accessed Feburary 2017.

118 "The Human Development Index is calculated using various indicators for quality of life, such as health indicators and access to healthcare services, life expectancy at birth, nutrition levels, education and literacy levels, access to basic needs such as water and sanitation, and so on. It also takes into account GDP per capita in terms of Purchasing Power Parity and percentage of the population living below the poverty line." Ian Graham, 'Human Development Index' (*NationMaster Website*, 23 Feb 2005) <http://www.nationmaster.com/country-info/stats/Economy/Human-Development-Index> accessed 7 Jun 2017.

119 "Countries high on the Human Development Index tend to have annual population growth rates of 1 percent or less, high urban population percentages (65 percent and up) and balanced percentages of people under 15 and over 65 years of age. Those low on the index tend to have annual population growth rates of 1.5 percent or higher, less than 35 percent of the population in urban areas, and an under-15 population that greatly outnumbers those above 65 years (in most cases, more than 10 times as many.)" See ibid.

120 Aruba, Antigua and Barbuda, The Bahamas, Bahrian, Bermuda, Cayman Islands, Channel Islands, Curaçao, Faroe Islands, French Polynesia, Greenland, Guam, Isle of Man, Kuwait, Latvia, Monaco, New Caledonia, Northern Mariana, Islands, Oman,

operating under Article 5 of the Protocol, as well as considering the countries' classification as a developing country by the World Bank and the UN Development Program, the Meeting of the Parties also takes into account the difficulty of its economic situation and its low per capita consumption of ozone-depleting substances listed under Annex A.[121] The UNFCCC, as by far the most successful environmental agreement "divides countries into three main groups[122] according to differing commitments."[123] Countries listed under Annex II are generally industrialized countries included by the OECD, leaving out the members that are in their transition period.[124] The Annex II countries are imposed on with more obligations requiring them "to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change."[125] Such requirements include the responsibility to promote TT regarding environmental protection as well, through capital donations and other actions. In a sense, it represents the way that the UNFCCC's definition of a developing country consists of their economic development level and their vulnerability[126] to climate change.

So far, the most commonly employed criterion relies basically on the countries' economic level, classifying states into developed or developing countries. However, it does not take account of technological capacities. If based on empirical evidence, it is possible to distinguish

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[121] See for example Decision XIV/2: Application by Armenia for developing country status under the Montreal Protocol, adopted at the14th Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, 29th November, 2002

[122] Annex I, Annex II and non-Annex Countries

[123] UNFCCC, 'Parties and Observers' (*United Nations Framework Convention on Climate Change Website*) <http://unfccc.int/parties_and_observers/items/2704.php> accessed Feburary 2017

[124] Including the Russian Federation, the Baltic States, and several Central and Eastern European States.

[125] UNFCCC (n 123).

[126] for example Non-Annex I Parties under the UNFCCC "are mostly developing countries. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer." Ibid

between nations that have substantial scientific and technological capability from those which have not. Thus, it is important to consider the level of development of a country's independent technological capability as a parameter when classifying countries a research that studies justification for international TT. Patent growth seems the most straightforward mechanism to be used as a variable to examine the technology capacity development of a country. For example, the number of patent holders in the "BRIC" countries (Brazil, Russia, India and China) grew by 33 per cent from 1998 to 2008, with almost all of that growth occurring in China.[127] Growth in the number of patents registered, in theory, could indicate better technological development in a country with a greater capacity of receiving international TT as well as in independent technology development. For example, China has predicted that the number of Patent Cooperation Treaty (PCT)[128] patent applications in the country will increase to 60,000 by 2020.[129] Accordingly, the export volume of IP royalties will rise to 10 billion USD during the period of 2016–2020.[130] In three years, the amount of IP-pledge financing for one year will increase to 180 billion Yuan.[131] In fact, in 2014 Chinese patent office "received 928,000 invention patent applications, began ranking top in the world, accounting for 34 per cent of total world applications."[132] From this aspect, it is hard to identify China as a developing country, technology-wise.

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[127] Copenhagen Economics and The IPR Company, *Are IPR a Barrier to the Transfer of Climate Change Technology* (Copenhagen Economics Informed Decisions, 2009). Quoted by Kiel Downey, 'Intellectual Property Rights and Renewable Energy Technology Transfer in China' (2012) 9 SCJ Int'l L & Bus 89.
[128] Patent Cooperation Treaty, June 19, 1970, 28 U.S.T. 7645, 1160 U.N.T.S. 231.
[129] PTI, 'China to strengthen protection of intellectual property rights' *The Economic Times* (Bejing, Jan 17, 2017) <http://economictimes.indiatimes.com/articleshow/56619524.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst> .
[130] Ibid.
[131] SIPO, 'Indexes of IP Protection and Utilization in the 13th Five-year Plan Period' (*State Intellectual Property Office of The P.R.C* 2017-01-25) <http://english.sipo.gov.cn/specialtopic/number/201701/t20170125_1308117.html> .
[132] China IP News, 'WIPO Report: China Driving Growth in Global Patent Filings Rise' (*China Council for the Promotion and International Trade*, 01/07/2016) <http://en.ccpit.org/info/info_40288117521acbb801521b46c1f10010.html> .

Interestingly, in the thirteenth five-year plan index, China revealed that invention patent ownership will increase to 12 per 10,000 people.[133] This indicates that the Chinese government has taken patent applications by population together as a parameter to analyze its technology capacity. Based on the 2012 data provided by the European Patent Office, Joff Wild has made a table based on population and number of patent applications that shows how ranking has changed among countries from the top 50 countries of origin according to their total number of applications.[134] Ranking fourth in the top 50 list, China's position has dropped to the nineteenth, adding the population variable. This reminds us of the limitations of using patent application numbers as a criterion to classify countries' development levels. More factors need to be taken into consideration. For example, countries that have well-built R & D systems[135] and produce technologies on a regular basis, independently, are to be considered as developed. Countries that have the potential to attract R & D investment and product availability, with significant innovative/imitative/duplicative capacities but with less most advanced technologies such as Brazil, China, India and South Africa, are in a less-developed class. Those who have no such strengths at all and thus entirely depending on foreign assistance fall into a third group of the least developed. In addition, a country's economic development status as a whole does not represent the technology-development level of each industry in that country.[136] Recognizing what technology-development stage a country is at will help in developing a new criterion enabling nations to be properly defined as

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133 Xinhua, 'China Issues Plan to Develop Intellectual Property' *China Daily* (Beijing, Jan 13, 2017) <http://www.chinadaily.com.cn/china/2017-01/13/content_27950209.htm> .

134 Joff Wild, 'Forget the US, When it Comes to Patents per Person Switzerland Rules the Roost in Europe' (*IAM*, Jan-13, 2017) <http://www.iam-media.com/blog/detail.aspx?g=3cadcdf9-c6e7-47a2-84b0-7ca8f4e884ea> accessed 9 Mar 2017.

135 See data provided by Oecd Publishing, OECD Science, Technology and Industry Outlook 2010 (OECD Pub. 2010).

136 See detail discussion in later chapter on Climate Change Technology Transfer to China

developing countries in specific TT-related cases. The most widely used development criteria are based on income of citizen, which do not look at the technology capacity of a country. Therefore they do not distinguish between countries that have the ability to receive and output technologies from those that do not. In fact, countries classified differently according to their technology-development level should not theoretically have the same responsibility for promoting TT. The upper class should engage themselves in attracting TT as well as exporting technologies and experience to others. The lower class should be given more assistance related to capacity building with institutional and management guidance provided at an international level. This is practically feasible now, according to recent research.[137] At the end of the day, no matter what means of classification is applied, where a nation lies along the spectrum of "development" does have an effect on determining its sense of what responsibility is to be borne and how to achieve sustainable development in the future.

3.6 Sustainable development

As environmental derogation accelerates, the importance of a more balanced way of development magnifies. This originated from decolonization, beginning in earnest in the late 1950s and reaching its high point in the 1960s.[138] It occurred at the same point from the 1960s onwards as an increasing perception that the efforts of developing countries for sustained economic growth threatened both to exacerbate the environmental damage already being wrought by developed nations' activities and to conflict with the desire for environmental protection that has emerged as a major political issue globally in the past five

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[137] OECD, *Measuring R&D in Developing Countries: Annex to the Frascati Manual* (An Annex to the Frascati Manual, OECD DSTI/EAS/STP/NESTI(2011)5/FINAL, 2011).
[138] John Darwin, *The End of the British Empire: The Historical Debate* (Wiley-Blackwell 1991).

decades.[139] Although some concerns for environmental protection in developing countries are generated by developed countries either through altruistic motives or to hinder the development path of developing countries, it has resulted in a strong call for a sustainable way of development, as it is now widely believed that adverse effects will occur if nothing is done today.

There are many definitions of sustainable development, some in the narrow sense are directly linked to increasing household income[140] and more comprehensive ones are about "achieving a group of objectives for poor people including better educational and job opportunities, greater gender equality, better health and nutrition, the protection of the environment, natural resources and biodiversity."[141] The most famous is the Brundtland's definition, which stated "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[142] This definition emphasized the needs of the poorer countries to which overriding priority should be given. Moreover, the concept of needs includes needs of the present and future which are also to be assessed and valued by any international cooperation. It is, at least to some extent, a progression in identifying the special needs of developing countries but is still vague because it is far from enough to answer further related questions. For example, what are the needs of the present? Are there any needs that conflict with one another? If clean air is required, might it conflict with the growth of some industry that is still depending on an energy-intensive

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[139] Colin M. Alberts, 'Technology Transfer and Its Role in International Environmental Law: A Structural Dilemma' (1992) 6 Harv JL & Tech 63.

[140] Vinod Thomas and others, *The Quality of Growth* (Washington, D.C. : The World Bank. 2000) p.23.

[141] D. Narayan-Parker and R. Patel, *Voices of the Poor: Can Anyone Hear Us?*, vol 1 (Oxford University Press for the World Bank 2000) Chapter 2 Definiation of Poverty.

[142] The Brundtaland's definition, United Nations, *Report of the World Commission on Environment and Development* (General Assembly 96th plenary meeting, 11 December 1987, UN Doc A/RES/42/187, 1987).

approach to manufacturing? How would decisions made by a community or government about these conflicts reflect how they value these different interests? The situation gets even more complex when one country’s needs conflict with another’s: for example, when one country’s need for energy results in acid rain that damages another country's water recourses. Such a situation raises another question about how to decide whose needs are met? Is it more important to meet the needs of the poor or the rich, the people in one country or another, this generation or the next generation? Whose needs should be prioritized when there has to be a trade-off? With all of the unanswered questions, the Brundtland's definition is argued to be unclear. But the Brundtland definition is only a starting point for a principle to guide action. Therefore it is too much to ask for it to articulated further. Policymakers at the global, national and local level use sustainable development to establish more specific policy goals, targets and projects. No matter what context it is used in, meeting the needs of the future is essential and it possibly depends on how well objectives are balanced when making decisions today. Such objectives consist of social, economic, environmental goals, and so on, involving factors that conflict with one and another. For instance, a need to improve people’s living standard by pursuing industrial growth might conflict with preserving natural resources. However, in considering the future growth in industries, a responsible use of natural resources is needed from the present leaving enough for the later decades. The only difficulty is taking reasonable consideration of conflicts into planning.

In 2002, the Johannesburg Declaration on Sustainable Development[143] was adopted at the World Summit on Sustainable Development (WSSD). The Declaration made clear that "achieving the goal of sustainable development would require addressing the significant differences among the participating countries, with sensitivity to equity, poverty, and stages of development."[144] Article 11 of the Declaration[145] recognizes that "poverty eradication, changing consumption and production patterns and protecting and managing the natural resource base for economic and social development are overarching objectives of and essential requirements for sustainable development." At the same time, Article 18 of the Declaration calls for cooperative work

> to help one (country) another gain access to financial resources, benefit from the opening of markets, ensure capacity- building, use modern technology to bring about development and make sure that there is technology transfer, human resource development, education and training to banish underdevelopment forever.

This Article makes direct reference to TT in pursuing sustainable development. The summit agrees that the adverse effects of climate change are already evident[146] and encourages developed countries to offer all kinds of assistance in the implementation of sustainable development.[147] With the sustainable development goal adopted widely by countries in making national policies and negotiating in international agreements, TT is justified as an effective aid to the achievement of such a goal.

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143 Johannesburg Declaration on Sustainable Development, World Summit on Sustainable Development, 4 September 2002, UN Doc A/CONF.199/20

144 United Nations, The Road from Johannesburg: World Submit on Sustainable Development: What was Achieved and the Way Forward, quoted by Osofsky (n 87).

145 The Johannesburg Declaration (n 143), Chapter 1, Resolution 1.

146 Ibid Article 13.

147 Ibid Article 22.

3.7 Technology transfer impediments

There still exist many impediments that may hinder TT. In the 1970s, based on the awareness of the importance of technology, developing countries launches a series of actions aimed at rebalancing the gap that led to the old colonies falling behind Western economies.[148] And that is when TT impediments started to become serious. During that time, in line with the Declaration for the Establishment of the NIEO[149] adopted by the UN General Assembly in 1974, the International Code of Conduct on the Transfer of Technology[150] was established in 1977 of and under the guidance of the UNCTAD. The intention of the Code was to regulate international TTs by eliminating the problematic clauses in TT contracts that will harm economic development of developing countries. For example, during the licensing period, if grant-back provisions are employed in a licensing agreement, they will require the licensee to disclose and transfer all improvements made to the licensed technology. Such a provision deprived the transferee parties from enjoying the fruits of their independent innovations. Other resorts like exclusive dealing[151] are frequently used in TT contracts. It requires a supplier to sell their goods only through a particular retail or wholesale outlet within a particular region. Thus the transferor company is able to directly or indirectly manipulate the price and sales volumes. Likewise, there was collusion among competitors to control the market, called price-fixing.[152] Such behaviour will affect product selling by unifying price and discounts according to order quantities, qualities, or types. Every change made to the sale will

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[148] Peter K. Yu, 'A Tale of Two Development Agendas' (2009) 35 Ohio NUL Rev 465.
[149] The New International Economic Order (n 3). For a retrospective analysis of the effects of the Declaration, see UNCTAD, 'Transfer of Technology' (n 37).
[150] International Code of Conduct on the Transfer of Technology, United Nations General Assembly, 17 December 1985, UN Doc A/RES/40/184.
[151] 'Exclusive Dealing' (*BusinessDictionary*) <http://www.businessdictionary.com/definition/exclusive-dealing.html> accessed 11 Jun 2017.
[152] 'Price Fixing' (*BusinessDictionary*) <http://www.businessdictionary.com/definition/price-fixing.html> accessed 11 Jun 2017.

have to be agreed among colluders.[153] The appearance of such harmful clauses that needed to be regulated or forbidden revealed the fears of technology owners and the tense relations between transferor and transferee. Unfortunately, the late 1970s and early 1980s economic recession has diminished support for the Code and in 1985, negotiations over the issue finally stopped.[154] But these harmful clauses could impede green TT nowadays and still have to be considered in everyday business and future MEA practice.

3.8 Concluding and bridging

A historical view recognizes that TT has been an important need in the past and it remains so today, as it is a crucial aid for developing countries to improve the welfare of citizens and to narrow the technology gap between them and the more developed nations. Having reviewed the different definitions of TT, this thesis took a lens to look at it with full consideration of the crisis of climate change, therefore, focus on technologies that are environmentally sound. In such a context, where climate change is viewed as a global issue, the responsibility for resolving the problem must also be globally distributed. In deciding on differentiated responsibilities, and what exactly is meant by developing countries, the author choses the definition employed by MEAs and suggests that such decision should reflect a country's technology level as well. As ideal as this idea is, the actualization of it depends on the prominence of international cooperation. In the following chapter, MEAs, especially the most important, UNFCCC, will be studied and its function and future will be looked at in a more detail.

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[153] Walter B. Erickson, 'Economics of price fixing' (1968) 2 Antitrust L & Econ Rev 83.

[154] "The activist developing countries' legislation, which had inspired numerous provisions in the draft code, was called into question by the countries' own lawmakers and subsequently amended to reflect new economic realities. These trends, which became evident in the early eighties, led most developing countries to lose interest in the code effort." Susan K. Sell, *Power and Ideas: North-South Politics of Intellectual Property and Antitrust* (SUNY Press 1998).

Chapter IV: Climate Change TT and International Cooperation

4.1 Introduction

The need for TT has never been more important than now as a result of the global goal to confront the crisis of climate change. There has been an increasing amount of evidence of climate change and its damage confirmed in the last two decades, such as the shrinking of the ice sheets in the Arctic and increases in extreme weather.[1] In addition, there is a growing awareness that the increasing national and international environmental problems, including global warming, are anthropogenic.[2] Fortunately, some argue that the advancement of technology is limitless and can solve all the consequences of manmade environmental damage.[3] Some even believe that there are already enough technologies now to confront climate change.[4] This is overly optimistic, as it is almost impossible to estimate the damage of climate change precisely due to the difficulties in finding counterfactuals during assessment in the first place.[5] Ideally, it should offset environmental deterioration at some point with green-tech – the primary means of addressing these problems – being adopted by the majority of countries. Turning that vision into a practical reality is not easy and requires lots of effort and international cooperation. There is a growing realization that the distinction between national and international environmental problems is more and more blurred;[6] and

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1 IPCC, *Climate Change 2007: The Physical Science Basis* (Contribution of Working Group I to the Fourth Assessment Report, approved at the 10th Session of Working Group I of Intergovernmental Panel on Climate Change (IPCC), Paris, February 2007, 2007).
2 Peter H. Sand, 'Lessons Learned in Global Environmental Governance' (1990) 18 BC Envtl Aff L Rev 213.
3 James E. Krier and Clayton P. Gillette, 'The Un-Easy Case for Technological Optimism' (1985) 84 Michigan Law Review 405.
4 For example, Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière, 'What Drives the International Transfer of Climate Change Mitigation Technologies? Empirical Evidence from Patent Data' (2013) 54 Environmental and Resource Economics 161.
5 Even if a counterfactual is found, to fully account for the possibilities that may develop in the future is difficult. The progress of adaptation to climate change is unpredictable, and it is also difficult to fully understand new future global states because adapting to climate change requires a long time perspective. Thomas Sterner, 'Climate Change & Developing Countries: Considerations for Rio+20' Resources for the Future Issue 180 Spring/Summer 2012, (Jun 8, 2012) <http://www.rff.org/research/publications/climate-change-developing-countries-considerations-rio20> accessed 14 Jul 2017.
6 Sand (n 2).

a reluctance to transfer climate change technologies could result in climate change problems being suffered by the whole world. Thus, to address the global import of environmental challenges and this global warming crisis, it is not enough to rely on the limitless[7] technological advances but also a disinterested and radical attitude towards TT without reservation.

4.2 Climate change related technology transfer

Green technology is a general term used in describing climate-change-related technologies and referring to "technology whose use is intended to mitigate or reverse the effects of human activity on the environment."[8] This definition indicates that it goes back in the history and will continue being a significant subject in the future. For example, as far back as 1000 BC, "Asia and Europe began harnessing and advancing wind energy, developing more efficient and newer windmills."[9] Such idea was introduced to the America in the 1850s and widely applied to irrigation and providing water for livestock. During the late-nineteenth century, the first wind power turbine that generated electricity was invented in the US.[10] This is one of the early cases that can be referred to as a green technology example. Nowadays it is seemingly beyond doubt that the issue of TT is taken seriously within the international climate change debate. However, this term is mostly used in a colloquial way by commentators and policymakers and results in the problem that there exists no unified definition of green

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[7] We do not know if there are 'limitless' technologies. Not every problem can be solved by technology. There are many who believe the 'belief' in scientific fixes prevents nations addressing the problems which cause the environmental problems in the first place (e.g. consumption). See also Yoon-Suk Baik, 'An Empirical Study of Patent Disclosure' KAIST Business School Working Paper Series No 2006-003 (May 2006) <https://ssrn.com/abstract=903689> accessed 9 Jun 2017.

[8] 'Definition of green technology in English' (*The Oxford Dictionaries Website*) <https://en.oxforddictionaries.com/definition/green_technology> accessed 2 Sep 2017.

[9] 'Green Technology – Past, Present, Future' (*StudyModeResearch Website*) <http://www.studymode.com/essays/Green-Technology-Past-Present-Future-472128.html> accessed 8 Sep 2017.

[10] Robert W. Righter, *Wind energy in America: A history* (University of Oklahoma Press 1996).

technology. Therefore in actual TT, the term "green technology" is rarely used due to the lack of a common and precise understanding of the length and breadth of the concepts.

4.2.1 The Meaning of EST

The most commonly used definition of climate change technology is that of ESTs. The term was coined in Agenda 21, Chapter 34,[11] which was written at the Earth Summit. Since then, no undisputed contribution has been made to develop the outlines of this concept further.[12] A Special Report of the IPCC[13] defines ESTs as

> technologies which protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, handle residual wastes in a more acceptable manner than the technologies for which they were substitutes, and are compatible with nationally determined socio-economic, cultural and environmental priorities.[14]

Moreover, "ESTs are not just individual technologies. They can also be defined as total systems that include know-how, procedures, goods and services, and equipment, as well as organizational and managerial procedures for promoting environmental sustainability."[15] The concept is broad enough to cover the types of technology considered in this research.

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[11] Agenda 21: Programme of Action for Sustainable Development, U.N. GAOR, 46th Sess., Agenda Item 21, UN Doc A/Conf.151/26 (1992). Earth Summit: "ESTs as technologies which 'protect the environment; are less polluting; use all resources in a more sustainable manner; recycle more of their wastes and products; and handle residual wastes in a more acceptable manner than the technologies for which they are substitutes'"

[12] Jérôme de Meeûs and Alain Strowel, 'Climate Change and the Debate around Green Technology Transfer and Patent Rules: History, Prospect and Unresolved Issues' 3 WIPOJ 178.

[13] IPCC, 'Summary for Policymakers' in Bert Metz and others (eds), *Methodological and Technological Issues in Technology Transfer: A Special Report of IPCC Working Group III* (Cambridge University Press 2000) 432.

[14] UNFCCC, *Application of Environmentally Sound Technologies for Adaptation to Climate Change* (United Nations Framework Convention on Climate Change (UNFCCC), Technical Paper, FCCC/TP/2006/2, 10 May 2006).

[15] Agenda 21.

However, the problem remains at the outset in finding out what technologies should be included by the definition.

4.2.2 Environmental or economic motivations for TT

Typically, it is thought that technologies that are irrelevant to environmental protection should not go into the definition. However, in practice, distinguishing between them is not a straightforward job. In order to include as many types of green technology as possible and to promote the widest application of these technologies, it is better not to exclude the seemingly "less green" technologies from the definition of EST. Firstly, it is more practical to avoid distinguishing ESTs according to the motivation behind them because environmental goods and services can be dual-motivated by environmental concerns as well as economic profit. This characteristic is intrinsic to many kinds of cleaner technologies. For example, unlike many expensive green technologies,[16] employing certain technologies can be cheaper than following more polluting ways. Such as in the chemical industry, "the use of mixers to reduce sludge formation in storage vessels; leak detection; cleaning heat exchange tubes; and better reaction control to eliminate hot and cold spots or to speed reaction can be more economical than the traditional end-of-pipe measures."[17] Moreover, "since pollution is managed here as another kind of resource use, reducing the costs of (polluting) resources will be factored in along with the costs of other resources."[18] Another more straightforward example is that the "Brazilian production of biofuel from sugarcane is already cheaper than other existing energy

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[16] For example, the application of smart-grid technologies requires a considerable amount of investment in acquiring technology, get access to ancillary technologies and significant construction accomplished (i.e. cable laying)

[17] Cristina Tébar Less and Steven McMillan, 'Achieving the Successful Transfer of Environmentally Sound Technologies: Trade-Related Aspects' OECD Trade and Environment Working Paper No 2005-02, COM/ENV/TD(2004)33/FINAL <http://www.oecd.org/trade/envtrade/35837552.pdf> accessed Feburary 2017.

[18] OECD, *Environmental Goods and Services* (OECD Publishing, Paris 2001).

sources such as petroleum."[19] In cases like this, it is hard to distinguish environmentally motivated efforts from the economically motivated ones.[20] Accordingly, it is difficult for those governing TT and those seeking TT agreements to exclude the use of more economically motivated technology from any favourable policy made primarily to facilitate usage of ESTs in order to offset the disadvantages of often more costly green productivity. In theory, if the application of a greener technology were cheaper than the more polluting ones, transferring of such technology would benefit the transferor as well. Thus, the issue is perhaps not whether we can distinguish economic or environmental motives, but whether TT motivated by economic benefits to the transferor or even the transferee should be wrapped up in TT designed to improve the environment or reduce environmental ill effects. The answer is positive. It does not really matter if the transferor gets financial benefits as long as the transferee is able to address their environmental problems or their contribution to environmental problems. But it is also clear that if the transferors are gaining reasonable profits, it is feasible to ask them to sacrifice part of their IPRs for returns.

4.2.3 A pollutant standard

Second of all, although green technology conserves traditional resources, some can still be pollutant to the environment. Therefore, it is better not to deny a technology rashly because of its minor polluting character. For example, the innovation and widespread use of ethanol fuels as an alternative to gasoline in recent years is an effort to reduce reliance on

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[19] Although it might have other environmental costs; see John H Barton, 'Mitigating Climate Change Through Technology Transfer: Addressing the Needs of Developing Countries' Energy, Environment and Development Programme: Programme Paper 08/02, (October 2008) <https://www.chathamhouse.org/sites/files/chathamhouse/public/Research/Energy,%20Environment%20and%20Development/1008barton.pdf> accessed 22 Aug 2017.

[20] Less and McMillan (n 17)

non-renewable natural resources. While these fuels are intended to reduce carbon emissions caused by the gasoline used in vehicles, they may have unintentionally caused the opposite effect.[21] For example, the most debatable ethanol fuel – E85 could release more toxic substances[22] into the atmosphere than traditional fuel, which can, in turn, impact health.[23] Another example is wind power technology: although seen as clean and renewable, wind farms are believed to have an adverse impact on the local environment.[24] For example, wind turbines generate a low-frequency noise similar to a family car travelling at 70 mph, causing noise pollution.[25] Countries are therefore requiring wind farms to be built far from residential areas. While remote site-selecting can solve noise pollution, the location of wind farms in rural areas can create a threat to wildlife. "Birds[26] have a tendency to fly into the wind blades," with studies[27] showing that "about 45,000 birds having perished over the last 20 years due to these turbines."[28] Also, the foundations of a wind turbine that go deep into the Earth could have a negative effect on underground water.[29] However, most ethanol fuels and wind energy are ultimately less polluting and many countries are still showing keen interest in these technologies irrespective of negative perceptions. They believe, at least for now, that it is the option that delivers most good (or least harm) to the environment.

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[21] Their environmental damage is different to gasoline (e.g. development of monocultures in previous biodiverse environments). Rebecca Lake, 'What Are the Disadvantages of Going Green?' (*LiveStrong.com*, Jun 13, 2017) <http://www.livestrong.com/article/148998-ten-reasons-why-we-should-go-green/> .

[22] "The statistical analysis suggests that the use of E85 results in statistically significant decreases in emissions of NOX (−45%), NMHC (−48%), 1,3-butadiene (−77%), and benzene (−76%); statistically significant increases in emissions of formaldehyde (73%) and acetaldehyde (2540%), and no statistically significant change in CO, CO2, and NMOG emissions." Lisa A. Graham, Sheri L. Belisle and Cara-Lynn Baas, 'Emissions from Light Duty Gasoline Vehicles Operating on Low blend Ethanol Gasoline and E85' (2008) 42 Atmospheric Environment 4498.

[23] Mark Z. Jacobson, 'Effects of Ethanol (E85) versus Gasoline Vehicles on Cancer and Mortality in the United States' (2007) 41 Environmental Science & Technology 4150.

[24] See generally, R. Saidur and others, 'Environmental Impact of Wind Energy' (2011) 15 Renewable and Sustainable Energy Reviews 2423.

[25] Rinkesh, 'Various Disadvantages of Wind Energy' (*Conserve Energy Future*) <http://www.conserve-energy-future.com/Disadvantages_WindEnergy.php> .

[26] Especially the migrating breeds such as gold eagles and tailed hawks.

[27] See generally, Saidur and others (n 24).

[28] Rinkesh (n 25).

[29] Information gathered from research interviewees.

4.2.4 Adaptation and mitigation technology

In addition, climate change technology also encompasses technologies for promoting mitigation and adaptation[30] to climate change. While such a dichotomy demonstrates a clear difference between them. Mitigation focuses on slowing climate change while adaptation deals with the effects of climate change.[31] Both types of measures are considered to be complementary and critical to technological improvement.[32] First, climate change mitigation technology refers to:

> technological change and substitution that reduce energy resource inputs and emissions per unit of output. Although several social, economic and technological policies would also lead to an emissions reduction, for climate change mitigation encompasses implementing policies to reduce GHG emissions and to enhance sinks.[33]

This technology type covers a vast range of sectors including "energy supply, transport, buildings, agriculture, forestry, and waste management."[34] Renewable technologies for electricity production have been the typical examples of the mitigation type.[35]

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30 Meeûs and Strowel (n 12).

31 Preeti Soni and others, 'Technological Cooperation and Climate Change Issues and Perspectives' Working papers presented at the Ministry of Environment and Forests, Government of India-UNDP Consiltation on Technology Cooperation for Addressing Climate Change, 24th September, 2011 <http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Climate%20Change/climate_change_report_30-11-2011.pdf> accessed August, 2017.

32 The definitions is given by the Intergovernmental Panel for Climate Change (IPCC), IPCC, *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007* (B. Metz and others eds, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA 2007).

33 Ibid.

34 For a list of key mitigation technologies see IPCC, 'Summary for Policymakers' in B. Metz and others (eds), *Climate Change 2007: Mitigation Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA 2007).

35 Moreover, based on a long history of TT, there are now major industries producing both wind and photovoltaic electricity that have firms from developing countries competing head-to-head with the traditional industrial leaders from developed countries. See John H. Barton, 'Intellectual Property and Access to Clean Energy Technologies in Developing Countries' (2007) ICTSD Issue Paper No 2.

Adaptation, according to a UNFCCC paper, shall not be considered as an alternative to climate change mitigation as both need to be pursued actively and in parallel.[36] Mitigation is obviously essential because, "without firm action now, future generations could be confronted with climate change consequences."[37] If climate change is not controlled here and now, the magnitude of its effects could be so severe that no adaptation will be able to make a difference. But due to the temporal hysteresis in the response of environment pollution to climate change, it is hard to predict precisely the result of today's mitigation. In case the efforts made are not enough on their own, adaptation will be needed inevitably. That is the main reason why mitigation is essential and why adaptation is inevitable.

Adaptation technology concerns:

> Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished,[38] including anticipatory and reactive adaptation.[39]

For example, building up a climate change early-warning system[40] could be classified as anticipatory adaptation, and technology for enhancing gas-pipeline efficiency is a reactive adaptation. The problem with the reactive type is that it only starts after the impacts of

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36 UNFCCC, *Technologies for Adaptation To Climate Change* (Peter Stalker ed, Climate Change Secretariat (UNFCCC) Bonn, germany 2006).
37 Ibid.
38 IPCC, *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007* (n 32).
39 Ibid (n 32),
40 Such Systems are generally aiming at improving capacity for predicting climate hazard and warning people live in the local area. "These systems effectively generate and communicate impact-based early warnings, delivering risk information for hazardous hydro-meteorological and climate events. They protect lives, livelihoods, and property in more than 50 Least Developed Countries (LDCs) and Small Island Developing States (SIDS)." Lima-Paris Action Agenda, 'Climate Risk and Early Warning Systems Initiative Strengthening Systems at the Heart of Resilience' (*UNFCCC newsroom*) <http://newsroom.unfccc.int/lpaa/resilience/climate-risk-and-early-warning-systems-initiative-strengthening-the-systems-at-the-heart-of-resilience/> accessed July 2017.

climate change have been felt. Therefore, the shortcoming of such technologies is that they are normally slow in effect on climate change mitigation. However, they are particularly valuable when reacting to extreme events and disasters. For example, the flood control plan to relocate settlements to higher ground is the reaction by the government to the 2000 flood, which effectively prevented the 2008 flooding of the same areas along the Limpopo River floodplains in Southern Africa. Such measures and corresponding techniques based on climate change experiences can reduce the impact of events and disasters in the future.[41] Technologies such as new irrigation systems or drought-resistant seeds, or even more intangible measures such as insurance schemes or crop rotation patterns could be of equal importance to renewable energy technologies in different scenarios.[42]

4.2.5 Hard and soft technology

The term EST shall also be interpreted with no prejudice shown to either hard or soft technologies as they are the integral parts of the commercialization and industrialization of climate change technologies.[43] According to Jin, "*hard* refers to the tangible entity upon which an operation is conducted. *Soft* refers to an entity without physical form."[44] "Examples of hard technologies include equipment and products to control, reduce or prevent anthropogenic emissions of greenhouse gases in the energy, transportation, forestry, agriculture, industry and waste management sectors, to enhance removals by sinks and to

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[41] The Climate System Analysis Group, 'Climate Change Adaptation' (*University of Cape Website*) <http://media.csag.uct.ac.za/faq/qa_5adaptation.html> accessed 2 Jul 2017.

[42] UNFCCC, *Technologies for Adaptation To Climate Change* (n 36).

[43] IPCC, *Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change* (Bert Metz and others eds, Cambridge University Press 2000) ch.1.2.

[44] Zhouying Jin, 'Technological Progress in History: A Survey of Evolution and Shift of Research Emphasis from 'Hard-tech' to 'Soft-tech' Development' (2004) 3 International Journal of Technology Management & Sustainable Development 133; See also Zhouying Jin, 'Soft Technology: The Essential of Innovation' Futures Research Quarterly <http://millennium-project.org/millennium/beijing-0702.PDF>

facilitate adaptation,"[45] while soft technologies include things like "capacity building, information networks, training and research."[46] According to this definition, it is hard to turn an acquired blueprint[47] into products and to occupy market share without employing a combination of hard and soft technologies. The process of TT receiving: from patent/technology acquisition to conversion, commercialization, and finally industrialization, requires a serious amount of equipment to be purchased and services provided. Thus to facilitate TT until the subject technology is well adopted by the receiving market and society, soft technologies should be "injected and infused" into products and services imported from abroad in the first place.[48] Moreover, follow-on works including standardization, processing, and regularization during subsequent enterprise operation, strategizing and R & D investments to remain competitive shall be considered as examples of soft EST.[49] Even the softness of technology varies, as it depends on "the degree to which the orchestration of phenomena is actively performed by a human or humans."[50] As the percentage of unbreakable processes imposed decreases, either within human organizations or physical/virtual machines, the technology becomes softener. So, for example, some prescriptive industry standards are harder technologies compared with the assistance provided by transferors based on their practical experiences. TT is actually a continuum of the

[45] René van Berkel and Erik Arkesteijn, *Transfer of Environmentally Sound Technologies and Practices under the Climate Convention: Survey of Experiences, Needs and Opportunities among Non-Annex II Countries* (IVAM Environmental Research 1998).
[46] Ibid
[47] Which is often available from patent registry office.
[48] Jin, 'Technological Progress in History: A Survey of Evolution and Shift of Research Emphasis from 'Hard-tech' to 'Soft-tech' Development' (n 44); See also Jin, 'Soft Technology: The Essential of Innovation' (n 44).
[49] Jin, 'Technological Progress in History: A Survey of Evolution and Shift of Research Emphasis from 'Hard-tech' to 'Soft-tech' Development' (n 44); See also Jin, 'Soft Technology: The Essential of Innovation' (n 44).
[50] Jon Dron, 'The Nature of Technologies' (*MOOC.CA*, Nov 21, 2011) <http://change.mooc.ca/post/367> .

transaction of hard and soft technologies. Very few TTs are reliant on the transaction of purely hard or purely soft technologies.

4.2.6 The broadest definition

The intention of drawing a line between ESTs and non-ESTs is in fact to clarify which technologies can be promoted by MEAs and be transferred under favourable terms. Therefore, regardless of the variety and the contradictory characteristics, the definition of EST should endeavours to embrace technologies that become:

> more environmentally sound; captures the full life cycle flow of the material, energy and water in the production and consumption system; covers the full spectrum from basic technologies that are adjunct to the production and consumption system, to fully integrated technologies where the environmental technology is the production or consumption technology itself; includes closed system technologies (where the goal is zero waste and/or significant reductions in resource use), as well as environmental technologies that may result in emissions; and considers technology development within both the ecological and social context.[51]

These ESTs encompass technologies ranging from techniques for generating energy to establishing pollution management which will also evolve continuously. Methods that available for building industrial standards and environmental governance should also be considered as EST. Technologies that fall into the area of energy,[52] green building,[53] green

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[51] Agenda 21.

[52] "This includes the development of alternative fuels, new means of generating energy and energy efficiency." 'Green Technology- What is it?' (*Green Technology Atrategy and Leadership for Clean and Sustainable Communities*, 2015) <https://www.green-technology.org/what.htm> accessed July 2017.

[53] "Green building encompasses everything from the choice of building materials to where a building is located." Ibid.

chemistry,[54] and green nanotechnology[55] are ESTs in a more obvious way. And policies that regulate transferring these technologies should show respect and adapt to the particular needs of climate change TT irrespectively.[56] In my research, I will focus on one type of technology targeting the reduction of global carbon dioxide emissions – renewable energy technology. So, although there are many factors,[57] which are equally encountered by ESTs, they will not be discussed in this thesis with detail.

4.3 Methods of transfer

Regarding transferring ESTs, the WTO Committee on Trade and the Environment (CTE) identified four different methods:

> (1) a transaction involving only the supplier of technology, e.g. foreign direct investment in a wholly owned subsidiary; (2) a transaction involving only those in the host country who use the technology, e.g. the situation where the host country national copies the technology, including through reverse engineering; (3) a transaction involving both the supplier and user of technology, where specific commercial conditions are stipulated with regard to the use of the technology, and/or the sales or distribution of profits by the enterprise in the host country, e.g. technology licensing or a joint venture involving foreign direct investment; (4) a transaction involving both the supplier and user of technology, but without any commercial conditions stipulated regarding the operations,

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[54] "The invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances." Ibid.

[55] "Nanotechnology involves the manipulation of materials at the scale of the nanometre, one billionth of a meter. Some scientists believe that mastery of this subject is forthcoming that will transform the way that everything in the world is manufactured. "Green nanotechnology" is the application of green chemistry and green engineering principles to this field."Ibid.

[56] In terms of the motivation of TT, the impact on the environment of the technology, and their softness.

[57] For example, the biotechnology, agricultural and medicinal exploitation factors. Daniel Alexander, 'Some Schemes in Intellectual Property and the Environment' (1993) 2 Intellectal Property and Environment.

sale or distribution of profits by the enterprise using the technology (e.g. purchase of a machine in the market, which embodies the technology).[58]

However, not all of the listed methods are legally acceptable under the current IP law system. For example, the second type of transaction happens in the situation where the host country duplicates the technology, such as through reverse-engineering, regardless of legal rights acquired from the technology owner, is currently considered as IP infringement under most IP laws.[59] In practice, TT to developing countries with a certain absorptive capacity often involves different levels of illegal technology duplication concealed beneath a combination of legal types of transaction. Patent licensing is where a patentee has a legal right to "exclude others from making, using, offering for sale, or selling, or importing the invention."[60] However, in practice, "a patent licensing agreement is in essence nothing more than a promise by the licensor not to sue the licensee"[61] for using the technology. The actual result of adoption of the technology is not guaranteed. Therefore, in order to offset the crudity of the license by pursuing technology with full know-how related to its proper application and future innovation, technology acquisition through takeovers is becoming a common method

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58 WTO Council for Trade in Services, 'Environmental Services' World Trade Organization, S/C/W/46, 6 July 1998 <https://www.wto.org/english/tratop_e/serv_e/w46.doc> , para. 19.

59 For example, "in the U.S., Section 103(f) of the Digital Millennium Copyright Act (DMCA) (17 USC § 1201 (f) states that that it is legal to reverse engineer and circumvent the protection to achieve interoperability between computer programs." The law is similar in India and UK. "The UK's Copyright, Design and Patents Act 1998 expressly permits reverse-engineering in certain limited circumstances to encourage competition and better engineering among many other important things - not least of legally permitting UK small companies to produce products which can interoperate with other more established products." On the other hand the Chinese law is looser on such activities. "Article 12 of Interpretations of the Supreme People's Court on the Application of Laws in Trial of Civil Cases of Unfair Competition (Interpretations), which entered into force on February 1st, 2007, provides that trade secrets gain from independent development and reverse-engineering should not be deemed as a violation of the provisions of Article 10 (a), (b) of the Anti-Unfair Competition Law. "Reverse engineering" in the preceding paragraph refers relevant technical information obtain from demolishing, mapping and analyzing of a product gain from public sources by technical means. Parties that obtain trade secrets by improper means and then defend themselves with reverse engineering will not be supported." Anne Zhang, 'IP mysteries in reverse engineering' (*China Intellectual Property*, 27th August, 2013) <http://ipr.chinadaily.com.cn/2013-08/27/content_16961368.htm> accessed July 2017.

60 For example, Chapter 14 Issue of Patent, Section 154 (a) (1) of U.S. Patents Law, 35 U.S.C. §§ 1 et seq. (Public Law 103–465, as amended up to December 8, 1994) para.19.

61 Fiona Macmillan, 'The World Trade Organization, Intellectual Property and the Transfer of Environmentally Sound Technologies' (2001) 7 International Trade Law & Regulation, Int TLR 178.

among technology-receiving countries. This is currently the most efficient method to transfer technological know-how.

4.4 Technology transfer cooperation

Knowing the contents of climate change technology and how they can be transferred, extra effort needs to be put into enacting policies that lower costs and stimulate the dissemination of those technologies. Such actions are based on an epistemic assumption maintained by the global community – a basic faith and confidence in the ability of science and engineering to fix climate change problems. A passive argument made by Chow says that "we need to emit no more than one trillion tons of carbon in order to stand a good chance of limiting global warming to 2°C. Only the problem is that technology is not progressing fast enough to make this happen."[62] Another difficulty is that firms in the developed countries that produce such technologies may not wish to TT, as it may undermine the return on their R & D investment. However, equity[63] imposes an ethical duty on developed countries to promote transfer of these technologies. Slow technology development compared with environmental derogation is making climate change situation severe enough, and reluctant attitudes from technology holders cannot be used as an excuse for not making such efforts of TT.[64] Technology advances and TT were and will continue to be two of the most important issues in the international environmental order when the means to sustainable growth is considered. Indeed, all of the major UN General Assembly resolutions related to demands for a New

[62] Denise Chow, 'IPCC Report: Strongest Case Yet for Human-Caused Global Warming' (*LiveScience*, September 27, 2013) <http://www.livescience.com/39998-ipcc-climate-change-report.html> .

[63] See Chapter, section 3.4

[64] Indeed developing countries need to go beyond this at some point and encourage climate change technology rather than ralying on assistance from developed countries. Otherwise it might be a risk discourage private companies from developing the climate change combatting technology.

International Economic Order include references to the TT.[65] In implementing such an objective, there are numerous types of interactions through which stakeholders may work in order to TT including, among others: direct purchases, licensing franchising, direct foreign investment, subcontracting, exchanging scientific and technical personnel, science and technology conferences, and the education and training of nationals and foreigners.[66] Accelerating TT also requires external[67] and internal[68] participation in the decision-making process regarding strategy, investment, international trade, market opportunities,[69] and so on, to cooperate with society in legal, social, political, economic and technological factors.

4.4.1 The development of TT promotion

Regarding the scientific aspects of the complex TT issue, "despite the very significant socio-economic problem antique that lies behind the environmental crises, it is the development of new technology that is often perceived to be pivotal in the design and implementation of effective response and adaptation strategies."[70] As early as 1972 the international community realized that "science and technology... must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems".[71] This principle has evolved to become a critical component of many MEAs.

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[65] Declaration on the Establishment of a New International Economic Order, A/RES/S-6/3201, 1 May 1974.
[66] IPCC, *Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change* (n 43). ch. 1.6.
[67] International cooperations and agreements
[68] participation of domestic industries and efforts of national/regional governments
[69] IPCC, *Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change* (n 43).
[70] Duncan A. French, 'Managing Global Change for Sustainable Development: Technology, Community and Multilateral Environmental Agreements' (2007) 7 International Environmental Agreements: Politics, Law and Economics 209.
[71] Principle 18 of United Nations, 'Chapter 1 Declaration of the United Nations Conference on the Human Environment' in *Report of the United Nations Conference on the Human Environment, Stockholm 5-16 June 1972* (UN Doc A/CONF.48/14/Rev.1 1972).

The formation of international TT derives from "the context of NIEO in the early 1970s, which aimed to restructure economic and political relations between North and South."[72] Most nations, irrespective of their economic level, had come to recognize that the goal of a sustainable means of development for environmental protection was the ideal for a new World Economic Order.[73] The Declaration on the Establishment of a New International Economic Order points out that "the benefits of technological progress are not shared equitably by all members of the international community."[74] Therefore the NIEO tried to found itself on full respect for the principles. These principles include:

> giving to the developing countries access to the achievements of modern science and technology, and promoting the transfer of technology and the creation of indigenous technology for the benefit of the developing countries in forms and in accordance with procedures which are suited to their economies. [75]

In order to pursue an even and balanced development of the global economy, developing countries, which constitute 70 per cent of the world's population, started to devote their efforts to closing the gap between the developed and the developing countries by advocating active promotion by developed countries to facilitate TT, instead of leaving TT to develop only at business-to-business level.[76]

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[72] Gary Cox, 'The Clean Development Mechanism as a Vehicle for Technology Transfer and Sustainable Development-Myth of Reality' (2010) 6 Law Env't & Dev J 179.
[73] Robert D. Munro, *Environmental Protection and Sustainable Development: Legal Principles and Recommendations* (Experts Group on Environmental Law, Springer Netherlands, 30 Oct 1987 1987).
[74] The New International Economic Order (n 65).
[75] Article 4 (p) of ibid (n 65).
[76] C. J. Hamelink and B. Pavliè, *The New International Economic Order: Links between Economics and Communications*, vol Volume 98 of Prominent Figures of Slav Culture (Paris: UNESCO 1985).

TT as a tool with which to address environmental issues was raised at the United Nations Conference on the Human Environment in Stockholm in 1972. The most significant achievement of the conference was that it has conceived the idea of developing in a sustainable way[77] and pointed out the importance of the issue to the international community. Such a goal towards sustainable growth generated the need to widely spread technologies, supporting a long-term projected manufacturing approach. However, it seemed like a ruse to shed non-differential environmental protection obligations on every country, a ruse by which the Third World's aspirations to economic growth and development would have been impinged while developed nations maintained a disproportionate share of the world's industrial wealth.[78] Nevertheless, in Principle 18 of the Stockholm Declaration[79], science and technology are considered to be an inevitable contribution to climate change mitigation and in turn, "must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind." Principle 9 further points out the importance and necessity of transferring these technologies to developing countries to help solving the environmental problems. "The free flow of up-to-date scientific information and transfer of experience" highlighted by Principle 20, reinforced the importance of soft technologies, and requires that they "must be supported and assisted, to facilitate the solution of environmental problems." The same principle also gives full respect to the different situation of developing countries, thus requiring the more

[77] Although many of the clauses, especially 1 and 2 describe approaches which are now encompassed in the concept of sustainable development, the term was not used there. It is not really until the Brandt Report that 'sustainable development' is developed as a concept. See Duncan French, *International law and policy of sustainable development* (Manchester University Press 2005).
[78] United Nations Environment Programme, "Review of the Areas of Environment and Development and Environmental Management", UNEP Report No.3, 1978 quoted by Colin M. Alberts, 'Technology Transfer and Its Role in International Environmental Law: A Structural Dilemma' (1992) 6 Harv JL & Tech 63.
[79] United Nations, 'Chapter 1 Declaration of the United Nations Conference on the Human Environment' (n 71).

developed countries to make an effort for environmental technologies to be "available to developing countries on terms which would encourage their wide dissemination without constituting an economic burden on the developing countries." The 1989 resolution of the UN General Assembly in preparation for the Rio Conference reiterated the needs of developing countries and confirmed the essential role of EST transfer.[80] More recently, Principle 9 of the 1992 Rio Declaration on Environment and Development[81] has reaffirmed the belief in the function of TT and put forward that scientific advances could improve economic development in developing countries as well as climate change issues globally. Chapter 34 of Agenda 21[82] further elaborated the need for international cooperation in capacity building on top of EST transfer. "This stresses the 'soft' side of technology transfer" again with specific reference to, "encompassing the transfer of technological know-how and local managerial capabilities in the context of long-term collaborative partnerships."[83] More worth notice is that in Principle 7[84] of the Rio Declaration[85] the "common and differentiated principle" was laid. This concept consists of two parts: common responsibilities and differentiated responsibilities.[86] The former can be defined according to the preamble of the Rio Declaration,[87] which aims at establishing partnerships between countries to work on a type of growth that respects the

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80 See United Nations Conference on Environment and Development, United Nations General Assembly 85th plenary meeting, 22 December 1989, UN Doc A/RES/44/228.
81 The Agenda 21
82 Ibid, Chapter 34, in United Nations, *REPORT OF THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT* (United Nations General Assembly, 14 August 1992, UN Doc A/CONF151/26 (Vol III), 1992).
83 Cox (n 72).
84 "States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command." The Agenda 21 Annex 1 principle 7.
85 Annex I Rio Declaration on Environment and Development, United Nations A/CONF.151/26 (Vol. I)
86 Nico J. Schrijver and Friedl Weiss, *International law and sustainable development: principles and practice*, vol 51 (Martinus Nijhoff Publishers 2004).
87 "With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people, Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system, Recognizing the integral and interdependent nature of the Earth, our home …" Rio Declaration.

welfare of people and the environment. The later element of differentiated responsibility is mainly interpreted as being in favour of developing countries and seems to be based on the theory of equity discussed in the earlier chapter.[88] To many it is recognition that the developed world takes responsibility both for its past contribution to global environmental harms and its need to help developing nations deal with these problems. This is where TT comes into play. Other than that, the subsequent World Summit on Sustainable Development (WSSD) in Johannesburg 2002 also helped to define terms, establishing rules, objectives, and a framework in which to address global environmental problems. These key footprints in the history of the world effort to mitigate climate change show respect to the needs of developing countries with no exception. Such early references already included both financial and technical assistance institutions as key to actualizing the aims.

The development and dissemination of green technology was thus increasingly becoming a major feature of any serious approach to tackling climate change problems and consolidating environmental cooperation. Therefore, climate change technology and transfer are treated with relatively high prioritization within MEAs.[89] Such a preference is based on a belief that "countries and international organizations may be best served by applying pragmatic approaches that enhance long-term commitment to collaboration through existing bilateral and multilateral partnerships and demonstrate a commitment to rapid scaling up of technology cooperation and financing."[90] As a result, many international efforts[91] were made to accomplish this goal. These include, as well as the UNFCCC, international agreements

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88 See Chapter III Section 3.4

89 R. Benioff and others, *Strengthening Clean Energy Technology Cooperation under the UNFCCC: Steps toward Implementation* (National Renewable Energy Laboratory (NREL) NREL/TP-6A0-48596, August 2010, Boulder, Colorado, 2010).

90 Ibid.

91 Ibid.

such as the Vienna Convention for the Protection of the Ozone Layer,[92] the Convention on Biological Diversity,[93] the Major Economies Forum,[94] the Climate Technology Initiative,[95] indeed they are too numerous to discuss in detail here.

In accordance with the special needs of developing countries addressed by the Stockholm and Rio Declarations, many multilateral and bilateral programmes encourage cooperation between developed and developing countries regarding development and diffusion of climate change technology development were established in support of the most effective and comprehensive MEA to date – the UNFCCC. For example, in 2001 the Special Climate Change Fund (SCCF)[96] was established under the UNFCCC to finance projects relating to TT as well as other aims.[97] The GEF operates the SCCF through project.[98] Most GEF projects are "implemented by the World Bank and other multilateral development banks and by United Nations agencies."[99] For example, the Asia-Pacific Partnership on Clean Development and

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[92] UNEP, *Vienna Convention for the Protection of the Ozone Layer* (1986).

[93] Convention on Biological Diversity, 1760 UNTS 79; 31 ILM 818 (1992).

[94] The "Major Economies Forum (MEF), comprised of the 17 countries with the largest economies, has developed a portfolio of 10 Technology Action Plans (TAPs) to advance global cooperation on clean energy technologies." Benioff and others (n 89); more examples such as the Climate Technology Initiative, the International Energy Agency, the International Partnership for Energy Efficiency Cooperation and the International Renewable Energy Agent see ibid (n 89).

[95] The Climate Technology Initiative (CTI; www.climatetech.net) is a multilateral partnership that supports international cooperation to advance adoption and diffusion of climate friendly technologies; The International Energy Agency (IEA) includes 24 member countries from the developed world working together to advance energy security, economic growth, and environmental protection; The International Partnership for Energy Efficiency Cooperation: The G8 countries plus Brazil, China, India, Korea, Mexico, and the European Commission are working together to accelerate the implementation of energy efficiency through the recently established International Partnership for Energy Efficiency Cooperation (IPEEC; http://ipeecshare.org); The International Renewable Energy Agency: As of October 2009, 138 countries are members of the new International Renewable Energy Agency (IRENA; www.irena.org). IRENA's mandate is to accelerate the global transition to widespread and sustainable renewable energy use. IRENA seeks to improve access, especially for developing countries, to renewable energy information and data, policy and program best practices, financing mechanisms, and technology expertise.

[96] UNFCCC, 'Decision 7/CP.7 Funding under the Convention' in *PART TWO: ACTION TAKEN BY THE CONFERENCE OF THE PARTIES* (United Nations Framework Convention on Climate Change, 7th session, FCCC/CP/2001/13/Add.1, 21 January 2002 2002).

[97] Such as "adaptation; capacity building; energy, transport, industry, agriculture, forestry and waste management; and economic diversification." 'The Special Climate Change Fund (SCCF)' (*UNFCCC website*, 28th Ocboter, 2013) <http://unfccc.int/cooperation_and_support/financial_mechanism/special_climate_change_fund/items/3657.php> accessed May, 2017.

[98] The United Nations Environment Program and United Nations Development Program support the preparation of technology needs assessments required by the UNFCCC.

[99] These banks and organizations also have their own sets of green-tech cooperation programmes. Benioff and others (n 89).

Climate[100] promotes climate change mitigation cooperation through TT by involving government, private, and technical institute representatives from seven countries.[101] The CDM as another important mechanism provides flexibility to countries ratified to emission reduction targets to achieve the goal through projects development in developing countries. CDM is also a way of encouraging TT. Seres and Haites[102] point out that at least 39 per cent of the registered and proposed CDM projects claim TT in their PDDs. These TTs includes equipment transfer and knowledge transfer from sponsor to host countries. As CDM projects are the subjects of this thesis, more discussion of the mechanisms will be laid out in the following sections.

4.4.2 The United Nations Framework Convention on Climate Change

UNFCCC is one of the most significant MEAs as it provides a vital mechanism for multilateral action to combat climate change and its impacts on humanity and ecosystems.[103] The Convention aims to achieve the "stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[104] Such an objective is to be achieved through the specified framework of general principles and

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[100] Ibid (n 89).
[101] Australia, Canada, China, India, Japan, South Korea, and the United States.
[102] Kevin Murphy and others, 'Technology Transfer in the CDM: An Updated Analysis' (2015) 15 Climate Policy 127: "The prevalence of technology transfer (TT) for Clean Development Mechanism (CDM) projects is analysed, based on information in the project design documents (PDDs) of 3949 projects registered as of 31 March 2012. Responses to a follow-up survey indicate that the PDD statements that concern TT are reasonably accurate and at least 39% of the related projects are expected to involve it. It also usually involves both knowledge and equipment and differs significantly by host country. Technology transfer has declined over time in China, India, and Brazil, the countries that host most of the CDM projects, but it has remained high for other host countries. A host country's existing capacity specific to the technology, the scope for economic deployment of the technology, and complementary policies to build capacity and promote TT, increase the frequency of TT by CDM projects. The technology used by CDM projects originates mostly from Germany, the US, Japan, Denmark, and China, with multiple suppliers of the technology for all project types."
[103] UNFCCC, 'Decision 7/CP.7 Funding under the Convention' (n 96)
[104] United Nations Framework Convention on Climate Change, 1771 UNTS 107; S. Treaty Doc No. 102-38; U.N. Doc. A/AC.237/18 (Part II)/Add.1; 31 ILM 849 (1992) Article 2.

institutions with ratified parties meeting regularly and agreeing to certain climate change actions over time.

The Convention is based on a belief that human activities are the main source of GHG emissions, which lead to severe climate change problems. In addition, it recognizes that climate change is inherently global in nature due to emissions "into the atmosphere from sources anywhere on the globe will affect atmospheric concentrations."[105] Thus, with the composition of the atmosphere being determined by the aggregating actions of all nations, the UNFCCC is motivated to push collective and global action to cope with environmental issues to the globally integrated climate system. The Convention focuses on facilitating cooperation under more comprehensive treatment of principles and more specific commitments from all signatories.[106]

Principle 7 of the Rio Declaration[107] sets out that "states shall cooperate in a spirit of global partnership […] In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities." This provides a fundamental justification for the obligations regarding TT forwarded by Article 4 of UNFCCC – the Commitments; and more importantly, Principle 7 ratification from developed countries of such obligations as they "acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command." Consequently,

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[105] UNFCCC, 'What does the UN Climate Change Regime Do?' (*"Understanding Technology Developmentand Transfer" page in UNFCCC*) <http://bigpicture.unfccc.int/content/technology-transfer.html> accessed 6 Jun 2017.
[106] The establishment of the Convention has a well-developed foundation based on the preparation and experience of the 1985 Vienna Convention and the Rio Declaration. The former provides instrument structure and the later consolidates several guiding principles. See Cox (n 72).
[107] Agenda 21.

later in the UNFCCC, developed countries are committed to accelerate and facilitate TT to developing countries and to view differently the rights and duties between Annex I parties and Non-Annex I parties under the Convention.[108]

The main provisions on TT are included in Article 4 of the UNFCCC. Article 4.1(c) sets out a range of ESTs, the transferring of which need to be promoted by the Convention. The provision requires all parties to "promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices, and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases". And by stating "control, reduce, or prevent," the article indicates that "its application relates to mitigation technologies only and does not encompass adaptation technologies."[109] This is a rather narrow definition of climate change technology in comparison with the meaning of EST discussed earlier, but it is ratified and executed in the supplementary subsequent agreements such as the Kyoto Protocol and the Paris Agreement.[110]

Article 4.3 sets up obligations on the Annex II countries[111] to help developing countries overcome difficulties in implementing the Convention.[112] This provision requires the more developed countries to provide financial resources within and outside of financial mechanism

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108 Annex I of the UNFCCC has listed 40 developed countries/economies in transition parties and the European Economic Community. 'Guide to the Climate Change Negotiation Process' (*UNFCCC Website*) <http://unfccc.int/not_assigned/b/items/2555.php> accessed Feburary, 2017. Annex II has 23 developed country parties, all OECD members, plus the European Economic Community. Non-Annex I parties are not separately listed but are developing country parties to the Convention.

109 Cox (n 72).

110 This means that there can be funding under Kyoto mechanisms for adaption as well.

111 See Chapter III Section 3.5

112 "The developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations under Article 12, paragraph 1. They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures that are covered by paragraph 1 of this Article and that are agreed between a developing country party and the international entity or entities referred to in Article 11, in accordance with that Article. The implementation of these commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among the developed country Parties." Cox (n 72).

established under Article 11.[113] More importantly, the article makes a clear link between these financial resources and TT implementation by specifically mandating Annex II countries to offer financial resources for TT needed by a developing country.[114] This provides a basic structure for effective mechanisms to be established under the Convention to help undertake the commitments applicable to all parties under Article 4.1.[115] In order to facilitate TT, Article 4.5 further prescribes the obligations of Annex II parties. The Article stipulates that these countries are to "take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties." However, there are inadequate measures to determine whether Annex I/II countries have complied with their TT commitments. The implementation of UNFCCC is assessed by the COP[116] and the subsidiary bodies.[117] However, these bodies function subject to the political relationships between member states. Therefore if a country failed to implement their obligations, there are often failures in dealing with the problem.[118] Moreover, the Article mandates developed parties to assist developing countries in the development and enhancement of their endogenous technological capacities. This

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113 "The operation of the Financial Mechanism is partly entrusted to the Global Environment Facility (GEF). At COP 17 Parties decided to designate the Green Climate Fund (GCF) as an operating entity of the Financial Mechanism of the Convention, in accordance with Article 11 of the Convention. The Financial Mechanism is accountable to the COP, which decides on its climate change policies, programme priorities and eligibility criteria for funding. The Kyoto Protocol also recognizes, under Article 11, the need for the Financial Mechanism to fund activities by developing country Parties. In addition to providing guidance to the GEF, Parties have established four special funds: the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF), both managed by the GEF, and the GCF under the Convention; and the Adaptation Fund (AF) under the Kyoto Protocol." UNFCCC, 'Climate Finance' (*United Nations Framework Convention on Climate Change*) <http://unfccc.int/cooperation_and_support/financial_mechanism/items/2807.php> accessed Feburary 2017.

114 Cox (n 72).

115 "Including promotion of sustainable management, cooperation in preparing for adaptation to climate change impacts, and scientific and technological cooperation and exchange." Ibid (n 72).. See respectively Articles 4.1(d), 4.1(e), and 4.1(,) and (h)

116 "the COP is the supreme body of the UNFCCC comprised of all the states that have ratified or acceded to the Convention" Xueman Wang and Glenn Wiser, 'The implementation and compliance regimes under the Climate Change Convention and its Kyoto Protocol' (2002) 11 Review of European, Comparative & International Environmental Law 181.

117 The Subsidiary Body for Implementation and the Subsidiary Body for Technological Advice.

118 Wang and Wiser (n 116).

expands the scope of TT adopted by the Convention to encompass transferring soft technologies, such as know-how and management experience.

In order to be well informed about the most up-to-date climate change situation and to have technologies available to deal with the issues, the subsidiary body for Scientific and Technological Advice established under Article 9 is required. It was intended to advise on conducting broader international scientific cooperation between member states. However, in practice the subsidiary involves experts nominated by governments representing their own national interests. Thus the role of the subsidiary body was perceived to be more political than neutral.[119] As a result, after six years, the IPCC – the scientific and intergovernmental body under the auspices of the United Nations– finally became the primary source of scientific, technical and socio-economic advice that supports the UNFCCC.[120] IPCC reports are conveniently available at the request of the COP on climate change issues and the reports are considered to be more objectively conducted.[121]

Other than offering proposals and general guidance, the Convention failed to contribute to the promotion of TT in practice.[122] According to the Convention, the ratified governments "have met annually at the COPs since 1995 to take stock of their progress, monitor the implementation of their obligations and continue talks on how best to tackle." [123] Consequently, more difficult works have been accomplished within these meetings to facilitate TT. For example, to enhance the implementation of Article 4.5 of the Convention,

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[119] Ibid (n 116).
[120] Farhana Yamin and Joanna Depledge, *The International Climate Change Regime: A Guide to Rules, Institutions and Procedures* (Cambridge University Press 2004).
[121] Spencer R. Weart, 'International Cooperation: Democracy and Policy Advice (1980s)' in *The Discovery of Global Warming* (Harvard University Press 2008).
[122] Yamin and Depledge (n 120).
[123] R.A.P. and CHANGCE, *Research on the Reform of China 's On-Grid Tariff Mechanism* (The Regulatory Assistance Project, Feburary 2016).

the “technology transfer framework” was established at COP 7.[124] The framework is meant to take effective actions within five key themes: “technology needs assessments, technology information, enabling environments, capacity building, and mechanisms for TT.”[125]

4.4.3 The Kyoto Protocol and CDM

One of the most significant achievements during the implementation of the UNFCCC was the Kyoto Protocol adopted at COP 3 in December 1997.[126] This is due to recognition of the inadequacy of the insular commitments contained in Article 4 of UNFCCC. In Article 10(c), the Kyoto Protocol echoed the objective sets out by the Convention which requires the parties to:

> cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries.

This provision, specifically referring to the promotion of the development and transfer of ESTs, extends the 1992 UNFCCC to commit parties to TT and in turn to reduce GHG emissions based on more specific obligations. For example, the negotiations endeavoured to “set quantified limitation and reduction objectives within specified timeframes, such as 2005, 2010, and 2020, for their anthropogenic emissions.”[127] Moreover, it highlighted the

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124 Five key themes, see UNFCCC, ‘Decision 4/CP.7 Development and transfer of technologies (decisions 4/CP.4 and 9/CP.5)’.

125 Joëlle De Sépibus, ‘Reforming the clean development mechanism to accelerate technology transfer’ Working Paper No 2009/42, November 2009 <http://www.nccr-trade.org/fileadmin/user_upload/nccr-trade.ch/wp5/WP%202009_42_de%20Sepibus_Reforming%20the%20CDM%20to%20acc%20TT.pdf> accessed Feburary 2017.

126 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), UN Doc FCCC/CP/1997/7/Add.1, Dec. 10, 1997; 37 ILM 22 (1998).

127 United Nations, *Part Two: Action Taken by the Conference of the Parties at its 1st Session* (UNFCCC 5th session Berlin, 28 March - 7 April 1995, UN Doc FCCC/CP/1995/7/Add1, 6 June 1995, 1995).

importance of TT by stating that "among the issues to be considered shall be the establishment of funding, insurance and transfer of technology."[128] More details, such as promotion of the transfer of the soft technologies that are "are publicly owned or in the public domain"[129] are included in the provisions. However, due to the tremendous difficulties of reaching consensus among numerous issues,[130] much of the detailed rules and guidelines were left to later meetings.[131]

Article 10 is a significant provision. Firstly, it recognizes the difference between developed and developing countries, requiring all parties to take "into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances" while complying with the commitments in the Convention. Secondly, it clarifies the meaning of climate change technology referred by the UNFCCC. By using EST instead of simply referring to "technology" as the UNFCCC does, this article is more in accord with the language of Chapter 34 of Agenda 21 and makes it easier to identify subsequently invented technologies through the nature of their improved environmental performance within the ambit of EST.[132] Furthermore, the same provision particularly requires cooperation among parties to "promote, facilitate and finance" any "promotion of effective modalities for the development, application and diffusion" of ESTs through practical steps to developing countries. This is only one of the many references in the Protocol to special assistance that should be made available to developing countries, which includes the

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[128] The Kyoto Protocol Article 3 (14).
[129] Ibid Article 10.
[130] See Philippe Sands and Jacqueline Peel, *Principles of International Environmental Law* (Cambridge University Press 2012), quoted by Cox (n 72).
[131] "These later agreements on implementation modalities and methodologies, known as the Marrakesh Accords, were endorsed by COP-7 in 2001." Cox (n 72).
[132] Yamin and Depledge (n 120).

transfer of ESTs. The Protocol clearly recognizes the responsibility of developed countries to TT to developing countries so they and the global community can cope with the risks of climate change.

Article 11 states "the implementation of these existing commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among developed country Parties." This is reaffirming the obligation of developed countries to provide financial resources in support of environmental mitigation and TTs to developing countries. More importantly, the fund provided has to be with "adequacy and predictability," which is a very ambitious task. Also, Article 11 especially focuses on the financial assistance that shall be made available "through the entity or entities entrusted with the operation of the financial mechanism of the Convention" to developing countries. It thus requires developed countries to "provide new and additional financial resources" with accessible mechanisms "to meet the agreed full costs incurred by developing country Parties."[133] The Kyoto Protocol has thus successfully committed its parties to specific binding emission-reduction targets and the permitted financial support from signatories is quantifiable and easier to assess.

4.4.3.1 Article 12 – The CDM

The CDM was established under Article 12 of the Kyoto Protocol. Countries that committed to an emission-reduction target under the Kyoto Protocol could use it to implement the target by participating CDM projects to acquire certified emission-reduction (CER) credits,[134] which can

[133] See Kyoto Protocol, Article 11.2(b).
[134] each equivalent to one tonne of CO2.

be counted towards meeting Kyoto targets.[135] "It is the first global, environmental investment and credit scheme of its kind, providing a standardized emissions offset instrument, CERs."[136] The mechanism provides great flexibility for Annex II countries in meeting their emission-reduction targets. Although the mechanism does not have an explicit TT mandate, its general objective of contributing to the sustainable development of developing countries has improved the flow of TT in many of its projects.[137] The 7th COP[138] aims to "reiterate a number of the policy objectives set out in the Bonn Agreement and in addition state that projects should lead to the transfer of environmentally safe and sound technology and know-how' beyond existing UNFCCC obligations."[139] This is accomplished in particular through "financing emission-reduction projects that use technologies currently not available in the host countries."[140] The CDM is managed by the Executive Board under the UNFCCC composed of ten members from parties to the Kyoto Protocol according to guidance issued by the COP,[141] while the projects are monitored by the Designated Operational Entities[142] which consist of several private independent institutions.[143]

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[135] UNFCCC, 'Clean Development Mechanism (CDM)' (*United Nations Framework Convention on Climate Change*) <http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php> accessed Feburary 2017.
[136] Ibid.
[137] "Roughly 39% of all CDM projects accounting for 64% of the annual emission reductions claim to involve technology transfer." Stephen Seres, *Analysis of Technology Transfer in CDM Projects* (Prepared for the UNFCCC Registration & Issuance Unit CDM/SDM, 2008).
[138] The outcome of the 7th COP is referred to as the Marrakech Accords, which is a set of agreements reached at the 7th Conference of the Parties (COP7) to the UNFCCC on the rules of meeting the targets set out in the Kyoto Protocol. See Report of the Conference of the Parties on its Seventh Session, held at Marrakesh FCCC/CP/2001/13/Add.1.
[139] UNEP (n 92), quoted by Cox (n 72).
[140] United Nations, *The Contribution of the Clean Development Mechanism under the Kyoto Protocol to Technology Transfer* (United Nations Framework Convention on Climate Change, November 2010) p1
[141] Kyoto Protocol, Articles 12.4 and 12.5. The certified or designated operational entities (DOEs) are generally large international consulting firms.
[142] "A designated operational entity (DOE) is an independent auditor accredited by the CDM Executive Board (CDM EB) to validate project proposals or verify whether implemented projects have achieved planned greenhouse gas emission reductions." 'Designated Operational Entities' (*UNFCCC website*) accessed Feubrary 2017.
[143] Jim Watson and others, *UK-China Collaborative Study on Low Carbon Technology Transfer* (Final Report by Sussex Energy Group SPRU - Science and Technology Policy Research, 2011)

The establishment of CDM was indeed creative, for it has exceeded the expectations of many debating countries.[144] Gary Cox[145] describes the CDM as a "surprise" to signatories because projects registered under the mechanism are issued with CERs according to the amount of emissions reduction and GHGs capture. Such credits are "tradable on carbon markets and countable against member states' emissions targets."[146] The mechanism has significance in reconciling the bipolar positions conceived by developed and developing countries.[147] On the one hand it encourages the former countries to provide assistance in many aspects by enabling Annex II countries to fulfil their emission-reduction goals with greater geographical flexibility[148] and cheaper construction costs.[149] On the other, it stimulates companies in developing countries to pursue environmental friendly ways of manufacturing, by offering them financial support, production experience and technological resources. Through development of CDM projects, developing countries will benefit from TT, acquiring technologies that are not currently available to them. Empirical data collected from PDDs of CDM projects[150] also indicates that TT from developed countries (Annex I countries) to developing countries (non-Annex I countries) are "significantly affected by the contemporaneous establishment of projects under the CDM."[151] However, the persistent effect of CDM projects upon knowledge diffusion and technology innovation is ultimately

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144 Farhana Yamin, 'The Kyoto Protocol: Origins, Assessment and Future Challenges' (1998) 7 Review of European Community & International Environmental Law 113, quoted by Cox (n 72).
145 Cox (n 72).
146 United Nations, *The Contribution of the Clean Development Mechanism under the Kyoto Protocol to Technology Transfer* (n 140).
147 Hugh Wilkins, 'What's New in the CDM?' (2002) 11 Review of European Community & International Environmental Law 144, quoted by Cox (n 72).
148 Sebastian Oberthür and Hermann E. Ott, *The Kyoto Protocol: International Climate Policy for the 21st Century* (Springer Science & Business Media 1999) quoted by Cox (n 72).
149 Harro van Asselt and Joyeeta Gupta, 'Stretching Too Far? Developing Countries and the Role of Flexibility Mechanisms Beyond Kyoto' (2009) 28 Stanford Environmental Law Journal 311, quoted by Cox (n 72).
150 Seres (n 137).
151 Ivan Haščič and Nick Johnstone, 'CDM and International Technology Transfer: Empirical Evidence on Wind Power' (2011) 11 Climate Policy 1303.

determined by domestic absorptive capacity and policy support in the host country.[152] Some studies[153] based on project-level data have examined TT in CDM projects and concluded that "TT is more likely to feature in larger CDM projects, in those involving foreign parties, and in projects in which intermediaries are involved in project development."[154]

4.4.3.2 Limitations of the CDM and decline in number of projects

In recent years, a succession of studies on the implementation of CDM projects and the trends of TT through these projects has been published. Even though many studies[155] have confirmed that CDM has positive effects on TT promotion, after the first phase of Kyoto, statistical results clearly show that this international binding treaty on cutting emissions has failed to slow GHG emission globally.[156] The emission-reduction target of Kyoto Protocol is for the committed countries to cut of around 5 per cent relative to 1990 levels by 2012. This was successful to some extent, since some signatories have in fact reduced emissions significantly.[157] More than half of the Annex I countries have met their reduction targets

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[152] See generally Erik Haites, Maosheng Duan and Stephen Seres, 'Technology Transfer by CDM Projects' (2006) 6 Climate Policy 327; Heleen De Coninck, Frauke Haake and Nico Van Der Linden, 'Technology Transfer in the Clean Development Mechanism' (2007) 7 Climate Policy 444; Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière, 'The Clean Development Mechanism and the International Diffusion of Technologies: An Empirical Study' (2008) 36 Energy Policy 1273; Malte Schneider, Andreas Holzer and Volker H. Hoffmann, 'Understanding the CDM's Contribution to Technology Transfer' (2008) 36 Energy Policy 2930; Stephen Seres, Erik Haites and Kevin Murphy, 'Analysis of Technology Transfer in CDM Projects: An Update' (2009) 37 Energy Policy 4919; Haris Doukas, Charikleia Karakosta and John Psarras, 'RES Technology Transfer within the New Climate Regime: A "Helicopter" View under the CDM' (2009) 13 Renewable and Sustainable Energy Reviews 1138; quoted by Haščič and Johnstone (n 151).

[153] Dechezleprêtre, Glachant and Ménière, 'The Clean Development Mechanism and the International Diffusion of Technologies: An Empirical Study'; Schneider, Holzer and Hoffmann (n 152); Seres, Haites and Murphy(n 152); quoted by Haščič and Johnstone (n 151).

[154] Haščič and Johnstone (n 151).

[155] The Dechezleprêtre, et.al's study recommends "the bundling of projects in order to exploit increasing returns on technology transfer and to promote technology transfer within non-Annex I subsidiaries of Annex I companies." Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière, *The North-South Transfer of Climate-Friendly Technologies Through the Clean Development Mechanism* (Research programme Gestion et Impacts du Changement Climatique (GICC), 2007); R. O. B. Youngman and others, 'Evaluating Technology Transfer in the Clean Development Mechanism and Joint Implementation' (2007) 7 Climate Policy 488; Wilkins (n 147) p.149.

[156] Analysis of the 'Kyoto Protocol Base Year Data' (*UNFCCC*) <http://unfccc.int/ghg_data/kp_data_unfccc/base_year_data/items/4354.php> accessed 23 Aug 2017.

[157] for example Russia and the UE 15. European Environment Agency, *Tracking Progress towards Kyoto and 2020 Targets* (European Environment Agency Report (EEA Report No 6/2012), 2012); See conversely Duncan Clark, 'Has the Kyoto Protocol Made Any Difference to Carbon Emissions?' (*TheGuardian*, 26 November 2012) <https://www.theguardian.com/environment/blog/2012/nov/26/kyoto-protocol-carbon-emissions> accessed 22 Jul 2017.

according to the UNFCCC data.[158] However, "emissions in the rest of the world have increased sharply – especially in China and other emerging economies."[159] Overall, "China's CO_2 emissions rapidly grow at an average annual rate of 7.03% from 1997 to 2012."[160] In fact, this emission growth undermines the contribution of the Annex I countries because "much of the growth in China and other emerging economies has been driven by the production of goods and services exported to developed nations."[161] The outsourcing production pattern of many developed countries is the missing variable of the Kyoto calculation because carbon footprints are accounted for on behalf of the countries producing goods, not those consuming them under the Protocol. If imports are calculated, the emission reductions accomplished by developed countries are cancelled out by the enormous goods they have imported from countries that are still relying on emission-intensive productions.[162] Therefore, the Kyoto Protocol has been a failure in this sense. But it has played an undeniable role in global climate diplomacy for its explicit binding obligations, flexibility and cost-effective mechanisms. Consequently, a more ambitious and rational second step is what the world is really looking for to continue the fight against climate change while avoiding the obstacles that appeared during the implementation of its antecedents.

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[158] 'GHG Data from UNFCCC' (*United Nations Framework Convention on Climate Change*) <http://unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php> .
[159] Clark (n 157).
[160] Wei Li, Ya-Bo Shen and Hui-Xia Zhang, 'A Factor Decomposition on China's Carbon Emission from 1997 to 2012 Based on IPAT-LMDI Model' (2015) 2015 Article ID 943758 Mathematical Problems in Engineering.
[161] Clark (n 157).
[162] "When you look at total carbon footprint of each nation (including imports and excluding exports), the progress made under Kyoto looks extremely poor, with Europe's savings reduced to just 1% from 1990 to 2008 and the developed world as a whole seeing its emissions rise by 7% in the same period." Ibid (n 157); At Felixstowe container port, "imported goods in developed countries cancel out carbon emissions savings, according to a new analysis." Duncan Clark, 'Carbon Cuts by Developed Countries Cancelled Out by Imported Goods' (*TheGuardian News Report*, 25 April 2011) <https://www.theguardian.com/environment/2011/apr/25/carbon-cuts-developed-countries-cancelled> accessed 22 Jul 2017.

Moreover, based on quantitative data, the UNFCCC study group concluded that TT through CDM was more common during the early rather than later years of the first commitment period of Kyoto (2005–2008 and 2009–2012).[163] One reason for this is that the former technology-receiving countries are now transferors themselves in many sectors. This trend is particularly evident in China, India, and Brazil, which are the three countries hosting the most CDM projects. For example, "the results show that over 90% of Chinese projects entering the pipeline in 2004 and 2005 made use of TT while the same can be said in 2009 and 2010 for only 14% of projects."[164] Such statistics can be explained by the growth of technology capability in the hosting country. CDM's ability to contribute significantly to TT towards developing countries eventually reduced the need for international transfer. This is possibly attributed to its indirect impact on the improvement of local sources of knowledge and equipment.[165]

However, decline of TT through CDM projects could also be a result of its intrinsic limitations. For example, China used to have a rate of TT through CDM that was higher than the average for other host countries but the rate is now substantially lower.[166] It is easy to associate such a decrease in CDM projects of TT to China with the fact that these activities have created independent capacity in the country, allowing later projects to rely more on domestic

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[163] United Nations, *The Contribution of the Clean Development Mechanism under the Kyoto Protocol to Technology Transfer* (n 140): "The CDM has grown rapidly since 2007. And technology transfer studies were completed. With a number of countries now hosting a considerable quantity of projects, the 2007 and 2008 studies, respectively, showed technology transfer to occur in 39% and 36% of projects, accounting for 64% and 59% of estimated emission reductions from the CDM." But until 2010 the percentage of projects involve TT has declined.

[164] Ibid (n 140) p12.

[165] Ibid (n 140).

[166] In *Measures for Operation and Management of Clean Development Mechanism Projects in China*, the Government of China requires that "CDM project activities should promote the transfer of environmentally sound technology to China." Measures for Operation and Management of Clean Development Mechanism Projects in China, Nov 21,2005; "This is a general provision for the country's use of the CDM rather than a mandatory requirement for each project. The rate of technology transfer for projects in China is about half the average for all CDM projects measured in share of projects (19% versus 40%) and about 80% of the average for annual emission reductions (47% versus 59%)." United Nations, *The Contribution of the Clean Development Mechanism under the Kyoto Protocol to Technology Transfer* (n 140).

knowledge and equipment supply.[167] Yet, there are several other less direct factors that contribute to these results. Under the Kyoto Protocol, CDM projects are certified when the proposals satisfy the general project eligibility requirements criteria.[168] One of these required criteria is the "additionality" which specifically means that "the project activity is expected to result in a reduction in anthropogenic emissions by sources of greenhouse gases that are additional to any that would occur in the absence of the proposed project activity."[169] Additionality is "the crucial test of whether a CDM project results in emission reductions that are in excess of what would have occurred under a business as usual scenario, and thus whether the project should be awarded carbon credits." [170] Therefore, it is required to certify GHG emissions reduction only if the reduction would not occur in the absence of implementation of a CDM project. In other words, if an emission-reduction project is to be implemented without CDM registration, then it is non-additional.[171] The validity of such a requirement is questioned by Lohmann.[172] He looks into the PDD of projects hosted by India, Brazil and Kenya as well as China and points out that the requirement is lacking clarity because it mainly depends on various countries' regulatory decisions.[173] For example, my interviewee[174] from the Shandong Dongyue HFC-23 Decomposition Project said that the CERs gained were based on decomposition of HFC-23 generated from its production process in

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167 United Nations, *The Contribution of the Clean Development Mechanism under the Kyoto Protocol to Technology Transfer* (n 140).

168 Kyoto Protocol, Article 12.5: (i) voluntary participation by the parties involved, (ii) 'real, measurable, and long-term benefits' for climate change mitigation, and (iii) additionally. Quoted by Cox (n 72).

169 3/CMP.1, Annex, paragraph 43. More details of the modalities and procedures as requirements for validation at the 'CDM Rulebook' (*UNFCCC Website*) <http://cdmrulebook.org/> accessed 11 Mar 2017.

170 Ben Pearson and Yin Shao Loong, *The CDM: Reducing Greenhouse Gas Emissions Or Relabelling Business As Usual?* (Third World Network, CDMWatch, March 2003).

171 , 'CDM Rulebook' (n 169).

172 Larry Lohmann, 'Toward a Different Debate in Environmental Accounting: The Cases of Carbon and Cost–benefit' (2009) 34 Accounting, Organizations and Society 499 quoted by Watson and others (n 143).

173 Watson and others (n 143).

174 interview with the manager from the Shandong Dongyue HFC23 Decomposition Project

order to reduce GHGs emission. Currently under Chinese law, there are no regulations requiring the decomposition of HFC-23, thus the project clearly satisfied the CDM additionality requirement. However, with the continuous modification of the national environmental laws, Chinese HFC-23 decomposition projects will not be able to qualify for CDM once decomposition is required under domestic regulations. This could be another reason to explain the drop in TT through CDM. In general, energy policy – especially policy concerning renewable energy – in China is largely determined by the NDRC. Therefore there is uncertainty over the meaning of "business as usual." If a project would have occurred in any case (e.g. the decomposition would have happened without CDM because of national legislation) it is considered "business as usual" and, in turn, "additionality" criteria required by the CDM would have disqualified companies from applying projects due to a change of domestic policies.[175]

An argument against CDM playing a significant role in international TT is that the mechanism mainly "encourages Annex I parties to claim the 'low-hanging fruit' in developing countries, […] without contributing to a long-term strategy of transforming these countries into low carbon economies."[176] According to the reviews of other studies[177] and results generated from interviews[178] conducted in this research, TTs through CDM at this stage are mainly one-off transfers of equipment, with a minimum level of know-how that is only sufficient to operate normally. Rarely is assistance provided to the host developing country during the

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175 Gang He and Richard K. Morse, 'Making Carbon Offsets Work in the Developing World: Lessons from the Chinese Wind Controversy' (March 12, 2010) Program on Energy and Sustainable Development Working Paper No 90, quoted by Watson and others (n 143).

176 Asselt and Gupta (n 153) p.349, quoted by Cox (n 72).

177 Wilkins (n 147) p.157.

178 especially interviews with managers and technicians from the wind projects.

implementation of CDM projects with the purpose of developing the indigenous and lasting bedding-in of ESTs in that country. Many researchers[179] have imputed the failure of establish sustainable TT by CDM to the lack of technology capacity in the host countries. However, it is actually the diffusion of ESTs that mostly matters to the long-term extensive development of a country's technological level and application. Successful sustainable TT must go through several stages[180] and it requires the wide replication of the technology, the absorption of know-how, and ample assimilation until the integration of indigenous technologies is achieved.[181] Although the proportional relationship between TT growth and sustainable development is indeterminate, it is too early to state whether mechanisms like CDM have not been the necessary agitation that triggered technological renaissance in large emerging economies like China, India and Brazil.[182] Thus the question remains: what other obstacles have deterred or slowed the long-term goals of the CDM?[183] Problems generated from issues such as "private sector competition, restrictive business practices and refusal of licensing" may decelerate progress.[184]

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[179] For example, Intergovernmental Panel on Climate Change, IPCC Third Assessment Report - Working Group III: Mitigation, para. 5.1 (Geneva: IPCC, 2001) para 5.1; Damilola S. Olawuyi, 'Achieving Sustainable Development in Africa through the Clean Development Mechanism: Legal and Institutional Issues Considered' (2009) 17 African Journal of International and Comparative Law 270 p.293: "The conclusion centres on the finding that there is no 'red thread' connecting a country's sustainable development strategy to the eventual technology selection for CDM projects. Van der Gaast and Begg argue for the bundling of small-scale projects to enable them to be more attractive to large investors as well as for smooth and reliable 'technology implementation chains'" Wytze van der Gaast and Katherine Begg, 'Enhancing the Role of the CDM in Accelerating Low-Carbon Technology Transfers to Developing Countries' (2009) 3 Carbon & Climate Law Review 58 p.59,62, quoted by Cox (n 72).

[180] "This would necessitate the embedding of what Maskus describes as 'technology ladders', with key steps being the duplicative imitative stage, creative imitation and implementation of knowledge-intensive inputs stage, and finally an implied autonomous technology development stage." Keith E. Maskus, 'Transfer of Technology and technological Capacity Building' (2003) ICTSD-UNCTAD Dialogue, 2nd Bellagio Series on Development and Intellectual Property p.8-9, quoted by Cox (n 72).

[181] IPCC, *Climate Change 2001: Mitigation: Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Bert Metz ed, Cambridge University Press 2001), para. 5.1.

[182] Schneider, Holzer and Hoffmann (n 152).

[183] Wilkins (n 147) p.157.

[184] Cameron Hutchison, 'Does TRIPS Facilitate or Impede Climate Change Technology Transfer into Developing Countries?' (2006) 3 University of Ottawa Law & Technology Journal 517 p.537.

Scholars[185] have also highlighted the issue of IPRs and whether they present a further obstacle to facilitating TT and technology diffusion. Hutchison believes that "overly restrictive IPR regimes may stifle precisely the type of local follow-on innovations" in developing countries that are needed.[186] There has yet to be any dispute regarding IP that directly relates to a climate change TT brought before the Dispute Settlement Body[187] but there is already evidence of refusals for licences for climate-friendly technologies.[188] Such a trend is expected to become an increasing problem over future climate change mitigation. And it is claimed[189] to do with a negative effect of the TRIPS regime.[190] However, in this research, the influence of TRIPS will be addressed in a much narrower environment (in China, and the renewable energy sector mainly). It is discussed with full consideration of the current IP system and a *sui generis* case of a large mid-income emerging economy in order to identify more rational minimum standards of patent protection for ESTs. Such standards shall be tailored according to the characteristics of climate change technology development in large developing countries that are capable of benefiting from increased and more fluent flows of licensed technology and which are able to attract significant FDI. Fundamentally, this thesis is aimed at an amended IP system that works better with the facilitating mechanisms provided by the climate change regime to increase EST transfer to developing countries and eventually

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[185] See detail discussion in Chapter I.
[186] Hutchison (n 184) p.528; Cox (n 72).
[187] "The General Council convenes as the Dispute Settlement Body (DSB) to deal with disputes between WTO members […]The DSB has authority to establish dispute settlement panels, refer matters to arbitration, adopt panel, Appellate Body and arbitration reports, maintain surveillance over the implementation of recommendations and rulings contained in such reports, and authorize suspension of concessions in the event of non-compliance with those recommendations and rulings." WTO, 'Dispute Settlement Body' (*WTO website*) <https://www.wto.org/english/tratop_e/dispu_e/dispu_body_e.htm> accessed July 2017
[188] Third World Network, Brief Note on Technology, IPRs and Climate Change (Penang: Third World Network, 2008). See also D. Shabalala and M. Orellana, Technology Transfer in the UNFCCC and other International Legal Regimes: The Challenge of Systemic Integration 2 (Geneva: International Council on Human Rights Policy, 2009) at 12.
[189] Hutchison (n 184) p.528; Cox (n 72).
[190] Peter Drahos, 'Developing Countries and International Intellectual Property Standard-Setting' (2002) 5 The Journal of World Intellectual Property 765; TRIPS Agreement.

contribute to environment protection. Expectations of CDM, are not high for the second commitment period[191] given that the major beneficiaries of CDM first time around (e.g. China) are no longer seeking as many CDM projects (detail of reasons is included in Chapter VI). However, such a flexible market mechanism is highly likely to be incorporated in any other post-2012 climate change regime[192] with more effort on cooperation among countries and more efficiency in moving towards the sustainable development objective embedded in the UNFCCC.[193] The outcome of such a mechanism will depend on how successfully it uses TT to address climate change.

4.4.4 The Paris Agreement

After several less constructive COPs[194] following the Kyoto Protocol, on 4 November 2016, the 2015 Paris Climate Change Agreement[195] entered into force.[196] The core objective of this

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[191] Began on 1 January 2013 and will end in 2020.
[192] Cox (n 72).
[193] Teresia Rindefjäll, Emma Lund and Johannes Stripple, 'Wine, Fruit, and Emission Reductions: The CDM as Development Strategy in Chile' (2011) 11 International Environmental Agreements: Politics, Law and Economics 7.
[194] Climate change in context:
"This time line detailing the international response to climate change provides a contextual entry point to the Essential Background. You can also use the links on the left-hand column under Essential Background to navigate this section.
2015 - Intensive negotiations took place under the Ad Hoc Group on the Durban Platform for Enhanced Action (ADP) throughout 2012-2015 and culminated in the adoption of the Paris Agreement by the COP on 12 December 2015. More on the Paris Agreement.
2014 - At COP 20 in Lima in 2014, Parties adopted the 'Lima Call for Action', which elaborated key elements of the forthcoming agreement in Paris. More on the Lima Call for Action.
2013 - Key decisions adopted at COP 19/CMP 9 include decisions on further advancing the Durban Platform, the Green Climate Fund and Long-Term Finance, the Warsaw Framework for REDD Plus and the Warsaw International Mechanism for Loss and Damage. Under the Durban Platform, Parties agreed to submit "intended nationally determined contributions", known as INDCs, well before the Paris conference. More on the Warsaw Outcomes.
2012 - The Doha Amendment to the Kyoto Protocol is adopted by the CMP at CMP 8. More on the Doha Amendment. Several decisions taken opening a gateway to greater ambition and action on all levels. More on the Doha Climate Gateway.
2011 — The Durban Platform for Enhanced Action drafted and accepted by the COP, at COP17. More on the Durban outcomes.
2010 — Cancun Agreements drafted and largely accepted by the COP, at COP 16. More on the Cancun Agreements.
2009 — Copenhagen Accord drafted at COP 15 in Copenhagen. This was taken note of by the COP. Countries later submitted emissions reductions pledges or mitigation action pledges, all non-binding.
2007 — IPCC's Fourth Assessment Report released. Climate science entered into popular consciousness. At COP 13, Parties agreed on the Bali Road Map, which charted the way towards a post-2012 outcome in two work streams: the AWG-KP, and another under the Convention, known as the Ad-Hoc Working Group on Long-Term Cooperative Action Under the Convention. More about the Bali Road Map.
2005 – Entry into force of the Kyoto Protocol. The first Meeting of the Parties to the Kyoto Protocol (MOP 1) takes place in Montreal. In accordance with Kyoto Protocol requirements, Parties launched negotiations on the next phase of the KP under the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP). What was to become the Nairobi Work Programme on Adaptation (it would receive its name in 2006, one year later) is accepted and agreed on. More about the Nairobi Work Programme.

Agreement is to control the global average temperature increase to " below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels."[197] The Agreement also aims at "enhancing the implementation of the Convention,[198] including its objective"[199] and therefore to "strengthen the global response to the threat of climate change, in the context of sustainable development."[200] In general, stabilization of GHG concentrations in the atmosphere is the ultimate objective of all agreements under the UNFCCC, including the Kyoto Protocol. This is intended to reduce the risk and impact of climate change, as well as advancing the ability to adapt to possible damages caused by climate change by facilitating finance flows and TT in relation to GHG emissions reduction and adaptation.[201]

By now, 100 parties have ratified the Paris Agreement. It is therefore unquestionably the latest remarkable step in the evolution of the climate change regime, building on the efforts undertaken since the establishment of the UNFCCC.[202] Despite what appears on paper, there are certainly problems in practice. Many disagreements are recurring as they have over the last 25 years. Discord about the different contributions that should be made to tackle climate change among countries has postponed the progress of reaching an international agreement.

2001 – Release of IPCC's Third Assessment Report. Bonn Agreements adopted, based on the Buenos Aires Plan of Action of 1998. Marrakesh Accords adopted at COP 7, detailing rules for implementation of Kyoto Protocol, setting up new funding and planning instruments for adaptation, and establishing a technology transfer framework.
1997 — Kyoto Protocol formally adopted in December at COP 3. More about the Kyoto Protocol."
'Background on the UNFCCC: The international response to climate change' (*UNFCCC Website*) <http://unfccc.int/essential_background/items/6031txt.php> accessed Feburary 2017

[195] Paris Agreement, Paris, 12 Dec 2015, C.N.819.2016.TREATIES-XXVII.7.d.

[196] Wolfgang Obergassel and others, 'Phoenix from the Ashes: An Analysis of the Paris Agreement to the United Nations Framework Convention on Climate Change–Part II' (2016) 28 Environmental Law and Management.

[197] Paris Agreement, Art. 2.1(a). Decision 1/CP.21, Adoption of the Paris Agreement. FCCC/CP/2015/10/Add.1, Annex: Paris Agreement, 29 January 2016.

[198] Article 1 of Paris Agreement: "'Convention' means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.".

[199] The Paris Agreement Article 2.1.

[200] The Paris Agreement Article 2.1.

[201] UNFCCC, 'China and US Bring Early Paris Entry into Force Big Step Closer' (*UNFCCC Newsroom*, 03. SEP, 2016) <http://newsroom.unfccc.int/paris-agreement/china-and-us-bring-early-paris-entry-into-force-big-step-closer/> .

[202] , 'Background on the UNFCCC: The international response to climate change'

Nevertheless, efforts on forging an entirely new regime in all aspects, including climate change mitigation and adaptation, financing TT, and capacity building in less developed countries have never stopped.[203]

There are several notable features in the Agreement that have contributed to the final achievement of the consensus among parties. For example, by adding "in the light of different national circumstances"[204] to the "common but differentiated responsibilities and respective capabilities" adopted by the UNFCCC, the Paris Agreement explained the principle in a slightly different way.[205] The newly expressed article not only represents developing countries' intentions on reiteration of the differentiation principle but also shatters the traditional and non-flexible dichotomy of the UNFCCC Annexes.[206] Accordingly, issues concerning the bindingness of the Agreement were also tailored to accommodate the different national situations of the parties. Thus, the legal form of the Agreement diverges from[207] the Kyoto Protocol[208] and in turn makes it easier to be ratified by more countries, especially the US, and it thereby becomes a real global agreement.[209] On the negative side, the Agreement sacrificed any binding obligations with regard to emission-reduction or financing activities. Contributions provided by parties are voluntary during implementation of the Agreement. The

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[203] Obergassel and others (n 196).
[204] Paris Agreement, Art. 2.2. Decision 1/CP.21, Adoption of the Paris Agreement. (n 197).
[205] Raymond Clémençon, 'The two sides of the Paris climate agreement: Dismal failure or historic breakthrough?' (2016) 25 The Journal of Environment and Development 3.
[206] "new institutions such as the Green Climate Fund, the Adaptation Committee, the Technology Executive Committee and the Clean Technology Centre and Network founded have furnished the construction of the Paris Agreement." Obergassel and others (n 196).
[207] "This convention-protocol construction was the preferred approach developed in the late 20th century for environmental treaty regimes." Ibid (n 196).
[208] As for the history, see Oberthür and Ott (n 148) p.239 ff. quoted by Obergassel and others (n 196).
[209] "This, however, would have forced the US Government to submit the protocol to the Senate for ratification. The Parties in Paris thus chose a legal form that is not provided for in the UNFCCC because it is neither an amendment to the convention nor a protocol. This innovative legal approach immediately sparked a discussion in the US whether the Paris Agreement is a treaty and whether it has to be submitted to the Senate for ratification." See David Bookbinder, 'Is The Paris Climate Agreement A Treaty?' (*Climate and Energy Policy*, May 5, 2017) <https://niskanencenter.org/blog/paris-climate-agreement-treaty/> .

typical example is the dispute over wording in Article 4.4 of the final draft of the Agreement.[210] This change of wording raised by the US implied that the developed countries are "meticulous to ensure that no language would find its way into the Agreement that could be construed as constituting new commitments which would require Congressional approval."[211] In this case, through the use of the wording "nationally determined contributions" parties to the Agreement do not have to undertake an absolute emission-reduction commitment, therefore substantially weakening the obligations imposed on relevant countries.[212]

Another product of the Paris Agreement is the cooperative mechanism established under Article 6.4 of the Agreement. Such a mechanism is market-based, making use of the experiences accumulated under the Kyoto Protocol but not rigidly adhering to its patterns.[213] For example, the scope of this mechanism is considered broader than the Kyoto Protocol because it covers more than project-type activities. As a result, activities such as bilateral emission trading, international-level collaboration over EST capacity building and environmental policy amelioration will be counted as activities that "contribute to the mitigation of greenhouse gas emissions and support sustainable development."[214] Furthermore, Article 6.4(d) stipulates that the mechanism shall aim to "deliver an overall

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[210]The using of "shall" were requested to be changed for "should" in the sentence "Developed country Parties shall ("should" in the published version) continue taking the lead by undertaking economy-wide absolute emission reduction targets." According to the US government lawyers, this is "a vital word which could make the difference between rich countries being legally obliged to cut emissions rather than just having to try to." John Vidal, 'How a 'Typo' Nearly Derailed the Paris Climate Deal' (*TheGuardian News Report*, 2015) <https://www.theguardian.com/environment/blog/2015/dec/16/how-a-typo-nearly-derailed-the-paris-climate-deal> .

[211] Obergassel and others (n 196).

[212] Ibid.

[213] Paris Agreement, Decision 1/CP.21, Adoption of the Paris Agreement, para. 37f.

[214] Article 6.4

mitigation in global emissions."[215] The target of "overall" emission reduction would help avoiding loopholes that let unobligated developing countries continue their emission increases. These emissions are adding to the subtotal of global emission offsetting and the emission-reduction effort of developed countries. Such a requirement will probably become the norm of outsourcing from developed countries that has led to "the zero-sum game of the Kyoto Mechanisms to date."[216] However, it is still not possible at this stage to predict the success of the new mechanism compared to the Kyoto mechanisms. These opportunities hinge on yet-to-be-developed guidance and down-to-earth exploration.[217] By inviting both developed and developing countries to make use of the mechanisms and encourage participation of public as well as private entities under the oversight of UNFCCC, it is possible that the cooperative mechanism invented by Paris Agreement will go beyond the current flexible mechanisms such as the CDM.

The Paris Agreement is quite cautious in its approach to IPR issues. Text directly concerning IPR issues was considered to be too sensitive and controversial, so it does not appear in the final version of the Paris Agreement. This derives from the long history of differentiation over IPRs between developed and developing countries as discussed in chapter I. Therefore, it was highly predictable that any reference to IPRs in the text would incur strong opposition from developed countries, especially the US, and would have resulted in a deadlock barring the achievement of the Agreement.

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215 Paris Agreement, Art. 6.4d.
216 Obergassel and others (n 196).
217 Decision 1/CP.21, Adoption of the Paris Agreement, para. 37f. FCCC/CP/2015/10/Add.1, 29 January 2016.

With regard to TT, the Agreement also involves "further development of the UNFCCC's Technology Mechanism, including the work of the Technology Executive Committee, and the development and operationalization of the Climate Technology Centre and Network."[218] With the effort of developing countries, the Agreement also established a technology framework aiming at improving the UNFCCC Technology Mechanism. Article 10 especially points out the importance of technology development and TT "to improve resilience to climate change and to reduce greenhouse gas emissions."[219] Moreover, it encourages parties to "strengthen cooperative action on technology development and transfer."[220] Correspondingly, although not included in the text of the Agreement directly, it will inevitably confront IPR issues through the implementation of the aforementioned provisions.[221] However, any pertaining disputes remains unclear under any MEA to date.

For developing countries, the bright side is that they have successfully established a clear link between technology and finance.[222] Although the language concerning the legal obligations of financing contributions[223] for mitigation and adaptation in developing countries is vaguely expressed to accommodate the US's interior political constraints,[224] for now at least the finance needed for the acquisition of copyrighted technologies is acknowledged in the Agreement, providing a possible basis for future dispute settlements. Then again, the

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[218] Obergassel and others (n 196).
[219] Paris Agreement, Art. 10(1).
[220] Ibid.
[221] More details See A. E. L. Brown, 'Intellectual Property and Climate Change' in R. Dreyfuss and J. Pila (eds), *The Oxford Handbook of Intellectual Property Law* (Oxford University Press 2017).
[222] Paris Agreement, Art. 10(5).
[223] "The accompanying decision text reiterates that the goal of annual USD 100 billion of North-South financial flows in 2020 and beyond, promised already in Copenhagen, is still valid, and will be ramped up before 2025. The USD 100 billion must therefore be the floor of financial contributions. Until now, many industrialized countries regarded the pledge of Copenhagen more as a ceiling. However, the coming negotiations will prove interesting, as the current decision text does not specify who will contribute to the stronger financing goal, but only speaks of setting 'a new collective goal'." Obergassel and others (n 196).
[224] Ibid.

shortage of the weak binding power is a makeshift, being “a step that needed to be taken in order to get moving at all.” [225] From that perspective, the Kyoto Protocol failed to qualify as a successful treaty, due to having several non-compliant countries refuse to comply with the obligations in the first commitment period.[226] Furthermore, the former party Canada withdrew from the Protocol while other members such as Russia, New Zealand, and Japan took on no further commitment in its subsequent commitment period.

Despite the price paid in order to reach an agreement, the actual effect of such an achievement hinges on the subsequent negotiation between parties over implementation of the financial and other effectively enforced mechanisms. At this stage, the effectiveness of mechanisms under the Paris Agreement is doubtful for it has no caps, compulsory absolute emission targets or assistant obligations set in the provisions. This would have made the measuring of contributions, especially contributions to assist developing countries, more intricate and confusing. With the contributions being determined by each party voluntarily, there are no legally binding obligations securing the outcomes of its implementation. The Kyoto Protocol *quoad hoc* has an intrinsic advantage. Also, with the diplomatic atmosphere that surrounds international climate change negotiations, participants are scrupulous with issues that might incur conflict and consequently result in failures. Mention of IPRs within climate change treaties seems to be a presumptuous demand because it “has always been a red line issue” [227] and probably will not change in the future. Therefore, it is not enough to

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[225] Ibid.

[226] For example, “back in 1997, the Kyoto Protocol entered into force without the ratification by the US.” Igor Shishlov, Romain Morel and Valentin Bellassen, ‘Compliance of the Parties to the Kyoto Protocol in the first commitment period’ (2016) 16 Climate Policy 768.

[227] Obergassel and others (n 196).

rely on such concessions and requires more work to be done in a chapter on IPRs to see whether there is a better way out for the issue.

4.5 Conclusion and bridging to IP regime

The discussion in this chapter mainly looks into the international efforts to mitigate climate change, and the platforms established to coordinate actions by all countries. Nearly all important MEAs employ TT as a tool to encourage environmental protection capability and to generate enthusiasm for such in countries, especially the less developed ones. UNFCCC, as one of the most significant MEAs providing a vital mechanism for multilateral action to combat climate change,[228] has clearly promoted TT through its mechanisms (i.e. CDM under the Kyoto Protocol). However, these efforts are far from sufficient to solve climate change crises and unlikely to achieve global ratification. Moreover, MEAs are not dealing with IPRs issue directly arising from TT they have promoted. Almost unanimously, scholars and governors feel that the IP regime is a necessary and useful element that needs continued acknowledgement in any climate change agreement. Although the TRIPS preamble seems to be sufficient, the question is whether the provisional and institutional design under the Agreement is set up to reach the full potential of its objectives. This thesis believes that more could and should be done for the current international IP system (the TRIPS) to complement the MEAs regarding IP issues derived from climate change TT. This will be discussed in more detail in the next chapter.

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[228] UNFCCC, 'Introduction to the Convention' (*UNFCCC Newsroom*) <http://unfccc.int/essential_background/convention/items/6036.php> (n 96).

Chapter V: Bearing of Intellectual Property Rights and the TRIPS Agreement on TT to China

5.1 Introduction

Global climate change has already had observable effects on the environment. And while awareness of the crisis is increasing, the need for transferring green technologies between developed countries and developing countries is rising. IPRs that have a great effect on green TT should there from be reconsidered in the context of climate change and a revisiting of relevant agreements is important. In order to clarify the current imperfect legal environment pertaining to climate change TT, this chapter aims looking at the current international agreements, the TRIPS Agreement in particular, and whether the traditional justifications for IP provide a suitable rationale for protecting and disseminating climate change technologies. This chapter will refer to patent rights and issues regarding green technologies that could be protected under IPR regime specifically for they are closely bonded to TT activities.

Climate change influences range across several different areas. One of the most significant is the atmospheric temperature-rise, which leads to an increase in the frequency or severity of extreme weather events, such as storms, flooding, high winds, and other direct threats to people and property. Furthermore, an increase of the incidence of diseases may be caused by climate change as warmer temperatures may increase the concentrations of unhealthy air and water pollutants and extreme events might promote the further spread of some diseases such as malaria.[1] To a certain extent, the problem of climate change shall be considered crucial and unique, because the issue is extremely influential in terms of its impact on human health

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[1] Nicholas Herbert Stern, *The Economics of Climate Change: The Stern Review* (Cambridge University Press 2007) p.65-88.

and lifestyle. Solutions to the problem may need to be radical and this will significantly alter the paradigm of global economic activity and the relevant regulations. For example, "limiting GHGs emissions under the Kyoto Protocol requires developed countries to modify their primary economic structures, including making transformations within energy, transportation, manufacturing, agriculture, and investment sectors."[2] Such agreements identify the determination and the actual need for special treatment towards climate change technologies. A more important factor in determining the success of climate change mitigation is the strong and positive political will of each country. In other words, if global climate change is to be dealt with successfully, many countries may need to pass and enforce draconian legislation. In fact, some actions taken at a national level by internationally influential countries, like China, are already manifesting this political will.[3]

New technologies will inevitably be involved in solving the problem, and they are believed[4] to have great potential in the future of global sustainable development. The downside of reliance on technology is that it requires large capital costs for research, development and large-scale application. Such costs could be burdensome to many developing countries.[5]

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2 Cinnamon Piñon Carlarne, 'The Kyoto Protocol & the WTO: Reconciling Tensions Between Free Trade & Environmental Objectives' (2006) 17 Colorado Journal of International Environmental Law and Policy 45 p.48.

3 More detailed observations on this matter will be presented in chapter VI.

4 Stabilization Wedges, 'Solving the Climate Problem for the Next 50 Years with Current Technologies Pacala, S.; Socolow, R' (2004) 305 Science (Washington, DC, United States) 968.

5 According to the UNFCCC report on climate change adaptation costs, "total funding need for adaptation by 2030 could amount to $49–171 billion per annum globally, of which $27–66 billion would needed in developing countries." (Martin L. Parry, *Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC and Other Recent Estimates* (LIED 2009)) As an example, "removing the housing and infrastructure deficit in low- and middle-income countries will cost around $315 billion per year over 20 years; while adapting this upgraded infrastructure specifically to meet the challenge of climate change will cost an additional $16–63 billion per year." (ibid) In some positive cases, climate change technologies will not generate large costs to developing countries if the technology is properly commercialized during the process of large-scale application. For example, in Brazil, production of biofuel from sugar cane is mutually commercialized, which means that the production processes are already cheaper than traditional energy sources such as petroleum, meaning that "the necessary capital investment should be forthcoming from the private sector, both for research and for installation." (John H Barton, 'Mitigating Climate Change Through Technology Transfer: Addressing the Needs of Developing Countries' Energy, Environment and Development Programme: Programme Paper 08/02, (October 2008) <https://www.chathamhouse.org/sites/files/chathamhouse/public/Research/Energy,%20Environment%20and%20Development/1008barton.pdf> accessed 22 Aug 2017) However, these examples are few, while most of the technologies are expensive in many respects. Obviously, the costs must be envisioned before any climate change technology can actually work. Costs "may be high

Legislative solutions to offset the limited application due to high price of climate change technology, such as the establishment of a technology fund, could be feasible options in the short term. Yet such aid requires external force to consistently raise funds and manage the distribution of funds in order to maintain the proper functioning of the measures. In the long run, such aid can only scratch the surface if it does not make use of the invisible hand of the market.

In terms of the role that an IP system plays in climate change mitigation actions, it can be positive "in encouraging new business development, rationalization of inefficient (green) industry, and inducing technology acquisition and creation."[6] But IP protection is also suspected to "harm development prospects by raising the costs of imitation and permitting monopolistic behavior by owners of IPRS."[7] Herein lies the classic dilemma between the advantages and disadvantages of IP protection, regardless of industry sector. Because of the subtle relationship between IPRs and the development and TTs, a cooperative system between developed and developing countries – carefully designed for regulating IP in the climate change context that both encourages innovation and facilitates distribution of technology – is required. However, there will be impediments from people with vested interests that frustrate any changes to the established order. For this reason, Garrett Hardin[8] believes that international solutions intended to solve the problem must be based on a kind of

because the technology requires R&D before it can become economically attractive." (ibid) Costs will remain high unless adjusted by the environmental consequences of GHG emissions. For this reason, the cost will decline after several years of implementation of the relevant subsidy or regulation in the affected area. At present, some of these technologies are not well commercialized to compete in the market, for instance, the more advanced technologies for GHG emission reduction, such as carbon capture and storage technologies are simply not economical at current prices. "Hence, they will be applied only if required by law, subsidized by governments, or made competitive by a substantial carbon tax." (ibid).

[6] Keith E Maskus, 'Intellectual Property Rights and Economic Development' (2000) 32 Case W Res J Int'l L 471.

[7] Ibid.

[8] Garrett Hardin, 'The Tragedy of the Commons' (1968) 162 science 1243.

agreed “coercion”. Example agreements of such were indeed launched at the 1992 Earth Summit.[9] But it might be difficult for such coercion to be executable, feasible and implemented (ideally) in the short term. Bruch and Pendergrass propose “an alternative approach, which is to rely on voluntary partnerships between governments and the private sector to advance sustainable development.”[10] While it is more moderate and realistic, the voluntary approach[11] could be less strongly binding and not as regulatory as more coercive approaches. Despite the difficulties in developing a new way to look at IPRs, with an eye on the long term, this research seeks reforms to deal with the perpetual paralysis of the current IP system in regard to climate change, while retaining the function that IPRs already play in many areas. Therefore, a revisit at the justification for IPRs, patents in particular, and the currently widely ratified international IP regime is needed.

5.2 Justification for patents

IPRs protect objects that “are produced through mental or creative labor by human beings,” stated in laws that “describe the legal status and protection that allows people to own the

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9 In Rio, two legally binding Conventions aimed at preventing global climate change and the eradication of the diversity of biological species were opened for signature at the Summit: The United Nations Framework Convention on Climate Change and The Convention on Biological Diversity.
Moreover, Rio launched the process for four more conventions:
The 1994 Convention to Combat Desertification; The 1995 UN Agreement Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Species; The 1998 Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; The 2000 Stockholm Treaty on Persistent Organic Pollutants.
Finally, at Rio, governments adopted three major documents aimed at changing the traditional approach to development:
Agenda 21 - a comprehensive programme of action for global action in all areas of sustainable development; The Rio Declaration on Environment and Development - a series of principles defining the rights and responsibilities of States; The Statement of Forest Principles - a set of principles to underlie the sustainable management of forests worldwide.
United Nations, Earth Summit, at <http://www.un.org/geninfo/bp/enviro.html>; Hilary French, ‘Reshaping Global Governance’ [2002] State of the World 174, p.178-179.

10 See Carl Bruch and John Pendergrass, ‘Type II Partnerships, International Law, and The Commons’ (2002) 15 Geo Int'l Envtl L Rev 855.

11 For example, the World Band Publich-Private-Partnership (“A long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility and remuneration is linked to performance.” See World Bank, ‘Publich-Private-Partnership Referecnce Guide 3.0’ (*PPP Knowledge Lab*) <http://www.worldbank.org/en/topic/publicprivatepartnerships> accessed May 2017).

intangible products of their creativity and innovation imbedded in physical objects"[12] and their physical properties. In general, the reasons that protection is given to IPRs are twofold. One is to "give expression to the moral sentiment that a creator, such as a craftsman, should enjoy the fruits of their creativity;" and the other is to "encourage the investment of skills, time, finance, and other resources into innovation in a way that is beneficial to society."[13]

However, "the tension between stimulating creation and disseminating its benefits to society at large is delicate."[14] For example, Landes and Posner claim that "expanding IPR can actually reduce the amount of new IPR that is created by raising the creators' input costs, since a major input into new IP is existing (protecting) such property."[15] This is intuitively true with patent rights behind which lie inventions and innovations adding up to the foundation of future R & D activities. Patents, as a vital component of the IPR set,[16] in fact, provide no solid evidence to confirm the relationship between the strength of patent protection and the growth of international TT flow into a region. Even in a domestic market, for example the US, a patent is merely one of the few encouragements to R & D investment and economic growth.[17] Conclusions about the effectiveness of patents as an incentive to investment are ambiguous, as they are on patents' importance in encouraging inventors and innovators.

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[12] See Lionel Bently and Brad Sherman, *Intellectual Property Law* (Oxford University Press, USA 2014) p.1-3.
[13] See World Intellectual Property Organization (WIPO), *WIPO Intellectual Property Handbook: Policy, Law and Use* (World Intellectual Property Organization 2004).
[14] See, e.g., Thomas Cottier and Petros C. Mavroidis, *Intellectual Property: Trade, Competition, and Sustainable Development*, vol 3 (University of Michigan Press 2003). See also, Philippe Cullet, *Intellectual Property Protection and Sustainable Development* (LexisNexis, Butterworths 2005).
[15] William M. Landes and Richard A. Posner, *The Economic Structure of Intellectual Property Law* (Harvard University Press 2009) p.422.
[16] Patents "create a proprietary interest in non-excludable (The term is used to describe a good or service that can be assessed by non-paying consumers without being prevented from accessing it.), non-rivalrous (Non-rival goods are the opposite of rival goods. These goods allow consumption or possession to multiple users.) goods (i.e. the invention) by giving rights of exclusive use, manufacture and sale to the owner of an invention, and providing legal recourse against infringement (i.e. unauthorized use, manufacture or sale)." Cameron Hutchison, 'Does TRIPS Facilitate or Impede Climate Change Technology Transfer into Developing Countries?' (2006) 3 University of Ottawa Law & Technology Journal 517.
[17] IPRs have the potential to provide incentives for investment and trade, and thereby sometimes contribute to economic growth. This is proved by evidence found in American pharmaceutical R & D practice. However, "it is hard to find evidence suggesting

With the rising costs of exploring and applying new technologies, one might ask: "apart from encouraging the innovation required for economic growth, aren't IPR and patents also designed to contribute to the public good by ensuring the effective short-term dissemination and long-term assimilation of technology?"[18] With the effects of climate change becoming increasingly severe, lawmakers will be confronted with questions involving the rights to control information that may help in solving the problem.[19] Such contention leads to the necessary justification of the international framework of IPR protection. So many of the problems mentioned above should be dealt with a clearer understanding of the purpose of IPR/patents and of how to balance the demands of the different entities. The discussion of the theoretical aspects of patents aims to provide lawmakers and governments with new perspectives from which to look at these questions. This is so that their arguments will be "not merely systematic accounts of the impulses that have shaped extant legal doctrines, but guides that legislators and judges can use in modifying or extending those doctrines in response to new technologies and circumstances"[20] whenever needed.

5.2.1 Natural rights justification

As identified by Machlup,[21] the concept of the patent must have absorbed the theory of natural rights[22] that recognizes an inventor's certain basic rights which should not deniable

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patents are a major factor spurring R & D investment, that patents contribute to economic growth, or even that the patent system is a source of great wealth to important inventors and innovators (outside of a few industries like pharmaceuticals)." James Bessen and Michael James Meurer, *Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk* (Princeton University Press 2008).

[18] Wei Shi, *Intellectual Property in the Global Trading System: EU-China Perspective* (Springer Science & Business Media 2008).

[19] Should the inventors of green technologies be granted rights to manipulate the price, keeping more potential users from affording the applications? What degree of monopoly power should be just necessary to encourage innovation without it being abused by the companies and slowing down progress and the diffusion of knowledge? Should we scale down patent protection to boost future configurations of widely distributed products? Should governments intervene in the transfer of climate change technologies as a supplement to patent law, or should they establish a quasi-legal regime?

[20] William Fisher, 'Theories of Intellectual Property' [Cambridge University Press Cambridge, UK] 168 New essays in the legal and political theory of property.

[21] Fritz Machlup, *Essays in Economic Semantics* (New York University Press 1975).

[22] The most recognized theory is John Locke's conception of natural rights.

by any authority. This is based on the presumption that if a person owns himself, then he owns the product of his labour. A natural right is different fro patent right. It should be noted that a patent holder's rights are essentially rights to exclude others from performing acts that would severely damage benefit of the owner. “A patent by itself does not give its owner a positive right to make, use, sell or import the patented invention, as these acts could be governed by other laws, or may fall within the scope of earlier, broader patents.”[23] But it is believed by Lemley[24] to have a part of "absolute protection" in order to fulfil the objective of IP law, which is to encourage innovation. The underlying thinking is that creators will not have sufficient incentive to invent unless they are fairly respected by society and legally entitled to capture the full value of their inventions. Such view supports IP as a type of "real" property. However, there are parts of the IP system that are not designed in accordance with the theory. For example, the first to file an application for a patent, instead of the first to invent, is recognized as the right-owner. Although, on many occasions the first to file and the first to invent do dovetail, in cases where the two do not, the patent does not recognise the labour of the inventors who failed to file their patents in time. A similar example is that “patents are territorial, meaning that a patent granted in one country has no legal effect in another.”[25] One might argue that the state-of-the-art requirement entrenched in many jurisdictions would eliminate the effect of such territorial limitation. However, in some countries, like the

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[23] Antony Taubman and Jayashree Watal, ‘The WTO TRIPS Agreement – A Practical Overview For Climate Change Policymakers’ (13 Dec 2010) Intellectual Property Division of the WTO Secretariat <https://www.wto.org/english/tratop_e/trips_e/ta_docs_e/8_3_overviewclimatechange_e.pdf> accessed 30 June 2017.

[24] Mark A. Lemley, ‘Property, Intellectual Property, and Free Riding’ (2004) 83 Tex L Rev 1031.

[25] Taubman and Watal (n 23).

Chinese 2000 Patent Law,[26] state-of-the-art requirement does not necessarily imbue the true inventors with priority in the filing queue.[27]

Some countries and agencies have endeavoured to promote the international harmonization of the IP law system.[28] Such an effort was encouraged by proposals made by scholars to further harmonize domestic laws at international level, pursuing globalization from the nineteenth century on.[29] More advocates such as Sherwood[30] and Radack[31] believe in "a uniform patent law system that simplifies the law, making it easier to receive and enforce patents in many jurisdictions while reducing administrative costs."[32] This idea is adopted by the majority of the international patent community.[33] As a result, the World Intellectual

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[26] The Patent Law of the People's Republic of China (as amended up to the Decision of December 27, 2008, regarding the Revision of the Patent Law of the People's Republic of China).

[27] More details in Chpater VI. Article 22 highlighted a novel requirement for the granting of a patent right.According to article 22: "Novelty means that, before the date of filing, no identical invention or utility model has been publicly disclosed in publications in the country (China) or abroad or has been publicly used or made known to the public by any other means in the country, nor has any other person filed previously with the patent administrative organ under the State Council an application which described the identical invention or utility model and was published after the said date of filing." It should be noted that the article distinguished "disclosed in publications" from "other means" of disclosure. The latter is dealt with under a domestic regional standard rather than an absolute regional standard. In that case, inventions disclosed in a non-publication manner abroad might be considered as IP belonging to an applicant who filed them in China. Fortunately, such a loophole is counteracted by the amended 2008 Patent Law, yet it kept the old Article 24 in the text. Article 24 provides three circumstances where "an invention/creation for which a patent is applied does not lose its novelty. Within six months before the date of filing, if (1) it was first exhibited at an international exhibition sponsored or recognized by the Chinese Government; (2) it was first made public at a prescribed academic or technological meeting; or (3) it was disclosed by any person without the consent of the applicant." Within article 24 a six-month-long "grace period" argument is in fact not recognized in many other countries where they apply a rule of absolute novelty (Christopher B. Kilner, 'U.S. "Novelty" vs. International "Absolute Novelty"' (Vol6, Issue 8 - 8/15/2002) <https://www.marburylaw.com/images/files/usnoveltyvsinternationalabsolutenovelty.pdf> accessed 22 Aug 2017) and thus the inventor might not be able to secure patent protection in these countries. (The grace period argument will not be rejected in the US and Canada. See Dongwook Chun, 'Patent Law Harmonization in the Age of Globalization: The Necessity and Strategy for a Pragmatic Outcome' (2011) 93 J Pat & Trademark Off Soc'y 127; See also Geng Liu, 'Patent Novelty and Its Application in Intellectual Property Strategy' (2006) 7 Patent Law Research p.156-65 "This happens in some countries where they have a rule of absolute novelty to obtain a patent: any public disclosure of the invention, even by the inventor, is generally a bar to obtaining patent protection."(Kilner n 27) Again, it is far-fetched to explain the juridical limitation of patents through the lens of natural right, and it is hard to hope for a unitary patent on an international basis.

[28] Such as the Leahy–Smith America Invents Act, PL 112–29 [HR 1249] entered into force on 16th September, 2011; See also Chun (n 27).

[29] "when the Italian Minister of Justice Pasquale Stanislao Mancini sought to convene a conference for the harmonization of private international law" Max Rheinstein, Ulrich M. Drobnig and Peter Hay, 'Conflict of laws' (*Encyclopædia Britannica*, February 10, 2015) <https://www.britannica.com/topic/conflict-of-laws> accessed 27 Aug 2017, quoted by Chun (n 27)

[30] Sherwood argues that "a uniform intellectual property system makes sense for the world." Robert M. Sherwood, 'Why a Uniform Intellectual Property System Makes Sense for the World' (1993) 68 Global dimensions of intellectual property rights in science and technology 79.

[31] Radack further supported this idea as he stated that "the phrase [patent harmonization] refers to efforts to make individual national patent laws around the world more uniform." David V. Radack, 'Patent Harmonization: Creating Uniform Patent Laws' (1997) 49 JOURNAL OF THE MINERALS 66, available at http://www.tms.org/pubs/journals/JOM/matters/ matters-9705.html.

[32] John F. Duffy, 'Harmony and Diversity in Global Patent Law' (2002) 17 Berkeley Technology Law Journal 685 Quoted by Chun (n 27).

[33] Duffy (n 32) quoted by Chun (n 27).

Property Organization (WIPO) was established and the WTO also includes agreements that endeavour to uniform and standardize the patent systems in its Member States. Examples include: “the Paris Convention for the Protection of Industrial Property (Paris Convention), the Patent Cooperation Treaty (PCT), the Patent Law Treaty (PLT), and the Trade-Related Aspects of Intellectual Property Rights (TRIPS).”[34]

However, there are many different voices that are not interest in a one-fits-all legal system. This is not only due to the significant time and money costs required to join the patent system, but also because it fetters a country’s freedom to design its own IP structure to suit its domestic situation. In the context of climate change, where circumstances are extremely different between countries, the question remains: “to what level and in what order should harmonization take place?”[35] More importantly, the relevant policy decision must determine to what extent differing climate change situations, and differing independent technology capabilities between different jurisdictions, should be overlooked in order to achieve global uniformity. It is clear that a green-technology-friendly patent system would help a country to gain an edge in the field of intense international patent competition. By taking advantage of the jurisdictional feature of patent, some countries have been making efforts to secure ‘green’ patent applications. Certain inventions, such as energy or water solutions that are safe, clean, recyclable, and efficient, are more eligible for a prioritized patent application process,[36] which is more speedy and straightforward. Once a patent is filed in one of the countries, it

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34 Takashi Kinoshita, ‘Strategy for Harmonization of US Patent System with International Norm’ MACD Project (May 2001) <http://www.commercialdiplomacy.org/pdf/ma_projects/kinoshita_takashi.pdf> accessed 24 Aug 2017, quoted by Chun (n 27).

35 Jerome H. Reichman and Rochelle Cooper Dreyfuss, ‘Harmonization without Consensus: Critical Reflections on Drafting a Substantive Patent Law Treaty’ (2007) 57 Duke Law Journal 85 p.126.

36 Eric L. Lane, ‘Building the Global Green Patent Highway: A Proposal for International Harmonization of Green Technology Fast Track Programs’ (2012) 37 Berkeley Technology Law Journal. It has been noticed that China, Japan, the U.K. and the US have launched the accelerated patent examination for green-energy technologies.

actually affects potential applicants in other countries ratified by the PCT, which can enhance the advantage of future competition in the green-technology market and promise sustainable development for the country. Such an advantage could be visible in the environment-management input cost comparisons between green-technology owning and green-technology receiving countries, and the gap may extend further, since "a major input into new IP is the existence of such property."[37] After all, patents are by their very nature jurisdiction-based and aimed to benefit society in a particular jurisdiction. Therefore patent rights are not as absolute as natural right on which they claims to justify.

5.2.2 Reward theory or award justification

Another way to look at how to justify patents is that the grant of a patent with exclusive/monopoly rights can be considered as an award rather than an underlying fiscal reward to inventors. The premise for this discussion is a consensus that law-making should be based on efforts towards the maximization of net social welfare:

> It requires lawmakers to strike an optimal balance between, on one hand, the power of exclusive rights to stimulate the creation of inventions and works of art and, on the other, the partially offsetting tendency of such rights to curtail widespread public enjoyment of those creations.[38]

[37] Shi (n 18).
[38] Fisher (n 20).

The pursuit of such balance might sometimes be a dilemma when lawmakers are prioritizing the reward theory[39] over any other awarding measures. Thus it might be easier to test the law under the basic objective for patent establishment: to encourage inventive activities.

Indeed, in the absence of a fiscal reward, technology developers would struggle to recoup expenses needed in and for inventing. It would then discourage inventors from future inventive works, resulting in inadequate numbers of innovations available to society.[40] Therefore, historically and still today, monopoly patent rights are the preferred form of award for inventions, for they are considered to be a good way to reward the inventor for his or her risk and expense.[41] The reward justification of a patent is thus based on an acknowledgement that it "allows innovators to recoup their costs and make a profit from their inventions, thus offering incentive to invest in the research and development of technologies and, upon fruition, to disclose the details of their inventions."[42] This might be true today in some sectors of industry where there is extensive R & D on which millions of pounds are expended and where the cost of duplication is relatively low once the secret of the process is acquired. In high-technology sectors like pharmaceuticals:

> the risk of failure of expensive research to bear fruit is high and entrepreneurs must have good reason to expect that the cost of failure can be recaptured from the profits of future success. Otherwise there is little incentive to undertake innovative activities.[43]

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[39] Economist Fritz Machlup has ably and comprehensively reviewed the history of the reward theory. See F. Machlup, *An Economic Review of the Patent System* (U.S. Government Printing Office 1958), quote by Matthew Erramouspe, 'Staking Patent Claims on the Human Blueprint: Rewards a Rent-Dissipating Races' (1995) 43 Ucla L Rev 961.
[40] Erramouspe (n39).
[41] A. Smith, *The Wealth of Nations: An Inquiry into the Nature and Causes of the Wealth of Nations.* (R. H. Campbell and A. S. Skinner eds, Oxford: Clarendon Press 1976) p.339, quote by Erramouspe (n 39).
[42] Hutchison (n 16).
[43] Shi (n 18) p.24-66.

A granted monopoly will buy them some time to recoup their investment and make a profit. This is not only a variation of reward but, more importantly, it will provide them with a sense of security for future investments.

However, the causality between temporary monopoly rights and financial returns from an invention is weak. This is because a patent is defined only to the extent to which right holders may exclude others from activities that infringe or damage the IP.[44] In other words, instead of guaranteed rewards, the patent system simply "sets out and protects the boundaries of legal means of competition among firms seeking to exploit the value of creative assets."[45] Thus, although a patent provides some advantages for the inventor in future competition when exploiting the invention, it does not secure any capital gains. If the patent is not licensed, exploited or if it fails in subsequent commercialization, there will be no reward for the inventor to recoup expenses. In the environmental industry, most equipment manufacturers are also inventors themselves (usually they employ people to invent for the company). The UK Intellectual Property Office (IPO) statistics show that only 1.4 per cent of non-manufacturing firms patent.[46] Thus, the majority profit made by these manufacturers is from the selling and installation of equipment, which is dependent on the accumulation of a wide range of knowledge and the fruits of long-term R & D. In other words, it is impractical for firms that are not deeply specialized in a narrow area to duplicate competitive products for corresponding markets. As a result, the secrets of environmental inventions are naturally protected by the complexity of the technology itself. Even without patent protection, the reward will be

[44] Keith Eugene Maskus, *Intellectual Property Rights in the Global Economy* (Peterson Institute 2000) (n 6).
[45] Ibid
[46] Mark Rogers and others, 'The Use of Alternatives to Patents and Limits to Incentives' Intellectual Property Office Research Paper No 2012/21 (2012) <https://ssrn.com/abstract=2710628> accessed 21 Jun 2017.

secured anyway. Consequently, Community Innovation Survey (CIS) data[47] suggests that the overwhelming share of firms do not consider patents to be an important mechanism to protect inventions and secure rewards. Only between 2.8 per cent (CIS 3) and 5 per cent (CIS 5) of firms regard formal IP[48] with an emphasis on the trademark, not the patent, to be crucial.[49] After all, patenting is just the start of the commercialization journey and is not an end in itself. Many registered patents, which are expensive and difficult to obtain, are actually unexploited. In these situations, the patent system does not deliver the profits the reward theory promises.[50] Those who have successfully commercialized require much more than a patent description; they also require massive funding and labour to develop, examine and refine an idea to the point of commercial viability.

Do patented technologies secure companies' finance? The only benefits arise primarily from the potential to license the patent in exchange for royalty payments or to sell patented technology for a lump-sum payment (more cases being found in small technology companies and in company acquisitions[51]); and secondarily to secure inventors' income by excluding imitators from duplicating the technology, in order to protect their competence in the market. However, "it may be difficult for firms to determine the total stream of future expected

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47 The Community Innovation Survey (CIS)" based innovation statistics are part of the EU science and technology statistics. Surveys are carried out with two years' frequency by EU member states and number of ESS member countries. Compiling CIS data is voluntary to the countries, which means that in different surveys years different countries are involved. The CIS is a survey of innovation activity in enterprises. The harmonised survey is designed to provide information on the innovativeness of sectors by type of enterprises, on the different types of innovation and on various aspects of the development of an innovation, such as the objectives, the sources of information, the public funding, the innovation expenditures etc. The CIS provides statistics broken down by countries, type of innovators, economic activities and size classes." 'Community Innovation Survey (CIS) - Description of Dataset' (*Eurostat Website*) <http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey> accessed 11 Aug 2017.

48 "Formal IP contains patents, trademarks, registered designs and copyright; registered IP contains patents, trademarks and registered designs; informal IP contains secrecy, lead-time, complexity and confidentiality." Bronwyn H. Hall and others, *The choice between formal and informal intellectual property: a literature review* (No w17983, 2012)

49 Rogers and others (n 46).

50 William Kingston, 'Innovation Needs Patents Reform' (2001) 30 Research Policy 403; W. Kingston, 'Innovation Patents and Warrants' in J. Philips (ed), *Patents in Perspective* (London: ESC 1985); W. Kingston, 'An Investment Patent' (1981) 7 European Intellectual Property Review 207; quoted by Catherine Colston and others, *Modern Intellectual Property Law* (Routledge 2010) p.49.

51 However, in acquisition cases, know-how is more valuable than patents to the purchasing party.

profits since there is considerable uncertainty attached to the value of innovations."[52] In the clean-energy supply chain the focus could be on identifying game-changing new technologies that might be integrated into other industrial and manufacturing companies within a business empire.[53] But patent royalties do not directly cover the expenditure of these subsequent steps, thus patents are rarely licensed without being feasible for marketing in the first place. For example, European clean-technology companies are struggling to attract financing:

> On the generation side of the sector, project developers typically only secure project debt financing for proven technologies such as wind and solar. Other sectors with potential, like biomass, struggle to raise finance. Since 2009 the funding gap has continued to widen.[54]

The reward theory predictively discriminates spontaneous and fortuitous inventions from patent/reward-induced inventions. Yet the patent system never "distinguishes between inventions that were induced by the patent system and those that were not, and grant patent protection only for the former".[55] While patents are actually more often used for strategic reasons[56] for gaining in a broader area, Horstmann et al.[57] pointed to the fact that "when inventors patent they reveal information about the value of the innovation as well as technical characteristics in the patent document." Such information could be important to

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52 Jean O. Lanjouw, Ariel Pakes and Jonathan Putnam, 'How to Count Patents and Value Intellectual Property: The Uses of Patent Renewal and Application Data' (1998) 46 The Journal of Industrial Economics 405.
53 Dominic FitzPatrick and Carsten Bartholl, 'Private Capital and Clean Energy: Exploring a Growing Relationship' TaylorWessing, February 2012 <https://www.taylorwessing.com/fileadmin/files/docs/Private-Capital-and-Clean-Energy-Report.pdf> accessed 1 Jul 2017.
54 Ibid.
55 See Frederic Michael Scherer and David R. Ross, *Industrial Market Structure and Economic Performance* (2d ed. edn, Houghton Mifflin Harcourt (HMH) 1980) p.442-44; A. Samuel Oddi, 'Beyond Obviousness: Invention Protection in the Twenty-First Century' (1988) 38 Am UL Rev 1097 p.1101; quoted by Erramouspe (n 39).
56 Rogers and others (n 46).
57 Ignatius Horstmann, Glenn M. MacDonald and Alan Slivinski, 'Patents as Information Transfer Mechanisms: To Patent or (Maybe) Not to Patent' (1985) 93 Journal of Political Economy 837.

competitors that intend to imitate, whereas they have to invent around to avoid infringing the patent. Such "propensity to patent will be lower the more profitable a competing product is expected to be".[58] This is just another criticism of the reward theory, for it is not entirely consistent with the patent system. While the reward theory claims that its rewarding function is for inventors to recover their expenses during R & D and in turn encourage them to engage in future inventive activities, "for each individual invention, the patent system rewards only the first inventor to obtain a patent; other contributing inventors remain uncompensated, as do other innovators who might develop the same invention independently".[59] This in fact denies the innovative efforts of later inventors by leaving them unrewarded, and it even becomes a disincentive for subsequent innovators, for they are often blocked or burdened by a prior patent during further innovation. Thus, a strong patent system based on reward theory "may cause wasteful duplication of investment in R & D (that is, patent races) plus costly effort to assert ownership rights. Further, technical and judicial actions to enforce rights through excluding free riders may be costly."[60]

These arguments do not necessarily negate patenting as a stimulus to invention, but it is not the only way to construct a legal system for protecting creativity. If a patent is justified by the reward theory, it is hard to say whether the model was designed to encourage the inventor or to win more benefits for people in general. If the grant of a patent is truly to encourage inventors, there is more than one way to do so. Fisher, diverging from the reward theory,

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58 Ibid.

59 Mark F. Grady and Jay I. Alexander, 'Patent Law and Rent Dissipation' (1992) 78 Virginia Law Review 305 p.313. For example, in Tilghman, 102 US 707, the plaintiff devised a process for rendering animal fat into constituent elements used to make candles and soap. The plaintiff's application described a specialized apparatus with coils that subjected the fat to high pressure and heat. The defendant developed a more efficient refinement of the plaintiff's process, using a pressure cooker rather than coils. Extending the plaintiff's patent beyond the actual invention to encompass improvements, the Court held that the defendant's refinement infringed the plaintiff's patent. Ibid p.734. Quoted by Erramouspe (n 39).

60 Maskus (n 44).

pointed out that private property rights such as IPRs "are crucial to the satisfaction of some fundamental human needs; policymakers should thus strive to create and allocate entitlements to resources in the fashion that best enables people to fulfil those needs."[61] If personal human needs are valued more than materialism, patents may be justified on the grounds that "they create social and economic conditions conducive to creative intellectual activity, which in turn is important to human flourishing,"[62] and thus to be awarded with a set of legal rights as a ratification from the authority. In truth, some inventors are conducting R & D because they feel they will have a better product; others probably just have the desire to contribute to their businesses, which is natural. Some are motivated by passion, meaning that they really care and want to perform better in their profession, and are not so driven by monetary gain. Also, a potential inventor looks forward in time and evaluates the needs of the planet in the near future, for example the climate change problem; their reward could come from the satisfaction of accomplishment and enhanced reputation.[63] Inventors could also be awarded accordingly by earning "respect, honour, admiration, and money from the public,"[64] with fewer rights to prevent others from spreading or innovating based upon their inventions. As a matter of fact, to some large manufacturing companies, the most important meaning of a large patent-portfolio is as a propaganda tool to attract clients and investors. This is saying that an equivocal rewarding monopoly alone may not be what patents mean to inventors, while the dynamic of the corresponding market is the real driving force behind their motivation. This is true in the climate change context. For example, recently water started to

[61] Fisher (n 20).

[62] See Margaret Jane Radin, *Reinterpreting Property* (University of Chicago Press 1993); Jeremy Waldron, *The Right to Private Property*, vol 40 (Clarendon Press 1990) quoted by Fisher (n 20).

[63] Michael Pendleton, 'Intellectual Property, Information-Based Society and a New International Economic Order-The Policy Options?' (1985) 2 European Intellectual Property Review 31.

[64] See Justin Hughes, 'The Philosophy of Intellectual Property' (1988) 77 Geo LJ 287 p.330-350. Quoted by Fisher (n 20).

be viewed as a precious commodity and relevant companies that innovate by designing water-saving systems came to prosper in the UK. New systems and devices, such as showerheads, taps and washing machines, are being redesigned with this objective in mind. A UK company, Propelair, is manufacturing a new toilet that uses 80 per cent less water and energy per flush than conventional alternatives. The payback for customers in the form of lower bills will be between two and four years, making a strong financial case. As businesses, governments and households seek to cut their water and energy use, technologies such as this will be vital in helping them achieve such goals, and will become a popular R & D-target among companies.

So, better alternatives are available to award inventors in order to help stimulate invention and innovation rates; especially in large climate change relevant equipment such as industrial awards/prices, state support of research [65] or, even better, the creation of government/society-oriented market demands. In history, there have been different ways of rewarding inventors for their contribution to the community[66] and now there are still a variety of awards, for example the most-recognized Nobel Prizes; the Lafarge Invention Awards for contributions to sustainable construction; the Volvo Environment Prize, and so on. These prizes and awards are more than just an efficient encouragement for inventors and innovators to step forward: some have actually advanced climate change technology in a great sense. Such incentives might be a better solution than a globally united patent system to some extent.

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[65] Jerome H. Reichman and others, *Intellectual Property and Alternatives: Strategies for Green Innovation* (2014).
[66] See more National Research Council, *Global Dimensions of Intellectual Property Rights in Science and Technology* (National Academies Press 1993).

5.2.3 Exchange for secrets

A common objective of most IP laws is to promote creation[67], but creation itself would not be possible without the prior possession of certain types of knowledge. Human knowledge develops in cycles.[68] By granting limited exclusive rights to innovators, society would gain disclosure of these inventions and creative works in return. This is another basic rationale of the patent system – to encourage disclosure,

> since this prevents the duplication of research and, once the patent has expired, allows 'those skilled in the art' to quickly replicate the invention. This rationale is referred to as the 'contract theory' of patents by lawyers, as opposed to the 'reward theory' (which focuses on incentives to invent).[69]

For example, patent rights "prevent free-riding by imitators and encourage the disclosure of inventions that otherwise might remain trade secrets."[70] Additionally, patent files are available from the Patent Office to the public, which might inspire potential inventors who would otherwise have problem learning about and accessing the technology.[71] In such ways, the patent system is expected to benefit society by providing access to new knowledge and therefore securing the continuous accumulation of knowledge and information.

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[67] For example the US Const., art. 1, sec. 8, cl. 8.

[68] See James Bessen and Eric Maskin, 'Sequential Innovation, Patents, and Imitation' (2009) 40 The RAND Journal of Economics 611.

[69] Rogers and others (n 46).

70 Meir Perez Pugatch, *The International Political Economy of Intellectual Property Rights* (Edward Elgar Publishing 2004) p.19. See also, e.g., Vincenzo Denicolò and Luigi Alberto Franzoni, 'The Contract Theory of Patents' (2003) 23 International Review of Law and Economics 365; Suzanne Scotchmer, 'Standing on the Shoulders of Giants: Cumulative Research and the Patent Law' (1991) 5 The Journal of Economic Perspectives 29 p.39.

[71] Machlup (n 39) p.76; see also, Landes and Posner (n 15) p.329, arguing that the public might discover new uses for the patented invention that the patentee never thought to market or license; quoted by Benjamin N. Roin, 'The Disclosure Function of the Patent System (Or Lack Thereof)' (2005) 118 Harvard Law Review 2007.

Applying for a patent compels the disclosure of an idea to the community at an early stage, before the decision whether to grant a patent is taken.[72] Publication eighteen months after a patent application will reveal the information contained within it earlier than it would otherwise reach the public domain.[73] Oppenheim believes that a patent should provide information more quickly than other sources, such as technical and research literature.[74] This attributes to the patent application a very public process, in the sense that members of the public can view applications once they are received and administered by the IP Office. The logic here is that third parties can then use this public document as a launch pad for their own inventions. Research by Gambardella et al. on how much of a saving an imitator makes through "having access to the information in a patent provides a first set of estimates of cost savings incurred by follow-on inventors due to knowledge of the patent literature."[75] A survey among inventors was conducted and more than 22,000 inventors in 23 countries were involved. "Inventors were asked in this survey to quantify the time saved for the respective invention process when compared to a situation in which the information from patents had not been available."[76] The heterogeneity across technical fields was clear with median values range from 36 hours (organic chemicals) to one hour (digital communication technology). More importantly, patent literature provides information in great quantities on a large

[72] Colston and others (n 50).
[73] HÈlËne Dernis, 'Nowcasting Patent Indicators' Statistical Analysis of Science, Technology and Industry (STI) Working Paper, DSTI/DOC(2007)3 <http://www.oecd.org/sti/39485567.pdf> accessed 2 Jul 2017.
[74] C. Oppenheim, 'Information Aspects of Patents' in J. Philips (ed), *Patents in Perspective* (London: ESC 1985), quoted by Colston and others (n 50).
[75] Alfonso Gambardella, Dietmar Harhoff and Sadao Nagaoka, 'The Social Value of Patent Disclosure' Unpublished Manuscript, LMU Munich (2011) <http://www3.law.ox.ac.uk/denning-archive/news/events_files/Harhoff,_Dietmar.pdf> accessed 17 Jun 2017.
[76] Ibid.

number of commercialized technologies. For example, in the US and Japan, the commercialization percentage is 60 per cent.[77]

However, the disclosure function of a patent has only limited value. First, patents are considered to be "essential for inventions that are easier to reverse-engineer and copy than to actually invent from scratch."[78] If not protected by monopoly rights granted to the inventors, "competitors would quickly imitate such inventions, and these free-riders would drive down prices, thereby preventing the inventor from profiting off her invention."[79] However, many easily reverse-engineered patented inventions will be disclosed to the public at the time of selling or exploiting, regardless.[80] The situation and the dynamics of the inventors' world are now quite different from earlier times when "most inventions were held in the custody of individuals rather than companies."[81] Favour towards the secret exchange theory may have developed due to a fear that "inventors would take their secrets to the grave unless they filed for a patent,"[82] which is hardly the case today. Also, "many inventions that are difficult to reverse-engineer will never be patented because the inventor would be unable to detect infringement, rendering the patent of little value."[83] This might be due to the fact that "any

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[77] Sadao Nagaoka and John P. Walsh, *Commercialization and Other Uses of Patents in Japan and the U.S.: Major Findings from the RIETI-Georgia Tech Inventor Survey* (2009) Tokyo, Japan: RIETI Discussion Paper.
[78] Roin (n 71).
[79] Ibid (n 71); and also see, e.g., Landes and Posner (n 15); Steven Shavell, *Foundations of Economic Analysis of Law* (Harvard University Press 2009); Rebecca S. Eisenberg, 'Patents and the Progress of Science: Exclusive Rights and Experimental Use' (1989) 56 The University of Chicago Law Review 1017.
[80] Fritz Machlup and Edith Penrose, 'The Patent Controversy in the Nineteenth Century' (2011) 10 The Journal of Economic History 1 (recounting debates among European economists during the mid nineteenth century over the alleged disclosure value of the patent. Quoted by Roin (n 71).
[81] See Roberto Mazzoleni and Richard R. Nelson, 'The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate' (1998) 27 Research Policy 273 p.278, (citing Machlup (n 39) p.21). "This reasoning may explain why the Court has said that patent disclosures benefit the public when, upon the expiration of [the patent] period, the knowledge of the invention in use to the people, who are thus enabled without restriction to practice it and profit by its use." Bonito Boats v. Thunder Craft Boats, 489 US at 151 (quoting United States v. Dubilier Condenser Corp., 289 US 178, 186-87 (1933). "At first glance this argument seems strange, because most inventors who can keep their invention secret for longer than the twenty year patent term (as did The Coca-Cola Company with its secret formula) will probably opt for trade secrecy." Eisenberg (n 79). However, "if the Court is worried that private inventors might die before their invention can be reverse-engineered or disclosed, possibly depriving the public of ever discovering the inventor's secret, then the Court's argument makes a little more sense." Quote by Roin (n 71).
[82] Roin (n 71).
[83] Ibid.

technology that can be exploited in secrecy by its inventor can probably also be exploited in secrecy by an infringer, making a patent on such an invention difficult to enforce."[84] Therefore, where trade secrecy is a better alternative to secure returns from an invention (i.e. process innovation); the disclosure requirement might have become a greater deterrent to patenting. Empirical research by Levin[85] reaffirmed this view. In this sense, the patent system is of little influence in causing people to disclose technology secrets.[86]

Moreover, the effect of a patent on the dissemination of information contained in the files is not significant, according to Arora's research. This research has identified that "patent disclosures appeared to have no measurable impact on information flows from other firms, and therefore no measurable effect on R & D productivity."[87] In fact, in practice, patent records have not been a chief resource for companies and researchers to learn about the most advanced technologies available.[88] Publications, conferences and reverse-engineering studies of the newest products available in the industry are more popular ways to get access to information among, for example, American firms looking for the most recent technological advances. Patent disclosures play a minor role in disseminating technologies. A Europe-based research concluded with the similar finding that "the use of patent databases [...] are among the least important external information sources available to firms."[89] Such observations

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84 Eisenberg (n 79)

85 See Richard C. Levin and others, 'Appropriating the Returns from Industrial Research and Development' (1987) 1987 Brookings Papers on Economic Activity 783.

86 Wesley M. Cohen and others, 'Competition and Intellectural Property Law and Policy in the Knowledge-Based Economy' [2002].

87 Ashish Arora, Marco Ceccagnoli and Wesley M. Cohen, 'R&D and The Patent Premium' (2008) 26 International Journal of Industrial Organization 1153.

88 See Wesley M. Cohen and others, 'R&D Spillovers, Patents and the Incentives to Innovate in Japan and the United States' (2002) 31 Research Policy 1349; Puay Tang, John Adams and Daniel Paré, *Patent Protection of Computer Programs: Final Report* (Brussels-Luxembourg: ECSC-EC-EAEC, 2001). Interestingly, the patent system in Japan appears to be much more effective at disclosing information about new technologies. See Cohen and others (n 88) p.1362-64 quoted by Roin (n 71)

89 See A. V. Arundel, *Patents in the Knowledge-Based Economy* (2001), quoted by Roin (n 71).

appear to be true in my research based on empirical data collected from Chinese companies, where patents have only a minor effect on the flow of information to them.[90]

"The clean-energy industry has so far seen relatively little patent litigation compared to more mature industries such as the semiconductor and mobile phone industries."[91] This seems that the secret-exchange function of the patent system is performing well to satisfy the needs of society. However, as the market for clean-energy technology expands, the financial incentives will be more effective. Therefore, companies might act more aggressive in using their patents to occupy market share and to secure profits. This trend has been noticed by the US Government recently. Take for example, the US Sipco v. Florida Power and Light and Silver Springs Networks[92] case (in regarding three of Sipco's smart-grid patents infringement) and the case where EMS Technologies sued many companies[93] for they have been infringing smart-grid patent of the EMS Technologies. "The number of patent infringement cases being filed in US federal courts is certain to increase as the smart-grid sector grows into a multibillion-dollar market."[94] According to Cohen et al.'s research, "US companies generally prefer other sources of information over patents."[95] But one of the major reasons for them to pursue patents is not to acquire information but to strategically hold a technology – they use patents for blocking and preventing other companies from inventing around.[96]

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90 Details provided in the following chapter.
91 Rodger Sadler and others, 'Plan Your Clean Energy IP Strategy' [2010] No 202 Managing Intell Prop 48.
92 SIPCO, LLC v. Florida Power & Light Company et al, (S.d. Fla. July 27 2009) 1:09-CV-22209-FAM – Silver Spring Networks, Inc. sued by SIPCO, LLC for patent infringement in Florida Southern District Court.
93 including General Electric and Silver Springs Networks.
94 Sadler and others (n 91).
95 Cohen and others (n 88).
96 Nagaoka and Walsh (n 77).

Patent litigation may have been heated up in the area of smart-grid technology already, and the strategic holding rights granted by patent could be abused in a much-widened area. The US Patent Assertion Entities (PAEs)[97] tend to:

> focus on aggressive litigation, using such tactics such as: threatening to sue thousands of companies at once, […] and asserting that their patents cover inventions not imagined at the time they were granted. Suits brought by PAEs have tripled in just the last two years (2011–2012). Estimates suggest that PAEs may have threatened over 100,000 companies with patent infringement last year alone.[98]

Such a phenomenon constitutes the abuse of patent rights by entities known as patent trolls. Rights holders are gaining a considerable amount of profit mainly by enforcing patents against infringers/active users. Relevant patents are usually hard to substitute and thus more likely to be infringed. And it is suggested that these assertion-firms are therefore able to be sustainable in the long run. Such peculiar players who "are solely interested in the exclusion right, not in the underlying knowledge"[99] are betraying the secret-exchange justification of the patent system as they are indulged by patent rights granted to them.

Even more, some practising firms are beginning to use such tactics as well. For example, GE Energy, which controls a number of patents on the variable-speed technology used in wind turbines, has been seeking to use its patent strategy as an important competitive tool, and some foreign firms have had to design around its US patents in order to legally market

[97] PAEs, also known as "patent trolls" generally refer to firms that own patents but do not make products. These firms play an important role in the US innovation ecosystem, for example by connecting manufacturers with inventors, thereby allowing inventors to focus on what they do best.

[98] Executive Office of the President, 'Patent Assertion And US Innovation' The White House Washington, June 2013 <https://obamawhitehouse.archives.gov/sites/default/files/docs/patent_report.pdf> accessed 19 Jul 2017

[99] Timo Fischer and Joachim Henkel, 'Patent Trolls on Markets for Technology–An Empirical Analysis of NPEs' Patent Acquisitions' (2012) 41 Research Policy 1519.

themselves in the United States.[100] Instead of the traditional US federal court, patent holders are now becoming more interested in bringing disputes to the US International Trade Commission (ITC). This is because "the ITC actions proceed much faster and are particularly powerful against foreign importers".[101] Any technology that is deemed by the ITC to be infringing a US patent will be blocked from entering the US market. American technology holders can secure market share for they have kept advantage in rivalry with foreign importers running business in the country's growing clean-energy sector. For example,

> General Electric, facing stiff competition from Mitsubishi Heavy Industries, filed an ITC patent action seeking to block allegedly infringing Mitsubishi wind turbines from being imported into the US. Although General Electric was ultimately unsuccessful, ITC litigation will continue to increase as US patent owners seek to better position themselves in the competition with foreign imports.[102]

As far as patents are concerned, for a 20-year period of protection-duration, the rights owner will be the only supplier making a profit unless it decides to license. But restricted by the patent claims, other relevant inventions are held back in the wind turbine industry and thus there will not be enough suppliers in the market. As a consequence, society will not benefit from large-scale utilization of such green technology and a more affordable price attribute to a balanced supply demand relationship.

The long duration of a patent will cripple the timeliness of information, especially in more innovative industrial sectors, such as smart grids, computer modelling for blade alloy

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[100] Joanna Lewis and Ryan Wiser, 'A Review of International Experience with Policies to Promote Wind Power Industry Development' [2005] Prepared for the Energy Foundation China Sustainable Energy Program.
[101] Sadler and others (n 91).
[102] Ibid.

examination, and wind turbine overhaul. Aggressively sought and applied patents are creating a barrier for the majority of society to benefit from new technologies. And the increasing needs of society will create large potential markets and profits could be considerable. Many capable imitators are therefore tempted to become illegal IP infringers and this will increase the difficulty of IP protection implementation. In this case, the longer the duration of patents, the harder it is to protect them because it will construct an uneven supply-demand relationship. A short monopoly time-period would bring information into the public domain more rapidly, and early availability of information would certainly accelerate the exploitation and innovation of an invention.

As an information source, a patent is not quite eligible where inventions are not easily reverse-engineered. Indeed, most patent laws require patent applicants to provide specifications when filing for invention patents that require the document to "disclose the invention in a manner which is clear enough and complete enough for the invention to be performed by a suitably skilled person."[103] However, in practice, specifications available to the public are not necessarily to be understood or performed easily by a technician in the industry. There are reasons, such as "many applicants deliberately fail to disclose the trade secrets and know-how necessary to recreate or use the invention efficiently; the [specifications] are often drafted in ways that make them tedious or difficult for engineers to understand."[104] In fact, the hypothetical technician employed by courts when making judgements may be much more capable than a real-life skilled person, so it requires more resource and information for them to carry out the invention. Plus, it is practically difficult for

[103] For example, the UK Patent Act 1977, Section 14(3)
[104] Roin (n 71).

a third party, without help from an insider, to trace and identify the specific omitted information that led to a failure of performance in an invention, in order to challenge the validity of the patent. Thus, the inadequately disclosed patents remain valid and protected by law.

For example, many patents are drafted to deliberately hide important information about the invention, by hiring experts and agencies to draft using vague language about the invention's application. These professionals are skilled in drafting strategies that, on one hand, are meant to ensure that patents are interpreted broadly by the courts and on the other to make reading the patent specifications "an uncomfortable experience, [where] the document seems to be unreasonably repetitive and in parts almost incomprehensible."[105] As a result, it has become difficult for innovators and potential inventors to learn about cutting-edge technologies from patent documents.[106] To some extent, third parties began to lose all interest in the disclosure function of patents.[107] This has really diminished the value of the secret-exchange aspect of patents, as it has incurred a lot of unnecessary costs[108] and made the system "a poor medium for communicating technical information."[109]

Moreover, patent documents only provide the minimum information required to pass the application and do not give access to any additional valuable information, which may be vital

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[105] V. Irish, 'How to Read a Patent Specification' (2000) 10 Engineering Management Journal 71, quoted by Roin (n 71).

[106] Michael Abramowicz, 'The Uneasy Case for Patent Races over Auctions' (2007) 60 Stanford Law Review 803, quoted by Alan J. Devlin, 'The Misunderstood Function of Disclosure in Patent Law' (2010) 23 Harvard Journal of Law and Technology 401; "Patents in the information technology ("IT") industry are perhaps the worst offenders, being notorious for their vague language." Quoted by ibid; See also Arti K. Rai, John R. Allison and Bhaven N. Sampat, 'University Software Ownership and Litigation: A First Examination' (2009) 87 North Carolina law review 1519.

[107] See Mark A. Lemley, 'Ignoring Patents' (2008) Mich St L Rev 19. "Disinterest" here refers not merely to subjective indifference, but to deliberate ignorance of the prior art. Quoted by Devlin (n 106).

[108] See Patricia E. Campbell, 'Representative Patent Claims: Their Use in Appeals to the Board and in Infringement Litigation' (2006) 23 Santa Clara Computer & High Tech LJ 55 (noting the expense of prior art searches)

[109] See, e.g. National Research Council, *A Patent System for the 21st Century* (National Academies Press 2004), at 63 (noting that "patents [are] a less than ideal vehicle for communicating technical information," partly because "a patent is written by an attorney or a patent agent to persuade an examiner to grant and a court to uphold a property right of the desired scope"), quoted by Roin (n 71).

to the actual use of the invention. "Oftentimes, [...] there is a certain amount of know-how, show-how and other types of information available [only through] frequent consultation with the inventors."[110] Thus, many skills and human aspects of technology management and production-arrangement-links within which a technology operates[111] remain secret, without revelations or assistance from the rights holder. Interviewees of this research also confirmed that they “could not be more agree that patents provide information far less than enough to actually put the invention into use without extra work from and cost paid to the right holder.”[112] Environmental inventions, especially ones in the form of large equipment are not easily reverse-engineered without a great amount of know-how being transferred by the inventors, and it requires skilled experts to be involved in the exploitation of the final product. It is even harder for companies or countries that cannot afford the licence and facilities to absorb the information.[113] Therefore, the speculative secrets-exchange function of a patent is very limited and leaves the inventors with plenty of room to profit further by licensing know-how and relevant information,[114] or even, in contradiction to the function, keep hold of their secrets for as long as it is beneficial for them.

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[110] James D. Hamilton and William E. Beaumont, ‘Licensing Patents and Trade Secrets’ (American Conference Institute's Licensing Intellectual Property Conference, Chicago, Illinois June 5-7, 2000) §1.01 Determining What Rights Are Licensable; See also Federal Trade Commission United States, *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy* (DIANE Publishing 2003) ch. 3, at 33; Peter J. Toren, ‘Protecting Inventions as Trade Secrets: A Better Way When Patents Are Inappropriate, Unavailable’ (*FindLaw Website*) <http://corporate.findlaw.com/intellectual-property/protecting-inventions-as-trade-secrets-a-better-way-when-patents.html> accessed 21 Jul 2017, quoted by Roin (n 71).

[111] WTO Council for Trade-Related-Aspect of Intellectual Property Rights, *Report on the Implementation of Article 66.2 of the Trips Agreement* (IP/C/W/602/Add7, 23rd Feburary 2015).

[112] Interview transcript.

[113] Keith E. Maskus and Jerome H. Reichman, ‘The Globalization of Private Knowledge Goods and the Privatization of Global Public Goods’ in Keith E. Maskus and Jerome H. Reichman (eds), *Maskus and Reichman, International Public Goods and Transfer of Technology under a Globalized Intellectual Property Regime* (Cambridge University Press 2005).

[114] see Cohen and others (n 86). (statement of Daniel McCurdy) p.53; see also Toren (n 110) (noting that it is not uncommon for "patent protection [to] be sought for the invention and related information [to] be protected as trade secrets[,]... permit[ting] companies to have their cake and eat it too"). Quoted by Roin (n 71).

If the patent system is to be justified by its secrets-exchanging function, society might expect the paradigm to extract more from the patent holder.[115] As discussed above, patents are providing too little knowledge under the current requirements of disclosure, and the public might ask for more detailed information in order to actually benefit from the invention in question.[116] In the wind turbine blade-manufacturing industry, for example, there might be a strong case for requiring patent applicants to disclose the source of their raw materials and a serious processing technics. Key information needed to duplicate an innovation, such as technological know-how, should be made available by the patent system if secrets-exchange is the primary justification for it. And a step further if possible: to establish a voluntary-expertise labour model like the legal-aid system, including duty specialists, industrial technology institutions, and the governmental/guild payment of consultants to deal with cases for firms who are seeking professional aid. All in all, to get back to the root of justification for patents, the regime "should primarily be construed as a tool for incentivizing the invention and commercialization of…technology."[117] Secrets-exchange targets should be considered merely as an ancillary part of the system. Confronted by the conflict of interests between society's urgent need of technologies (especially environmental technologies to defeat climate change) and the benefits of rights holders to profit from their inventions, one has to return to the ultimate goal of incentivizing invention and commercialization in order to serve the public. Disclosure is only a tool, and should be put to best use to satisfy public interests.

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[115] See Christopher A. Cotropia and Mark A. Lemley, 'Copying in Patent Law' (2008) 87 NCL Rev 1421.

[116] Roin (n 71).

[117] Devlin (n 106).

5.2.4 Patent protection as international technology transfer incentives

"In terms of technology flows from developed countries, it is speculated that firms will be more willing to trade, licence, and invest in technologies in countries with strong IPR regimes."[118] Although not explicitly set forth by a lot of the literature, the incentive for TT or FDI function could be seen as new ground for the justification of patenting. "Patent protection facilitates the trade in goods by assuring exporters that there are remedies for infringements when imitators illegally copy or reverse-engineer patented technologies"[119] without permission, in other countries. Indeed, "it is widely accepted that the protection and enforcement of IPRs should encourage innovation and promote TT."[120] The same objective is found in the TRIPS Agreement,[121] showing that the stimulant effect of IP in general (including patenting) is well recognized and given prominence. Moreover, "one of the main forms of knowledge dissemination (and probably the most valuable from the point of view of developing productive and innovative capabilities) is TT."[122] Thus, the TT-incentive justification, which could be seen as a prolongation of the "ex ante justification,"[123] is important in valuing the patent system, as it is regarded not only as an inducement for innovation but also for broader dissemination, commercialization and application.[124]

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118 Maskus and Reichman (n 113). Guifang (Lynn) Yang and Keith E. Maskus, 'Intellectual Property Rights and Licensing: An Econometric Investigation' in Carsten Fink and Keith E. Maskus (eds), *Intellectual property and development: Lessons from recent economic research* (A Co-Publication of the World Bank and Oxford University Press 2005) p.111-12.

119 World Bank, *World Development Report 1998/1999 : Knowledge for Development.* (1999) p. 34–35.

120 See Tu Thanh Nguyen, *Competition Law, Technology Transfer and the TRIPS Agreement: Implications for Developing Countries* (Edward Elgar Publishing 2010) p.11.

121 Article 7 ("Objectives") states that "the protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations."

122 Dominique Foray, *Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies* (ICTSD Intellectual Property and Sustainable Development Series (May 2009), 2009).

123 Herbert Hovenkamp and Michael A. Carrier, *IP and Antitrust: An Analysis of Antitrust Principles Applied to Intellectual Property Law*, vol 1 (Wolters Kluwer Law & Business 2016).

124 See Nguyen (n 120) p.14.

However, it is easy to make a mistake by predicting TT as a simple mechanism under the "implicit assumption that the cost of technology diffusion is lower than that of its production."[125] Even after production, it requires a lot of effort before technology can be internationally applied. Foray states that the "difficulties and complexity of TT operations, particularly when they involve two countries' different levels of development, has been recognized."[126] The tacitness and stickiness of knowledge make the process of TT complex, especially:

> the difficulties created by the complementary role of tacit knowledge in successfully transferring incompletely codified technological knowledge from advanced to developing countries suggests that involving firms from the former countries via cooperative ventures, technology support and training contracts will be in the interests of firms in the latter countries.[127]

In fact, patents, as a form of IP included in most IP laws and TRIPS, are beneficial to some economies, when strongly enforced, as this strengthening will lead to an increased flow of royalties or profits in industries such as entertainment and pharmaceuticals.[128] Moreover, the patent system may fulfil a number of additional advantages beyond the legal right to prevent third parties from using an invention: such as

> signalling the quality of an invention to potential investors and customers, a generally improved public image by conveying technological leadership through large patent portfolios, deterrence of infringement suites, an increase in bargaining power in

[125] Foray (n 122).
[126] Ibid.
[127] Ibid.
[128] For example, both the US and EU. See ibid (n 122).

cross-licensing negotiations, the ability to participate in patent pools, the possibility to signal to potential research collaborators expertise in a specific area, or to block (entry of) competitors by restricting their freedom-to-operate.[129]

All of the additional functions are benefiting transferors' (especially multinational companies) bargaining position in international TTs. Thus these benefiting countries are placing strong pressure on developing nations over the negotiation of a global IP law system. Of course, to some extent this is a positive development for countries from which companies expect a growth in profit of their R & D investments. And according to one study[130], stronger IP protection encourages patented goods flows from developed countries to middle-income and large developing countries. Therefore, as a matter of fact, patents on the whole are a force for good. However, this conclusion cannot prove that strong IP protection is the sole incentive.

Growing evidence tends to prove that there is no causality between IPR and the volume of TT. Although in cases strengthening of IP protection can be important in increasing FDI,[131] TT from developed country companies to developing countries is depended on more factors except for willingness of giving from transferor. Without huge market potential in middle-income countries there might be not enough enticement for both transferor and transferee to pursue in a specific industry sector in that country. The question is, which is the major factor that increases TT: better IPR protection or market potential? This could be a

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[129] Rogers and others (n 46).
[130] Bernard M. Hoekman, Keith E. Maskus and Kamal Saggi, 'Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options' (2005) 33 World Development 1587; Bernard Hoekman, Keith E. Maskus and Kamal Saggi, 'Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options' Research Program on Political and Economic Change Working Paper PEC2004-0003 <http://www.colorado.edu/IBS/pubs/pec/pec2004-0003.pdf> accessed Feburary 2017p.15.
[131] "The strengthening of IP protection can be expected to result in an increase in the relative importance of licenses and direct investments, and in the quasi-disappearance of imitation. It can also be anticipated that within a specific mode – such as, direct investment – the TT will be more successful insofar as a strengthening of IP protection will increase the technology holder's incentives to transfer in an efficient manner." See Dominique Foray, *Economics of Knowledge*, vol 737 (Taylor & Francis 2004).

rather controversial rationale based on the idea that, in most cases, patent holders will target the market where their innovations and profits derived from sales represent pure economic rents.[132] And as beneficiaries of that market demand, they should pay back or make concession to customers in the country. The case in point is "China, which has one of the highest piracy rates in the world, yet is still attracting substantial FDI and the transfer of technology."[133] According to a survey conducted among foreign businessmen in China, the size and potential of the market act as the determining factors that induce FDI and TT.[134] A typical example is Microsoft. Like many Western companies that have had a notoriously difficult time in China, Microsoft has been battling against piracy in China for years. Although, the Chinese Government has been:

> sympathetic to the pirates, openly hostile to the Microsoft monopoly and officially embraced Linux, the free rival to Windows. Cheap software has been critical to China's economic boom, and Beijing saw no upside to forcing citizens with an average annual income of $1,000 to spend much of it on Windows.[135]

Microsoft system and programmes are indeed severely pirated in China due to weak copyright protection in the Chinese market. Even so, the company has not reined its attempts at exploiting the Chinese market. The company actually took advantage of piracy to occupy the market and consolidate its position. In fact, Microsoft has enjoyed its monopoly power to

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[132] See Foray, *Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies* (n 122).

[133] "For example, in 1983 when China was still in its initial stage of reform and opening-up, China's real use of FDI only stood at 636 million US dollars. In 2002, the figure soared to 52.743 billion dollars, an increase of 82 times as against that in 1983, out-stripping that of the United States in the world." Shi (n 18).

[134] Paul Tackaberry, 'Intellectual Property Risks in China: Their Effect on Foreign Investment and Technology Transfer' (1998) 14 Journal of Asian Business 1. Quoted by "Yahong Li, 'The Wolf Has Come: Are China's Intellectual Property Industries Prepared for the WTO' (2002) 20 UCLA Pac Basin LJ 77.

[135] Rob May, 'Microsoft's China Strategy' (*BusinessPundit*, July 23, 2004) <http://www.businesspundit.com/microsofts-china-strategy/> accessed 22 Mar 2017.

maintain prices on its software for a long time. If it was not for a terrible downturn and rising competition, it would not consider shifting to a compromising approach, cutting prices on a variety of its products and services in China. "The idea is to accept lower margins in some businesses but boost overall earnings by going after a grab bag of growth opportunities."[136] Indeed, such changes in strategy range from expanding its share of big companies' software purchases, to lowering the price of MS Office software so that consumers in emerging markets are encouraged away from pirated version to pay for authentic software at an affordable price. For example, a price cut from $150 to $100 on MS Office (even lower in countries like Brazil and India) has led to a spark of optimism for significant growth in unit sales, which surged 415 per cent in the second half of the year.[137] The most aggressive price cut came in China, where 95 per cent of Office installations were pirated. And since the company began testing a $29 offer in China in 2008, 80,000 copies of Office in China sales have soared more than 800 per cent.[138] "Microsoft's willingness to bear millions of dollars of losses to Chinese piracy implied the firm's confidence that Microsoft will eventually receive huge returns despite today's lax protection."[139] And now the company is intending to make the low prices permanent.

So while it might be debated as a matter of IP infringement temporarily, it does not imply that Microsoft will allow piracy of its IP to continue without regaining monies and control, in a veiled form, in the future. The important fact remains that IP protection does not necessarily

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[136] Peter Burrows, 'Microsoft's Aggressive New Pricing Strategy' (*Bloomberg Businessweek*, 16 July 2009) <https://www.bloomberg.com/news/articles/2009-07-16/microsofts-aggressive-new-pricing-strategy> accessed 26-06-2017; See also David Kirkpatrick, 'How Microsoft Conquered China' (*Fortune Global 500*, July 17 2007) <http://archive.fortune.com/magazines/fortune/fortune_archive/2007/07/23/100134488/index.htm> accessed 26-06-2017

[137] Burrows (n 136).; See also Kirkpatrick (n 136).

[138] Burrows (n 136).; See also Kirkpatrick (n 136).

[139] Shi (n 18): The Justification for IPR Protection p. 23-66.

make much difference from an efficiency standpoint: the supply and exploitation of innovations would not be much diminished in countries that have some IP policies in place as long as it is profitable for the business either in the short term or in the long run. Maskus and Reichman's research pointed out that "trade flows to poor countries 'are not responsive to patent rights'";[140] it is therefore highly possible that the potential profit to be made in the market is much more important than the IP implementation in that nation. The more recent growth in global environmental product marketing in developing countries with emerging economies has tended to vitiate the conventional philosophy of IP protection as well. Evidence is provided in detail in chapter VI on TT to China, based on empirical data collected from practitioners in the renewable-energy sectors. Although, according to Arora,[141] IP protection may affect each individual industry differently, it has been proved true, only to a limited extent that the consolidation of IPRs is the right path to pursue.

In the meanwhile, there still remains a fear of illegal imitation in the mid-income and large developing countries, and the rights owners tends to retain control over their "technical information and the know-how needed to exploit them."[142] But it is argued that FDI may solve the problem of lack of know-how and capacity in developing countries. This usually means TT from the parent firm to the subsidiary in a developing country. Not only that, but in some large developing countries (i.e. China and India) company acquisition appears to be a more efficient way of transferring technology and know-how.[143] In this way an IPR portfolio

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140 Maskus and Reichman (n 113).

141 Ashish Arora, 'Intellectual Property Rights and The International Transfer of Technology: Settings Out An Agenda for Empirical Research in Developing Countries' (The Economics of Intellectual Property, January 2009).

142 Maskus and Reichman (n 113) p.11.

143 The effectiveness of company aquisition and how does it affect TT and innovation rates in the acquiring country will be discussed along with the analysis of field research of this thesis in the TT to China Chapter.

can be bought as a whole and with ease. A strong and varied IP portfolio could also make a huge difference in attracting investment or encouraging cooperation decisions. But again, strong IPR protection in a country is hardly likely to be a determinative consideration for investment or cooperation decisions by technology owning firms, so relatively few developing countries have benefited from it.[144]

Moreover, with regard to climate change, it is questionable "whether technologies from transnational corporations that invest in developing countries tend to be more environmentally sound"[145] or just sound enough to enable the running of foundries by parent companies in developed countries. Many multinational firms "rely on the splitting of R & D into different components across researchers and research labs, so that individual pieces of R & D do not allow a complete understanding and functioning of a given technology."[146] As a result, the positive impact that this intentional approach (i.e. FDI) has on TT is very limited. Strategic and astute knowledge-management itself protects technical secrets well enough, making the importance of IPRs less observable. When technology owners are cleverly abusing their possession of the knowledge, it is even more difficult for companies in developing countries to detect or police the misuse of IPRs, because they lack information about the most advanced innovations.[147] Access to upstream information inputs, including scientific and

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144 Arvind Panagariya, 'TRIPS and the WTO: An Uneasy Marriage' in Keith Maskus (ed), *The WTO, Intellectual Property Rights and the Knowledge Economy* (Edward Elgar Publishing 2004): The success of FDI in China, in the absence of strong patent protection may support this view

145 World Bank (n 119) p.5, 28-9.

146 Minyuan Zhao, 'Conducting R&D in Countries with Weak Intellectual Property Rights Protection' (2006) 52 Management Science 1185. The literature provides empirical evidence that multinational firms tend to split knowledge more if part of the research is executed in countries with weak IP rights protection.

147 quoted by Maskus and Reichman (n 113): see eg. Rebecca S. Eisenberg, 'Bargaining over the Transfer of Proprietary Research Tools: Is this Market Failing or Emerging?' in Rochelle Cooper Dreyfuss, Diane Leenheer Zimmerman and Harry First (eds), *Expanding the boundaries of intellectual property: innovation policy for the knowledge society* (Oxford University Press 2001) 223 <https://www.law.duke.edu/cspd/articles/reichman.pdf> ; Arti Kaur Rai, 'Regulating Scientific Research: Intellectual Property Rights and the Norms of Science' (1999) 94 Northwestern UL Rev 77 p.7; J. H. Reichman, 'Database Protection in a Global Economy' (2002) XVI Revue internationale de droit économique 455; Jerome H. Reichman and Pamela Samuelson, 'Intellectual Property Rights in Data' (1997) 50 Vand L Rev 49.

technical data as such, are distorted and this "could narrow access to the research commons and limit other transfer mechanisms, with incalculable long-term effects on international TT as it used to occur."[148]

After all the discussions above, it is clear that the patent system cannot be justified on irrefutable grounds; each theory has a blemish that could hinder the dissemination of technology and therefore raise "entry barriers for firms and competition in developing countries, while even the middle-income nations find their scope of action limited."[149] Nonetheless, this thesis is not trying to say that the justification of patents is absolutely without merit. In fact, the active function of patenting is proven both in the US and EU markets, for they have been benefiting economically from stronger foreign IPRs. Strengthening of IP protection is believed to:

> lead to an increased flow of royalties or profits in the entertainment, pharmaceutical, and other industries. The introduction of a global system to enforce IPRs is a positive development for multinational companies as well, which expect an increase in the profitability of their R & D investments.[150]

Moreover, Maskus & J Reichman point out that "weak IP protection is not the only path to technology growth" [151] They have provided some examples in other research that "a few now-developed economies underwent significant technological learning an industrial

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[148] quoted by Maskus and Reichman (n 113): see eg. Eisenberg (n 147) p.223.; Rai (n 147) p.7; Reichman (n 147); Reichman and Samuelson (n 147).

[149] Keith E. Maskus and Jerome H. Reichman, 'The Globalization of Private Knowledge Goods and the Privatization of Global Public Goods' (2004) 7 Journal of International Economic Law 279.

[150] Foray, *Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies* (n 122).

[151] Robert M. Sherwood, 'Global Prospects for the Role of Intellectual Property in Technology Transfer' (2002) 42 Idea 27

transformation without the benefit of weak IP protection."[152] The development history of Japan has demonstrated the effect of strategic IP policy reform.[153] By favouring small-scale innovation, adaptation and diffusion, and the licensing of new technologies, the country has become one of the most innovation-productive headstreams.[154] South Korea took a different path and is an equally valid example in its encouraging of "domestic firms to acquire and adapt mature technologies available on international markets for purposes of developing local innovation capacities."[155] These precedents give more reasons for society to keep the international IP order as it is. Nevertheless, when countries with vested interests place strong pressure on the negotiators of less-equipped developing nations, and when it becomes an obstacle to the dissemination and wide application of climate change technologies required for climate mitigation, it is time to revisit this system within the context of a global IPR system. The pros and cons of the impact of TRIPS – the most effective international IP regime so far – on TT flows into developing countries.

5.3 The TRIPS Agreement

The TRIPS Agreement was negotiated in 1994 and administrated by the WTO. The Agreement sets down minimum standards for IP regulation applicable to all WTO members. The TRIPS Agreement is legally binding on original WTO members and later WTO members must adhere to it when acceding to the WTO. Sustainable development is one of the objectives of the WTO

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[152] Maskus and Reichman, 'The Globalization of Private Knowledge Goods and the Privatization of Global Public Goods' (n 149) p.290. See as a comparison B. Zorina Khan, 'Study Paper 1a Intellectual Property and Economic Development: Lessons from American and European History' [2002] London: Commission on Intellectual Property Rights; Nagesh Kumar, 'Study Paper 1b IIntellectual Property Rights, Technology and Economic Development: Experiences of Asian Countries' [2002] London: Commission on Intellectual Property Rights.

[153] From the 1950s through the 1980s.

[154] "Key features of this system included pre-grant disclosure, rapid opposition to patent grants, narrow patent claims, local reliance on utility modals and advantages for licensing" Janusz A. Ordover, 'A Patent System for Both Diffusion and Exclusion' (1991) 5 The Journal of Economic Perspectives 43.

[155] Linsu Kim, 'Technology Transfer and Intellectual Property Rights: Lessons from Korea's Experience. UNCTAD' <https://www.iprsonline.org/resources/docs/Kim%20-%20ToT%20and%20IPRs%20-%20Blue%202.pdf> accessed Feburary 2017

Agreement. The TRIPS Agreement, as part of the WTO Agreement package, requires member states to comply with a certain level of IPR protection. In exchange for greater market-access rights to developed-country markets, many developing countries adjusted their national IP law to fulfil the entry requirements of the WTO. While developing nations seek to obtain easy access to the international markets opened by the WTO, they have comparatively little interest in adopting more expensive non-fossil ways of production. This is because the old way of growth using fossil energy is much cheaper than any greener alternatives. Without financing and assistance from the developed world, it is hard to promote a sustainable means of growth in these countries. In the meantime, under TRIPS, developing countries must adopt minimum standards of protection, meaning that 20-year patent terms must be granted for "inventions" in all "fields of technology" if they meet all other patentability requirements.[156] They are prohibited from favouring domestic innovation industries. The question, however, is whether these standards are working effectively in accordance with TRIPS principles and objectives? According to Maskus and Penubarti[157] there is a “trade-off between the enhanced market power for the firm created by stronger patents and the larger effective market size generated by the reduced abilities of local firms to imitate the product.” Thus it may require a longer time for developing countries that have more imitative capability than independent innovating ability to develop their economy in order to afford new technology; but climate change issues are urgent and cannot suffer from delays. Although the significance of IP reforms and the enforcement of strengthened IP laws are not negligible,[158] by focusing

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[156] Except for certain public interests are allowed (Articles 27.2 and 27.3).

[157] Keith E. Maskus and Mohan Penubarti, ‘How Trade-Related are Intellectual Property Rights?’ (1995) 39 Journal of International Economics 227 p.229.

[158] See for example, Lee G. Branstetter, ‘Do Stronger Patents Induce More Local Innovation?’ (2004) 7 Journal of International Economic Law 359; Keith E. Maskus, *Encouraging International Technology Transfer* (UNCTAD-ICTSD Project on IPRs and

on patent transfer as the main means of TT, TRIPS is conceptually based on a narrow view of the channels through which knowledge can diffuse.[159] Therefore, the fact that many alternatives that can contribute to TT are not emphasized and promoted by TRIPS entails revisiting the objectives and provisions of the Agreement. Focusing exclusively on one means of "providing better IP protection is likely to cause collateral damage to other complementary means"[160] and values of equal importance that support innovation and TT in different ways. In addition, the nature of patents is ambiguous, as they may be positive or negative for innovation and growth. Richard Fairchild categorized the effect that patent applications will have on TT or public welfare into three types according to the degree of their spill-over effect or profit dissipation. In two out of the three situations, patent obtaining will minimize welfare and diminish competition.[161] Some[162] others further suggest that stronger IP laws could make technologies expensive, and suggest that the whole system is not much help in improving access to technology and the promotion of TT. This is especially so where the patent system leads to detrimental knowledge spill-overs because it lessens the pressure of innovative competition between rivals to race for more advanced technologies. This is probably the main case where TRIPS fails to facilitate climate change TT.

Sustainable Development Issue Paper No. 7 2004); UNCTAD International Centre for Trade and Sustainable Development (ICTSD), *Intellectual Property Rights: Implications for Development Policy* (Policy Discuss. Pap., ICTSD, UNCTAD, Geneva 2003); Bronwyn H. Hall and Christian Helmers, 'The Role of Patent Protection in (Clean/Green) Technology Transfer' (2010) No. 16323 National Bureau of Economic Research Working Paper Series.

[159] See Foray, *Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies* (n 122).

[160] Ibid.

[161] Richard Fairchild, 'Patents and Innovation- the Effect of Monopoly Protection, Competitive Spillovers and Sympathetic Collaboration' University of Bath, School of Management, Working Paper Series <http://www.bath.ac.uk/management/research/pdf/2006-03.pdf> accessed March 2006.

[162] Ted O'Donoghue, Suzanne Scotchmer and Jacques-François Thisse, 'Patent Breadth, Patent Life, and the Pace of Technological Progress' (1998) 7 Journal of Economics & Management Strategy 1; Bessen and Maskin (n 68); Rochelle Cooper Dreyfuss, 'Are Business Method Patents Bad for Business' (2000) 16 Santa Clara Computer & High Tech LJ 263; Andreas Panagopoulos, 'When Does Patent Protection Stimulate Innovation?' Paper provided by Department of Economics, University of Bristol, UK in its series Bristol Economics Discussion Papers with <https://core.ac.uk/download/pdf/7352629.pdf> accessed November 17, 2004.

Literature in the field[163] has been highlighting the impacts of the TRIPS Agreement, which has reinforced IPRs. Studies have pointed out that effective patent protection is promoting international TT only towards countries that already have a certain level of technological capability, and it varies significantly among industry sectors.[164] However, a few financial incentives, such as those provided by Kyoto's CDM, were proposed to be explicitly implemented in a TRIPS/Doha-like agreement because such mechanisms had increased climate change technology innovation and fulfilled the TT objectives of TRIPS indirectly.[165] Such a standpoint is mostly asserted by developing countries[166] that believe that technology is a form of valuable knowledge[167] and an asset that belongs to mankind should be shared more freely between all societies. However, as the TRIPS Agreement was not based on "democratic negotiations between the larger public and commercial interests or between industrialized countries and the Third World,"[168] for it reflects more of the values and interests of developed countries. As a consequence, a TT mechanism was not valued enough by the negotiating members as if it is crucial to the achievement and implementation of the Agreement. At this special stage of combatting climate change, and at a time when Kyoto is sun-setting (without insisting on equal replacements), some ratification might be added to existing legal obligations for TT in TRIPS in cases where TTs are not being effective and

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163 See Chpater I Literature Review, Section 1.4

164 See for example, Maskus (n 44); Pamela J. Smith, 'How do Foreign Patent Rights affect US Exports, Affiliate Sales, and Licenses?' (2001) 55 Journal of International Economics 411; Hoekman, Maskus and Saggi (n 130); John H. Barton, 'Intellectual Property and Access to Clean Energy Technologies in Developing Countries' (2007) ICTSD Issue Paper No 2

165 Antoine Dechezleprêtre and others, 'Invention and Transfer of Climate Change–Mitigation Technologies: A Global Analysis' (2011) 5 Review of Environmental Economics and Policy 109: "Statistics suggest that the Protocol has induced more innovation in the recent period. While innovation in climate change technologies and innovation in all technologies were growing at the same pace until the mid-nineties, the former is now developing much faster. Between 1998 and 2003, innovation in climate mitigation technologies has been growing at the average annual rate of 9%. This increase has taken place in Annex 1 countries which have ratified the Kyoto Protocol but not in Australia and in the USA."

166 Vandana Shiva, *Biopiracy: The Plunder of Knowledge and Nature* (Boston: South End Press 1997).

167 Vandana Date, 'Global Development and Its Environmental Ramifications-The Interlinking of Ecologically Sustainable Development and Intellectual Property Rights' (1997) 27 Golden Gate UL Rev 631.

168 Shiva (n 166).

sufficient. At least this is one possibility in the future to help eliminate the effects of IP obstacles between green-technology holders and potential importers. Clearly it is easier said than done, given the difficulty of previous TRIPS negotiations. However, because the TRIPS Agreement was the result of multilateral negotiations trying to represent the interests of all member states, it is ought to keep up with time and situations, emancipate fixed minds about intangible assets, and continue to compromise between countries with strongly opposing views regarding the value of IP for development.[169]

5.3.1 Article 7: Objectives of the TRIPS Agreement

The first important aim is to identify the objectives of the TRIPS Agreement in Article 7.[170] Through this article, "TRIPS stipulates that the objective of the protection and enforcement of IPRs should be to both promote innovation and facilitate the diffusion of technology, balancing legitimate interests in a socially beneficial manner."[171] And by pointing out "the mutual advantage of producers and users of technological knowledge" this laudable provision is understood, in this thesis, as reflecting the search for a balanced approach to IPR protection that takes into account the interests of both technology creators and receivers.

The provision mentions in particular the transfer and dissemination of technology, which is not essentially achievable under the TRIPS strong IP protection requirements and, without feasible and practical mechanisms provided, is far-fetched. For example, by examining FDI flows into a country, scholars attempted to measure a country's situation regarding the

[169] Robert M Sherwood, 'The TRIPS Agreement: Implications for Developing Countries' 37 IEDA 491.
[170] Article 7 "Objectives: The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations."
[171] Taubman and Watal (n 23).

acquisition of technologies. Intuitively, stronger IPR protections imposed by TRIPS requirements should give technology owners more incentive to license, participate in R & D cooperation, and invest in affiliates abroad where intangibles used to be protected insufficiently. With IP law reforms, they ought to worry less about technology leakages and will therefore be more confident in offering FDI in that country.[172] Based on results generated from surveys of patent lawyers and manufacturing executives, Mansfield found that FDI is logically associated with IPR protection available in the targeted country.[173] This would be a sensible initial conclusion to draw. However, his research failed to isolate the effect of IPR protection on FDI from other influencing factors, such as the technological capabilities of the receiving country (which itself may be significant as an attractor for investors); nor did it particularly link the result to the effect of TRIPS implementation. In fact, TRIPS is just one variable while there are other more pressing and predominant influences relating to the investment climate, government stands, market size, infrastructure and labour costs in the receiving country.[174] Moreover, it is pointed out that the effect of IPR protection varies from sector to sector, while it matters least, even in higher-tech manufacturing industry, where the products are difficult to imitate and/or reverse-engineer.[175] The issue is looked at from another angle by Lippoldt and Park, who examine data from countries with different income levels (high-income, middle-income, and low-income countries).[176] The

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172 Amanda Watson, 'Does TRIPS Increase Technology Transfer to the Developing World? The Empirical Evidence' (2011) 20 Information & Communications Technology Law 253.

173 Edwin Mansfield and Banco Mundial, *Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer* (1994).

174 Maskus (n 158).

175 Keith E. Maskus, 'The Role of Intellectual Property Rights in Encouraging Foreign Direct Investment and Technology Transfer' in Keith E. Maskus and Carsten Fink (eds), *Intellectual property and development: Lessons from recent economic research* (World Bank Publications 2005) <http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1243&context=djcil> .

176 W. Park and D. Lippoldt, 'Technology Transfer and the Economic Implications of the Strengthening of Intellectual Property Rights in Developing Countries' OECD Trade Policy Papers No 62 <http://www.cas.american.edu/cas/faculty/wgpark/upload/Tech-Transfer-w-Doug-Lippoldt.pdf> accessed 25 Jan 2008. "They use

positive effect of strengthened IPR protection in middle-income and least-developed nations is much less significant than it is in the developed countries. This demonstrates specifically the weak role that TRIPS is playing in promoting international TT to less developed countries, and how it is unintentionally discriminating members according to their income levels.

In the medical industry, mere 'market pull' forces, such as feasible pricing, will better facilitate technology development and diffusion in the target market with higher customer acceptance.[177] But these kinds of practices are not as well-suited to climate change TT and diffusion because they concern different technical, financial, and political risks. Developing renewable energy, for example, plays to the oil and gas sector. Any investment made will have to take many factors into consideration, such as energy-market insight, ancillary infrastructure availability, technology know-how, mega-project management excellence, solid credit and community engagement experience. In many instances where renewable energy technologies are competing against cheap diesel- or propane-based power in on-grid applications, success is very much dependent on the preferences of the domestic policy at stake. Challenges naturally arise from low natural-gas prices and the comparatively high capital costs of renewable energy, coupled with comparatively low rates of return for renewable power projects.[178] Thus, to overcome a big, long-term problem like climate change, the implementation of Article 7 needs to combine with practical mechanisms consisting of

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the GP and Park and Wagh patent indices, a copyrights index, a trademark rights index, and an IPR survey from the World Economic Forum covering 120 high-, middle-, and low-income countries between 1990 and 2005. They find that increasing the strength of patent laws by 1% (as measured by the indices), raises FDI by 2%. When they examine each group of countries separately, however, results vary depending on income level: for developed countries, the 1% change in the index leads to an 11.2% increase in FDI. For middle-income and least-developed nations, the positive effect drops to less than 2%." Watson (n 172).

[177] Rod Coombs, Paolo Saviotti and Vivien Walsh, *Economics and Technological Change* (Rowman & Littlefield 1987) p.96.

[178] Jason Switzer, 'When Renewables Meet the Oil and Gas Industry, Opposites Attract' (*Renewable Energy World*, April 14, 2014) <http://www.renewableenergyworld.com/articles/2014/04/when-renewables-meet-the-oil-and-gas-industry-opposites-attract.html> accessed 26-June-2017.

financial and technical assistance, promoting research and development along with a range of targeted supports in order to efficiently encourage TT in diverse forms.

A more practical provision would be to promote international TT efficiency (e.g. amending the TRIPS Agreement to require patent applications to disclose know-how used in the inventions); and to focus national political efforts on climate change and renewables, including setting up a meaningful carbon price and encouraging renewable-energy literacy among different types of companies (state owned and privately owned companies). This again could be actualized through developed-country members' duty to provide "technical and financial cooperation" for TRIPS implementation to all developing countries.[179] At the same time, while ministerial declarations (i.e. on TRIPS and Public Health[180]) may not carry the same weight as the formal agreement, they do indicate that members consider the guiding principles to be crucial to TRIPS interpretation.[181] The Trade and Environment Committee under the Doha Ministerial Declaration[182] therefore pursued the objective by altering the way they look at the relevant provisions of the TRIPS Agreement.[183] Littleton points out that the "public health exemptions granted during the Doha Round of WTO negotiations must be construed broadly so as to include some technologies that guard against climate change."[184]

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179 Trade-Related Aspects of Intellectual Property Rights (unamended version), Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, signed in Marrakesh, Morocco on 15 April 1994.

180 Declaration on the TRIPS Agreement and Public Health, DOHA WTO MINISTERIAL 2001: TRIPS, WT/MIN(01)/DEC/2, 30 June 2017

181 Matthew Littleton, 'The TRIPS Agreement and Transfer of Climate-Change-Related Technologies to Developing Countries' (2009) 33 Natural Resources Forum 233.

182 Ministerial Declaration, Doha 9-14 Nov 2001 WT/MIN(01)/DEC/1 (01-5859) 20 November 2001

183 See more details in Section 5.3.3.

184 Littleton (n 181).

However, concerning the different viewpoints of developed countries and developing countries with respect to IP protection in reaching the TRIPS Agreement,[185] the chances of broadest disclosures (i.e. disclosure that includes know-how and other trade-secrets) being agreed to by signatories of TRIPS is likely to be low. Only such a huge shift in IP laws, and in particular the approach to patent applications, would survive through persistent efforts and the potential ways of bridging the gap between the viewpoints of the developed and developing countries regarding IP protection.[186] Just like the history of TRIPS, prior to which countries had widely varying levels of IP protection and enforcement due to divergent goals, values, history, culture, tradition and political climate, it is not 'mission impossible' to accomplish this.[187] "Because ratification of TRIPS is a compulsory requirement of WTO membership,"[188] the Agreement has become one of the most important multilateral instruments for the globalization of IP laws. To countries such as Russia and China that were very unlikely to commit themselves to restrictive IP obligations, the prospect of WTO membership has proved a powerful enticement.[189] Therefore, those countries that used to provide very little in the way of IP protection would be willing to compromise to secure better access to trade opportunities and to the most advanced technologies in developed countries. Likewise, nations are likely to shift IP systems given the scope of IP protections to be altered.

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[185] L. Danielle Tully, 'Prospects for Progress: The TRIPS Agreement and Developing Countries After the DOHA Conference' (2003) 26 BC Int'l & Comp L Rev 129; Littleton (n 181).

[186] See for example, Kevin W. McCabe, 'The January 1999 Review of Article 27 of the TRIPS Agreement: Diverging Views of Developed and Developing Countries Toward the Patentability of Biotechnology' (1998) 6 J Intell Prop L 41.

[187] Donald P. Harris, 'TRIPS' Rebound: An Historical Analysis of How the TRIPS Agreement Can Ricochet Back Against the United States' (2004) 25 Northwestern Journal of International Law & Business 99.

[188] "Any country seeking to obtain hard access to the numerous international markets opened by the WTO must enact the TRIPS mandates." Zhongfa Ma, 'The Effectiveness of the kyoto protocol and consummating the legal institution for international technology transfer' (2010) 6 Asian Social Science 19.

[189] B Ramakrishna and Anil Kumar H.S, *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers* (Notion Press 2017).

Even with wide ratification of the TRIPS Agreement, the original goal of IP law harmonization remains incomplete today. Quite obviously, reform of IP protection is deemed to be tough and something for the long run. However, it is no excuse for timidity when it comes to the direction of reform. The need to complement the TRIPS preference for the "pull" approach[190] has grown because the agreement is "more concerned with how developing countries can provide an appropriate environment for TT than how developed countries can actively propel TT."[191] Requirements on developed countries to actively act on promoting and facilitating TT are vaguely worded, making the provision largely unenforceable. Therefore, because it is said that "a right correction is overcorrection," actions that seem militant could be a stimulant to the now inactive TRIPS regime regarding TT.

5.3.2 Article 8: the principles

Article 8[192] recognizes member states' right to adopt measures that protect "not only public health and nutrition but also the public interest in sectors of vital importance to their socio-economic and technological development."[193] Any measure undertaken by a member state should be consistent with this TRIPS principle. This provision also recognizes that members may need to take appropriate measures "to prevent the abuse of IPRs by right holders or the resort to practices which unreasonably restrain trade or adversely affect the international transfer of technology."[194] As a principle article, especially the later part of it, it

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[190] Hutchison (n 16).
[191] Littleton (n 181).
[192] Article 8, Principles: 1. Members may, in formulating or amending their laws and regulations, adopt measures necessary to protect public health and nutrition, and to promote the public interest in sectors of vital importance to their socio-economic and technological development, provided that such measures are consistent with the provisions of this Agreement. 2. Appropriate measures, provided that they are consistent with the provisions of this Agreement, may be needed to prevent the abuse of intellectual property rights by right holders or the resort to practices which unreasonably restrain trade or adversely affect the international transfer of technology.
[193] Taubman and Watal (n 23).
[194] Ibid.

should have provided great significance in the context of climate change TT, while also having the potential to become a protectionist provision, and the actual effect of the provision being debatable.

In the view of some countries the Article 8 is a redundant statement that emphasises the balancing of goals that had already been negotiated the forming the process of TRIPS and had already been embodied in the final texts of the Agreement. In particular, the EC pointed to the last phrase of Article 8.1, which requires any government measures taken to protect important socio-economic policies to be consistent with the obligations of the TRIPS Agreement. This would not only involve a double counting of such socio-economic policies among other articles (i.e. Article 30) but also direct away from the basic purpose of the TRIPS Agreement according to the Preamble and Article 1.1– to lay down minimum requirements for the protection and enforcement of IPRs.[195] The Appellate Body seems to be affected by this argument and therefore interpreted the Article in a conservative manner. In the Canada: Term of Patent Protection case, the Appellate Body acknowledged that it has yet to determine:

> the applicability of Article 7 or Article 8 of the TRIPS Agreement in possible future cases with respect to measures to promote the policy objectives of the WTO Members that are set out in those Articles and that 'those Articles still await appropriate interpretation.'[196]

"Article 8 speaks about the protection of public health. But 'public health' is not mentioned anywhere else in the agreement."[197] However, the Doha Ministerial Declaration suggest that

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[195] Peter K. Yu, 'The Objectives and Principles of the TRIPS Agreement' (2008) 46 Houston Law Review 797.
[196] WTO, 'Canada—Term of Patent Protection' (2000) 12 World Trade and Arbitration Materials 1, WT/DS170/AB/R, para. 101.
[197] Sudip Chaudhuri, 'TRIPS Agreement and Amendment of Patents Act in India' (2002) 37 Economic and political weekly 3354.

"the TRIPS Council shall be guided by the objectives and principles set out in Articles 7 and 8 of the TRIPS Agreement and shall take fully into account the development dimension."[198] With this reaffirmed principle of the Article countries could find good ground available for them when facing refusal to transfer climate change related technologies and to claim their conventional rights. Actually, there is already strong evidence of IP abuse in the trading of green products. In the ozone regime, refusal to license due to fear of competition has been hindering TT to firms in some developing countries. For example, "according to Korean firms and R & D institutions, there were cases where the private firms and even public institutions of industrialized countries refused to license such green techs like HFC 134a, fuel cell and the Integrated Gasification Combined Cycle."[199] Such refuse to sell non-ozone-depleting products to Korea "forced local firms to invest $12 million over a six-year period to develop their own technology."[200] Article 8 authorizes members to take measures to prevent the abuse of IPRs and to promote trade and TT. Yet understanding of the scope of this provision can be different. "For one thing, 'unreasonable' practices are in the eye of the beholder."[201] For another, is it unclear what measures shall be considered as 'appropriate.'[202] Nevertheless, if developing countries makes fair use of it, Article 8 still has the potential to protect TT in some cases. For example, if the climate change issue is considered of "public interest in sectors of

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198 Ministerial Declaration, Doha 9-14 Nov 2001 WT/MIN(01)/DEC/1 (01-5859) 20 November 2001. See also Carlos Correa, *Trade Related Aspects of Intellectual Property Rights: A Commentary on the TRIPS Agreement* (Oxford University Press 2007) p.102-05.

199 IPCC, *Methodological and Technological Issues in Technology Transfer: A Special Report of the Intergovernmental Panel on Climate Change* (Bert Metz and others eds, Cambridge University Press 2000) p.98.

200 Rae Kwon Chung, 'The Role of Government in the Transfer of Environmentally Sound Technology' in Tim. Forsyth (ed), *Positive Measures for Technology Transfer under the Climate Change Convention* (London: Royal Institute of International Affairs 1998) p.52; See Korean Trade Promotion Agency, 'Case Study: The Republic of Korea and the Montreal Protocol' in Veena Jha and Ulrich Hoffman (eds), *Achieving Objectives of Multinational Environmental Agreements: A Package of trade Measures and Positive Measures* (United Nations Conference on Trade and Development UNCTAD/ITCD/TED/6) 62 <http://www.unctad.org/en/docs/itcdted6_en.pdf> : "In the opinion of Korean firms, the exorbitant high royalties are an expression of a lack of intention to transfer the alternative technology on the part of technology owners."

201 Yu (n 195).

202 Ibid (n 195).

vital importance", member states in such circumstances are entitled to ask for remedies from the technology owner's country. And a refusal to license to a competitor on commercial terms will have "adverse effect on the international TT", thus making it an abuse under Article 8.2 that can be addressed in a national legislation.[203]

Both Article 7 and Article 8 are treated only as goals without specific obligations being imposed. The spirit of the two articles "is not adequately reflected in the wording of the operative sections of the Agreement."[204] A fortunate part of the TRIPS Agreement is that the generically worded articles are influential as guiding principles.[205] Both these articles are, indeed at some length, vaguely drafted so as to allow signatory states considerable room for manoeuver when implementing the balance between TT and protecting jurisdictionally based IP rights. For example, as an objective article, Article 7 demands fair consideration of the rights of patent holders, which will affect the invocation of other provisions in the Agreement; for instance, limiting member states' ability to take advantage of flexibilities[206] provided under TRIPS. These flexibilities are made available to member states when amending national laws in terms of: what is being patented, on what basis, how are claims be interpreted, permitted exceptions, compulsory licensing, the remedying of abuses, and anti-competitive practices. They are especially important for developing countries maintain healthy competition in their domestic markets. Developing country governments may play with these flexibilities in order to buy some time for their indigenous companies that are less competitive at the current stage and need the special support of favourable policy. The Agreement does

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[203] Hutchison (n 16).
[204] Chaudhuri (n 197).
[205] They are supported by both the Doha Ministerial Declaration and the Declaration on TRIPS & Public Health (WTO, 2001c; 2001a)
[206] Flexibilities such as the compulsory licensing will be discussed in the later Section 5.3.6.

not constrain the freedom to adopt different types of policies by member states, whether these policies are to increase international TT.

However, even though reviews of the objectives and principles of TRIPS have identified that there is a supportive attitude towards technology diffusion and fair benefits for technology users, more can and should be done within the regime.[207] While member states find little room to manoeuvre from within the TRIPS themselves (because the Agreement requires them to be consistent with international standards of IP protection) "developing countries could be given increased discretion in adapting IPR laws to their economic, social and environmental needs. Climate-friendly technologies could receive special treatments like those afforded to essential medicines."[208] On the other hand, any significant amendments made to the Agreement will come at a cost to Member states, especially the developed ones, which will reduce the possibility of reaching agreements and enforcing implementation. Therefore, there is a need to provide a rationale and transitional measures for embedding commitments as part of a negotiating framework.

5.3.3 Article 27.1: Patentable subject matter

WTO members are obliged under Article 27.1[209] to grant patents to applicants for any invention, whether product or process, in all fields of technology, with some permitted

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[207] Details of action that could be done will be discussed later in the solution Section later in this Chapter
[208] Littleton (n 181).
[209] Article 27, Patentable Subject Matter: 1. Subject to the provisions of paragraphs 2 and 3, patents shall be available for any inventions, whether products or processes, in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application. (5) Subject to paragraph 4 of Article 65, paragraph 8 of Article 70 and paragraph 3 of this Article, patents shall be available and patent rights enjoyable without discrimination as to the place of invention, the field of technology and whether products are imported or locally produced. 2. Members may exclude from patentability inventions, the prevention within their territory of the commercial exploitation of which is necessary to protect order public or morality, including to protect human, animal or plant life or health or to avoid serious prejudice to the environment, provided that such exclusion is not made merely because the exploitation is prohibited by their law. 3. Members may also exclude from patentability: (a) diagnostic, therapeutic and surgical methods for the treatment of humans or animals; (b) plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any

exclusions, provided that three criteria are met: "that the invention is new, non-obvious, or involves an inventive element and is useful or industrial application. But how countries choose to set thresholds for these criteria is a matter of discretion."[210]

Firstly this means that a patent could be granted to basically any invention, whether it is a product or a process irrespective of the field of technology. For example, "whether the invention is a new reflector/concentrator system in solar power or a new process for storing heat longer,"[211] it can be protected by IP laws. This is an important incentive for everyone involved in industry from manufacturing to customer-facing. All of these people have the potential to become innovators. However, in practice, there are "broad patent claims stifling follow-on innovation, since subsequent inventors will find it difficult to 'invent around' a previous innovation, or too costly to obtain a licence from the patent holder."[212] According to Barton, broad patent claims clearly happen, for example, in the biotechnology field on all transgenic cotton and on biological receptors. He states that "biotechnology is perhaps special, in that almost any invention has a variety of analogues that may be claimed and in that the current development of the technology often identifies specific techniques that are useful in other inventions." [213] Barton also argues that "the existence of such broad patents can lead to a pattern of cross-licensing among the leading firms of a particular sector, and may

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combination thereof. The provisions of this subparagraph shall be reviewed four years after the date of entry into force of the WTO Agreement.

[210] See John Barton and others, 'Integrating Intellectual Property Rights and Development Policy' Report of the Commission on Intellectual Property Rights <http://iprcommission.org/papers/pdfs/final_report/ciprfullfinal.pdf> accessed London September 2002 p. 114-18; See also Carlos M. Correa, 'Patent Rights' in Carlos María Correa and Abdulqawi Yusuf (eds), *Intellectual Property and International Trade: The TRIPs Agreement* (Kluwer Law International 2008) p. 201: countries have discretion whether to patent new uses for known or patented products; and at 205, countries have discretion as to whether they interpret claims literally or purposively.

[211] Taubman and Watal (n 23).

[212] See Nancy T. Gallini, 'Patent Policy and Costly Imitation' (1992) 23 The RAND Journal of Economics 52 pp. 52-63; See also, Paul Klemperer, 'How Broad Should the Scope of Patent Protection Be?' (1992) 21 The RAND Journal of Economics 113.

[213] John H. Barton, 'Patents and Antitrust: A Rethinking in Light of Patent Breadth and Sequential Innovation' (1997) 65 Antitrust Law Journal 449

be usable to prevent entry by others into that network or may affect the inventive for further research by others."[214] Once this happens, members will find it hard to revoke patents on exceptional grounds. Even more, the TRIPS Agreement precludes "a member from revoking a patent in order to serve other general societal goals, such as promoting technology transfer for environmentally sound technologies."[215] Although Article 32[216] mentions the possible revocation/forfeiture as a result of the judicial review of any decision, there is no fast way under TRIPS to challenge these patents. If such broad patents are granted in a country, it is even harder for foreign competitors to enter the market. Any conflicts, however arguable, would not generate anything like a legal cause of action, leaving anyone that believes a member state's patent standards are inconsistent with the Agreement without a remedy under TRIPS.[217] This leaves competitors with only these means of recourse: seeking domestic forms of redressing the problem (highly risky in terms of cost and time invested), or cheating (which is a short cut) in order to obtain technology protected by these patents.[218]

On the bright side, this could be less problematic in jurisdictions such as the UK where broad/generic patent claims are regarded with a very dim view and not granted as a matter of law and policy. Indeed, the National Patent Offices in most countries carry out substantive examinations before granting patents to applicants. Often such substantive examination involves searching the prior art to determine whether the applicant is entitled to patent protection. In most cases, patent applications are filed with relatively broad claims and will be

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[214] Ibid.
[215] Taubman and Watal (n 23).
[216] Article 32, Revocation/Forfeiture: An opportunity for judicial review of any decision to revoke or forfeit a patent shall be available.
[217] M. Ho. Cynthia, 'Biopiracy and Beyond: A Consideration of Socio-Cultural Conflicts with Global Patent Policies' (2005) 39 U Mich JL Reform 433.
[218] Carlos M. Correa, 'Managing the Provision of Knowledge: The Design of Intellectual Property Laws' in Inge Kaul and others (eds), *Providing global public goods: managing globalization* (Oxford University Press 2003) p.415.

declined. And even in countries with less experience in enforcing IP laws, such issues could be solved through improvements in the granting of patents. But still, in Barton's view, whether a patent is too broad is in the eyes of the parties concerned; for instance, a company wishing to enter a particular market covered by a patent(s) is inevitably going to argue that the patent should be revoked. In a more recent US case, Mayo Collaborative Services v. Prometheus Laboratories Inc. (2012) a general message about broad patents was conveyed. Claims are likely to encompass non-patentable subject matter if "the steps in claimed processes involve well-understood, routine, conventional activity previously engaged in by researchers in the field."[219] Upholding patents as such "would risk [...] inhibiting their use in the making of further discoveries."[220] Messages like this will affect the thousands of existing patents that are considered too broad to harm innovation in society and encourage investors to remain optimistic regarding the potential for successful commercialization in relevant sectors.[221]

According to Article 27, apart from the specific exceptions in TRIPS, member states cannot exclude whole classes of inventions in fields of technology from patenting. An earlier example before India amended its IP law to meet TRIPS requirements is found in "the 1970 Indian Patents Act which prohibited product patents for agricultural and food".[222] Such exclusion of a whole class of technology from patenting is clearly against Article 27.1 of the TRIPS Agreement, which requires that patents should be available for any invention, in all fields of technology no matter they are products or processes. With the TRIPS Agreement several

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219 *Mayo Collaborative v. Prometheus Labs* 132 Supreme Court 1289 (2012).
220 Ibid.
221 Kwame Mensah, 'Mayo Collaborative Services v. Prometheus Laboratories, Inc. (2012)' (*PatentDocs.org*, March 20, 2012) <http://www.patentdocs.org/2012/03/mayo-collaborative-services-v-prometheus-laboratories-inc-2012.html> accessed 26 June 2017.
222 Jagjit Kaur Plahe, 'The Implications of India's Amended Patent Regime: Stripping Away Food Security and Farmers' Rights?' (2009) 30 Third World Quarterly 1197.

amendments[223] were made according to the Act in exchange for trade enabled by the WTO. Since the April 1989 mid-term review of the Uruguay Round, an ethos of expanded scope for IPRs and enforcement to ensure IPR standards emerged. The developed countries represented by the US insisted that the scope of IPRs be placed "in the wider developmental and technological context" in individual countries.[224] Although developing countries such as India have raised objections to the requirement – especially on the issue of process versus product patents and the negative effect of granting patents to all pharmaceutical and agricultural technologies[225]– most of these concerns failed to win sufficient attention during the negotiations. Even the developing countries have been advocating for a less comprehensive patentability agreement on IPRs to date, yet changes have been made.

This could be a barrier for countries seeking possible resolution to climate change problems through granting exceptions for a list of green technologies or other designated fields of environmental technologies to be non-patentable or semi-patentable. For example, "depending on the circumstances it may be considered discriminatory for members to exclude from patent grants an entire field of technology such as biofuels, or to provide special exceptions to patent rights only in one field of technology."[226] Exemption need not completely deprive green-technology owners from enjoying IP protection and its monopoly benefits, but instead of a full version of IP rights, limited/fewer IP rights could be granted, compared to other patents. As mentioned in the justification section earlier, innovators are

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[223] Ibid.

[224] WTO, *Standards and Principles Concerning the Availability, Scope and Use of Trade Related Intellectual Property Rights* (MTNGNG/NG11/W/37, 10 July 1989, Special Distribution, 1989).

[225] "The Indian government argued that 'the basic rationale behind process patents is that the same product can be manufactured by totally new and different processes'. The government also argued that product patents for food, pharmaceutical and chemical sectors would have other adverse implications for the country's socioeconomic development." Ibid p.7.

[226] Taubman and Watal (n 23).

not purely patent-driven but can be encouraged to invent through many alternative strategies. There are already similar exemptions accepted under TRIPS. In Article 27.3(a) it states that members can exclude three types of technology from patentability: the diagnostic, therapeutic and surgical methods for the treatment of humans or animals (in which sectors no significant delay in inventing and innovating is found); but the literal scope of the provision is not broad enough to cover green technologies directly. This optional exclusion could be further exploited during future climate change negotiations, given that application of a range of climate change technologies are highly relevant to human and animal health. The 2001 Doha Declaration emphasized that TRIPS does not prevent member states from taking the necessary steps to protect public health. As "the understanding that global climate change represents a profound threat to the health and well-being of human and non-human species worldwide is growing,"[227] states could also be able to apply the public health goal to climate change issues because climate change damages can affect diseases, agricultural resources, and water supply and quality, among other consequences. Therefore, Abbott suggest a declaration comparable to the Doha Declaration with respect to IPRs and climate change, saying that it "may be useful in the progressive development of international law, so that it properly balances the rights of innovators and access by the public to the benefits arising from new technologies."[228] The example of certain pharmaceutical products having been exempted, and the fact that "WTO Appellate Body has interpreted this non-discrimination

[227] Edward W. Maibach, Connie Roser-Renouf and Anthony Leiserowitz, 'Communication and Marketing As Climate Change–Intervention Assets' (2008) 35 American Journal of Preventive Medicine 488.
[228] Frederick M. Abbott, 'Innovation and Technology Transfer to Address Climate Change: Lessons from the Global Debate on Intellectual Property and Public Health' (2009) ICTSD Programme on IPRs and Sustainable Development Issue Paper No 24.

provision leniently",[229] indicates that such exempting measures may not pose a problem for countries wishing to isolate green technologies for special treatment. A stronger argument could be made with TRIPS dispute settlements clarification that "differential treatment of different fields of technology does not automatically equal discriminatory treatment."[230] The most difficult part of the search for exceptional regulation solutions to the world's environmental degradation is that the need for a constantly updated inventory of "new and emerging technologies and state capabilities."[231]

5.3.4 Article 28: IPRs

Article 28[232] sets out a number of rights that should be available under national IP law to the owner of a patent. It states that where the subject matter of a patent is a product, the patent owner shall have the right to prevent others from making, using, offering for sale, selling, or importing for these purposes that product. Unfortunately, "there is no corresponding section on the obligations of the patentees, although Article 7 speaks of balancing the rights and obligations."[233] This will possibly raise the cost of TT, making it harder to afford for developing countries. Because environmental protection already consumes a lot of money, higher costs on technology imports will further discourage developing countries from a

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[229] Frederick M. Abbott, 'The TRIPS-Legality of Measures Taken to Address Public Health Crises: A Synopsis' (2002) D. Kennedy and J. Southwick eds., Cambridge University Press, 2002 THE POLITICAL ECONOMY OF INTERNATIONAL TRADE: ESSAYS IN HONOR OF ROBERT E HUDEC 311 71.

[230] Taubman and Watal (n 23).

[231] Timothy A. Canova, 'International Law Confronts the Global Economy: Labor Rights, Human Rights, and Democracy in Distress' (2005) 8 Chap L Rev 1.

[232] Article 28, "Rights Conferred: 1. A patent shall confer on its owner the following exclusive rights: (a) where the subject matter of a patent is a product, to prevent third parties not having the owner's consent from the acts of: making, using, offering for sale, selling, or importing (6) for these purposes that product; (b) where the subject matter of a patent is a process, to prevent third parties not having the owner's consent from the act of using the process, and from the acts of: using, offering for sale, selling, or importing for these purposes at least the product obtained directly by that process. 2. Patent owners shall also have the right to assign, or transfer by succession, the patent and to conclude licensing contracts."

[233] Chaudhuri (n 197).

commitment to sustainable ways of growth. Studies[234] suggest that "patents and other IPRs may not be acting as barriers to market entry."[235] In fact, the relationship between strengthening IPR protection and economic growth in the countries where reform took place could be proportional. Park and Ginarte find "that IPRs affect economic growth indirectly [but positively] by stimulating the accumulation of factor inputs like R & D and physical capital."[236] Branstetter et al.[237] confirmed the above observation from a different perspective by looking at firm-level data. They found that TT within US multinational firms responded much more actively to IPR reforms undertaken by sixteen countries in an early period from 1982 to 1999. A clear increase in foreign-patent application rates was discovered during IP reforms meeting developed-country standards (strengthening IP protection), which, on the other hand, indicated a predictable decline in patenting and even more backsliding in innovation rates if IP reform poles apart (weakening the IP protection).

However, these studies are by no means conclusive[238] and proper abatement reform of excessive IP protections can in fact be beneficial to innovations in and the diffusion of climate change technologies. There have been a number of patent disputes affecting the US market. For example, in 1996 Enercon was barred by the US International Trade Commission from importing wind turbines into the US.[239] "The patent involved covered a particular method of

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[234] See, e.g., Barton, 'Intellectual Property and Access to Clean Energy Technologies in Developing Countries' (n 162), and also Reichman and others (n 65) and Hutchison (n 16).

[235] Frederick M. Abbott, 'Innovation and technology transfer to address climate change: lessons from the global debate on intellectual property and public health' ICTSD Programme on Intellectual Property Rights and Sustainable Development Issue Paper No 24 <http://ccsl.iccip.net/innovation-and-technology-transfer-to-address-climate-change.pdf> accessed Janurary 2017.

[236] Walter G. Park and Juan Carlos Ginarte, 'Intellectual Property Rights and Economic Growth' (1997) 15 Contemporary Economic Policy 51.

[237] Branstetter (n 158).

[238] Abbott, 'Innovation and Technology Transfer to Address Climate Change: Lessons from the Global Debate on Intellectual Property and Public Health' (n 235).

[239] *Enercon GmbH v. International Trade Com'n* 151 F3d 1376 (Court of Appeals, Federal Circuit 1998), quoted by Barton, 'Intellectual Property and Access to Clean Energy Technologies in Developing Countries' (n 162): "There are allegations that the technology was stolen from Enercon. see European Parliament, *Report on the Existence of a Global System for the Interception of*

controlling the inverter in order to provide power most effectively to the grid, and was held by Kinetech."[240] Another case is Gamesa Eolica, S.A. v. General Electric Co, where the plaintiff sought to enforce a patent on a strategy of controlling the turbine speed against GE.[241] More recently, in 2008 GE asked the US ITC to "bar imports of wind turbines made by Japan's Mitsubishi Heavy Industries Ltd., arguing that Mitsubishi's turbines infringe on its patents."[242] These cases demonstrate the potential hindering effects of patent protection on the diffusion of technology. Even acquitting of a barrier to market entry, it is not making IPRs an encouragement to TT as stated in TRIPS. This is especially so in the wind turbine industry, which is highly concentrated with the top four companies already accounting for nearly 75 per cent of the market[243] and where patent monopoly is undisputedly reinforcing the unbalanced power possessed by the technology holders. Major players like GE have a reputation for enforcing their patents aggressively in the US market, and it is not hard to foresee them repeating the same pattern in other developing countries if IP environments allow them to do so.

Article 28 goes on to state the rights of a process-patent owner to prevent others from the act of using the process, and from the acts of using, offering for sale, selling, or importing for these purposes the product obtained directly by the process in question. This further emphasizes the rights of the patent owner. For example, a patent on a novel, cheaper method of producing photovoltaic cells that used to be manufactured in a known way, could be used

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Private and Commercial Communications ((ECHELON Interception System)(2001/2098 (INI)): Motion for a Resolution, Explanatory Statement, 2001)".

240 Kinetech is a "technology investment and patent holding company managed by Lachman Goldman Ventures." Barton, 'Intellectual Property and Access to Clean Energy Technologies in Developing Countries' (n 162).

241 *Gamesa Eolica, SA v. General Electric Co* 359 F Supp 2d 790 (WD Wis 2005) quoted by Barton, 'Intellectual Property and Access to Clean Energy Technologies in Developing Countries' (n 162).

242 Reichman and others (n 65).

243 Ibid.

to prevent the sale of PV cells produced by this new method.[244] This is indicating that even though Article 28 does not grant rights to the owners to block the use of any other PV cells, the right over the control of sales is still there for them to influence the solar-energy industry.[245] Together with Article 33[246], under which states are obliged to grant 20-year monopoly rights to patent holders, developing-country members are prevented from selling products freely – as long as the innovation concerns the patented technologies – for many years. According to the study by Horowitz and Lai,[247] there is a countervailing effect of patent length upon the "size" and "frequency" of innovation. Longer patents increase the size, but decrease the frequency of innovation and vice versa. However, at an intermediate patent length, these two forces will balance eventually so as to maximize the overall rate of innovation. When pursuing a finite welfare-maximizing patent length, however, the decline in the frequency of innovation as the patent life is extended will affect the behaviour of its consumers. Consequently, from a welfare perspective, "the balance point between the size and frequency of innovation occurs at a shorter patent length."[248] In the climate change context, encouraging more users of green technology is the crucial point of welfare at stake; therefore, given the priority of climate change issues, a patent life that could maximize this welfare benefit is acceptably shorter than the secondary consideration, which would be to maximize the rate of innovation.

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[244] Taubman and Watal (n 23).

[245] see Frederick M. Abbott, Carlos M. Correa and Peter Drahos, *Emerging Markets and the World Patent Order* (Edward Elgar Publishing 2013) (n 235).

[246] Article 33, Term of Protection: The term of protection available shall not end before the expiration of a period of twenty years counted from the filing date.

[247] Andrew W. Horowitz and L. C. Lai Edwin, 'Patent Length and the Rate of Innovation' (1996) 37 International Economic Review 785.

[248] Ibid.

Even if developing countries' firms obtain non-infringing technologies independently, they will struggle to compete with their mature foreign competitors. Meanwhile, home states have little to help them as they are prohibited from applying preferential treatment to foster domestic innovative products under the WTO. A different perspective on the minimum length of patent protection derives from the chemical industry. As patents are granted to the "first to file" in many countries, in order to secure patent filing, pharmaceutical companies usually apply patents when the chemical is still at the laboratory stage. As a result, "many years will elapse whilst the product progresses through the various stages of development towards the market place."[249] Therefore, it is considered that a 20-year patent life is too short because the majority of it is consumed by further development of the product itself and by getting access to marketing approval from the public health regulatory bodies, leaving the effective term of a pharmaceutical product as, on average, eight years.[250] It has been observed in a WTO report paper that "for this reason, most of the major developed countries have introduced systems whereby a prolonged period of protection can be obtained to compensate, at least in part, for this loss of the effective period of protection."[251] However, if chemicals are intended by companies to get patent registered in a rush at their premature stage, should extra longer protection be granted to them in order to compensate time they have wasted deliberately? To date, there is yet request for prolonged period of protection from the green-technology field. This could be seen as an indicator that competition in the

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[249] 'Introduction to Intellectual Property Rights and their Relevance
To the Pharmaceutical Industry' (*Stratagem Intellectual Property Management*)
<https://www.stratagemipm.co.uk/media/1056/introduction_to_intellectual_property_rights-revised_oct_12.pdf> accessed Feburary 2017
[250] Ibid.
[251] WTO, 'Pharmaceutical Patents and the TRIPS Agreement' (*TRIPS Agreement*, 21 September 2006)
<https://www.wto.org/english/tratop_e/trips_e/pharma_ato186_e.htm> accessed 30 JUNE 2017.

climate change technology sector is less intense than in the pharmaceutical industry and that market access is comparatively fast and convenient. Moreover, the cost of developing a drug for market compared to the cost to reverse-engineer it is significantly different from costs related to green technologies. Imitative competitors in the green industry sector, especially renewable energy area, will have to pay considerable amounts of R & D costs and it requires remarkably long time spans to develop compatible products to market.[252] Therefore, the risk of investment-return loss is lower. Accordingly, there is less need for countries to deal with this problem by enacting legislation to partially restore the lost patent life.[253]

For indigenous innovators in developing countries, it may be beneficial to enjoy strong patent protection in the domestic market, and some firms in large developing countries are becoming more aware of the importance of IP protection as they transform from being a technology receiver to a producer. Not only that, but "based on the experience of Asian economies, developing countries should adopt standards of patentability, novelty, and utility that are stricter (i.e. they raise a higher bar to patenting) than those in the US and EU Members"[254] to effectively protect the order of the technology market. Yet in reality the majority of developing-country parties are limited due to their lower capability of conducting original R & D. Therefore, they tend to focus on minor follow-on innovations (including adaptation or the improvement of already developed technologies). So, any benefit from

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[252] See more detail in Chapter VI

[253] "For example, the Supplementary Protection Certificates (and in the USA Patent Term Extensions which will not be discussed here) are the mechanism by which governments have attempted to return to the patent holder something nearer the twenty year monopoly they once enjoyed. These Certificates or Extensions do not provide the same breadth of cover; they are usually restricted to the active chemical entity or a combination of active ingredients contained in the marketed product (and sometimes close derivatives). They do not therefore restore the broad monopoly otherwise enjoyed by the patent holder in the first twenty years." Abbott, 'Innovation and technology transfer to address climate change: lessons from the global debate on intellectual property and public health' (n 235).

[254] See also Hoekman, Maskus and Saggi (n 130).

strong patent protections accruing to domestic innovators in developing countries is, in most cases, "overwhelmingly outweighed by the high cost of importing patented technologies from developed countries."[255] It is indeed as the World Bank has suggested that "overly protective IPR regimes may inhibit follow-on innovations, thus generally slowing down technological development, particularly in developing countries."[256]

5.3.5 Article 30: Exceptions to IPRs

Article 30[257] authorizes members to allow limited exceptions to the exclusive rights conferred by a patent, "provided that such exceptions do not unreasonably conflict with normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account of the legitimate interests of third parties."[258] In a broader sense, as Watal states, "limited exceptions"[259] could be seen as "those recognized in most patent laws: private and non-commercial use, use for research, experimental or academic purposes, and use in the direct preparation of individual medicines by pharmacies."[260] The research exception, under which researchers can use patented inventions for research is important for academics who cannot afford to pay commercial licensing fees for a key patent.[261] "TRIPS negotiators adopted the approach of establishing general principles that national legislators should observe, rather than an exhaustive list that would have set out

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255 Duncan Matthews, *Globalising Intellectual Property Rights: The TRIPS Agreement* (Routledge 2003) p.110
256 World Bank (n 119) p.34.
257 Article 30, "Exceptions to Rights Conferred: Members may provide limited exceptions to the exclusive rights conferred by a patent, provided that such exceptions do not unreasonably conflict with a normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account of the legitimate interests of third parties."
258 Article 30, "Exceptions to Rights Conferred: Members may provide limited exceptions to the exclusive rights conferred by a patent, provided that such exceptions do not unreasonably conflict with a normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account of the legitimate interests of third parties."
259 The crucial sentiment here is 'limited' otherwise the exceptions would become meaningless.
260 Jayashree Watal, *Intellectual Property Rights in the WTO and Developing Countries* (Kluwer Law International 2002) p.314, quoted by Hutchison (n 16).
261 J. H. Reichman and J. Giordano Coltart, 'A holistic approach to patents affecting frontier science: Lessons from the seminal genomic technology studies' (European Patent Forum, May 2008) p.6-7.

specific exceptions to be implemented at the national level."[262] Thus, TRIPS does not ascertain the meaning of terms used in this Article (i.e. "limited exceptions", "unreasonably conflict", "legitimate interests") which are in fact independent requirements that must be applied cumulatively. This makes this article a possible juncture for climate change technology to seek remedial action to the current IP protection considered to be too stubborn to allow more exceptional use of climate change technology. However, there has been much scope to consider the immense difficulty in balancing these exemptions with the legitimate rights of patent holders. These exceptions, if widely defined, may hinder the very objective patents application rate and even further hinder the innovation rate across the whole of society. This explains why TRIPS only provides a general rule to be respected by national law in allowing exceptions rather than setting out specific exceptions. This is also reserving the right for the interpretation of the Article in a conservative way to restrict member states from interpreting it too far from its original intention.

For example, an interpretation given by a WTO dispute-settlement panel is available in its ruling where "while a Canadian law allowing generic drug manufacturers to use the patented medicine to obtain regulatory approval in order to market the product after patent expiry was legal under the TRIPS Agreement, allowing such manufacturers to make and freely stockpile medicines during the patent term was not."[263] This so-called 'Bolar' exception basically allows "manufacturers of generic drugs to use the patented invention for purposes of obtaining

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[262] Taubman and Watal (n 23).

[263] *Roche Products v. Bolar Pharmaceutical Co* 733 F2d 858 (Fed Cir 1984) quoted by Taubman and Watal (n 23).

marketing approval from drug regulatory authorities"[264] during the patent protection period, so that they can be launched immediately on expiry of the patent period. Potentially, with the growing interest in climate change mitigation, this provision could be meaningful in the context of certain environmental technologies. For example, the smart-grid technology and offshore wind-energy technology-related construction projects are currently subject to regulatory processes for national security reasons and central planning by the government in China. If such exceptions are made available to this area, they may help bring forward the project design process and accelerate the diffusion of such technologies.[265] However, this precedent is rather narrow in regard to its applicability. As we have said, the ruling of the WTO dispute-settlement panel recognized the exceptional use of patented medicine for the preparation of regulatory market access only. Actions like allowing "manufacturers to make and stockpile medicines in unlimited quantities during the patent term was not consistent with this three-step test."[266] In contrast, similar activities of producing renewable energy equipment should not be considered as violating Article 30 in the case of an EST because they are more expensive to produce, require immense capitals and virtually unlikely to "unreasonably conflict with a normal exploitation of the patent" as development and application of such technologies to a full commercialized level takes a long time once knowledge is acquired, and in turn would not "unreasonably prejudice the legitimate interests of the patent owner" during their entitled monopoly period. However, it is very uncertain

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264 Anthony Tridico, Jeffrey Jacobstein and Leythem Wall, 'Facilitating generic drug manufacturing: Bolar exemptions worldwide' (*World Intellectual Property Organization*, June 2014) <http://www.wipo.int/wipo_magazine/en/2014/03/article_0004.html> accessed Feburary 2017.

265 Taubman and Watal (n 23).

266 Ibid.

whether the Bolar exception can be applied to wind energy projects preparation, and even it can, whether such narrow exception will help accelerating widen of EST application.

Indeed, the issues are more complex in the context of climate change technology than they are for essential drugs, given, for example, that the question of what precisely counts as 'a green technology' that could be exempt from IPRs remains murky without consensus. Nevertheless, "developing countries might well choose to advocate broadening the conception of current licensing exceptions beyond essential medicines."[267] Therefore, the exact scope of Article 30 is depending on the interpretation of its limiting conditions while bearing in mind the objectives and limitations stated in Article 7 and 8.1 as well as other provisions of the TRIPS Agreement that helps understanding of these objectives and limitations.[268] If, for example, the "legitimate interests of third parties" in mitigating or adapting to climate change are to be given tremendous weight in the interpretation, using green technologies, especially in urgent cases, may be exempted from patent restrictions.[269] Such exceptions may not be sufficient for a competitor to imitate freely, whereas it will at least help accelerate the access and diffusion of such technologies. As limited in applicability, fortunately the dispute-settlement panel interpreting of Article 30 does not say that it would not be challenged or revised in future. And, more importantly, nothing should prevent a national law from elaborating on these requirements and exceptions. "The fact that some provisions of the TRIPS Agreement are ambiguous does not mean that developing countries will have to interpret it in terms favorable to patentees from the developed countries."[270] In

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[267] Littleton, (n 181).
[268] Carvalho Nuno Pires de, *The TRIPS Regime of Patent Rights* (Kluwer Law International 2010).
[269] Littleton, (n 181).
[270] Chaudhuri (n 197).

fact, the Doha Declaration[271] has opened up new horizons for reasons like public health to be interpreted as part of exception making. Therefore, it is reasonable to hope that environmental protection will be seen as important while requiring nations to amend law to make its TRIPS consistent.

5.3.6 Article 31: Compulsory licensing

Article 31[272] is commonly referred to as covering compulsory licensing[273] requirements. According to grounds set under the laws of each member state, a compulsory licence will be granted non-exclusively in the nation without permission from the patent holder. A certain

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[271] Declaration on the TRIPS Agreement and Public Health, DOHA WTO MINISTERIAL 2001: TRIPS, WT/MIN(01)/DEC/2, 30 June 2017, para 4.

[272] Article 31, "Other Use Without Authorization of the Right Holder: Where the law of a Member allows for other use (7) of the subject matter of a patent without the authorization of the right holder, including use by the government or third parties authorized by the government, the following provisions shall be respected: (a) authorization of such use shall be considered on its individual merits; (b) such use may only be permitted if, prior to such use, the proposed user has made efforts to obtain authorization from the right holder on reasonable commercial terms and conditions and that such efforts have not been successful within a reasonable period of time. This requirement may be waived by a Member in the case of a national emergency or other circumstances of extreme urgency or in cases of public non-commercial use. In situations of national emergency or other circumstances of extreme urgency, the right holder shall, nevertheless, be notified as soon as reasonably practicable. In the case of public non-commercial use, where the government or contractor, without making a patent search, knows or has demonstrable grounds to know that a valid patent is or will be used by or for the government, the right holder shall be informed promptly; (c) the scope and duration of such use shall be limited to the purpose for which it was authorized, and in the case of semi-conductor technology shall only be for public non-commercial use or to remedy a practice determined after judicial or administrative process to be anti-competitive; (d) such use shall be non-exclusive; (e) such use shall be non-assignable, except with that part of the enterprise or goodwill which enjoys such use; (f) any such use shall be authorized predominantly for the supply of the domestic market of the Member authorizing such use; (g) authorization for such use shall be liable, subject to adequate protection of the legitimate interests of the persons so authorized, to be terminated if and when the circumstances which led to it cease to exist and are unlikely to recur. The competent authority shall have the authority to review, upon motivated request, the continued existence of these circumstances; (h) the right holder shall be paid adequate remuneration in the circumstances of each case, taking into account the economic value of the authorization; (i) the legal validity of any decision relating to the authorization of such use shall be subject to judicial review or other independent review by a distinct higher authority in that Member; (j) any decision relating to the remuneration provided in respect of such use shall be subject to judicial review or other independent review by a distinct higher authority in that Member; (k) Members are not obliged to apply the conditions set forth in subparagraphs (b) and (f) where such use is permitted to remedy a practice determined after judicial or administrative process to be anti-competitive. The need to correct anti-competitive practices may be taken into account in determining the amount of remuneration in such cases. Competent authorities shall have the authority to refuse termination of authorization if and when the conditions which led to such authorization are likely to recur; (l) where such use is authorized to permit the exploitation of a patent ("the second patent") which cannot be exploited without infringing another patent ("the first patent"), the following additional conditions shall apply: (i) the invention claimed in the second patent shall involve an important technical advance of considerable economic significance in relation to the invention claimed in the first patent; (ii) the owner of the first patent shall be entitled to a cross-license on reasonable terms to use the invention claimed in the second patent; and (iii) the use authorized in respect of the first patent shall be non-assignable except with the assignment of the second patent."

[273] Compulsory licensing derived from 1873 Vienna, "Developing countries may implement compulsory licensing provisions to remedy a refusal to deal in situations where the patent has been filed in that country. They may explicitly incorporating climate protection as a ground for compulsory licensing." Hutchison (n 16).; TRIPS Agreement, article 29 requires sufficiently clear and complete disclosure, and best mode, of the invention to the skilled addressee in the art. "However, this may not be as sound a solution to the problem as may first appear. Developing country firms may lack the expertise to develop the technology without more than just the blueprint. In particular, compulsory licensing does not oblige the patent holder to transfer know-how (nor does patent law in general)." Ibid (n 16).

amount of adequate remuneration will be given to the patent holder.[274] Countries can develop their own grounds for compulsory licensing and this view has been confirmed in the Doha Declaration on Public Health.[275] Article 31 is not the only avenue for compulsory licensing; reference can also be made on some grounds in Article 7, 8, 30 and 40. "Members may, in their discretion, taking account of the balance of rights and obligations, set grounds for compulsory licensing under their national legislation."[276]

Compulsory licences provide developing countries with "another set of options, especially when foreign firms refuse to deal with local firms or refuse to make technologies available at prices that local firms can afford."[277] Compulsory licences could even be useful to the environmental sector in the form of government-use licences. Such a licence is for the use of government manufacturing to make patented products available to the public at large, with the relevant transaction costs being kept low. Another form of compulsory licence is the so-called "public interest" compulsory licence. This approach is widely used in many countries where the government will nominate a private party to produce the patented goods without a licence from the patentee. This is normally under the condition that "the public interest requires the goods in question to be made available in greater quantities or at lower prices than the patentee is willing to accept."[278] There is no limitation of grounds under Article 31 of the TRIPS Agreement, which grants the freedom for member states to determine grounds for granting such licences in domestic patent laws.

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274 For example, Barton and others (n 210).

275 Declaration on the TRIPS Agreement and Public Health, DOHA WTO MINISTERIAL 2001: TRIPS, WT/MIN(01)/DEC/2, 30 June 2017 (n 271) para. 5: "Each Member has the right to grant compulsory licenses and the freedom to determine the grounds upon which such licenses are granted."

276 Hutchison (n 16).

277 Reichman and others (n 65).

278 Ibid.

In terms of the impact of compulsory licensing, there is concern about the possible detrimental impact on patent applications and innovations if it became a mainstream practice; this is because it might reduce the incentive for innovation offered by the patent system.[279] First, there is a fear that widespread compulsory licensing could affect the patent rate. It might be argued: why apply for a patent if compulsory licensing may be the end result regardless of remuneration? However, according to Article 31(h) "the right holder shall be paid adequately in the circumstances of each case, taking into account the economic value of the authorization." Legitimate gain from a patent is clearly respected by the wording of this provision. It is actually the price at which remuneration is set that will determine whether and how much the future patent rate is affected. In general, remuneration of compulsory licensing whose price is set at a level below that which the market would offer might have operated to "effectively strip the patentee of its right to any monopoly profits."[280] But then again, if remuneration is priced essentially at the level that a patent holder asks for, there is no real reason to expect that innovation will be substantially harmed; more importantly, there is no sense in replicating/supporting the abusive behaviour of patentees by refusing to license.

In addition, there is a fear that compulsory licensing could become a discouragement to incentivise R & D. A survey of British pharmaceutical executives discovered that companies believed "in some extreme forms, [compulsory] licensing could harm innovation."[281] Indeed,

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279 See, e.g., Gregory J. Glover, *Competition in the Pharmaceutical Marketplace* (2002) ("[C]ompanies would not be able to invest the huge amount of time and money it takes to discover and develop a new medicine if they did not have a sufficient opportunity to make a sufficient return before generic competitors copy and market the drug at greatly reduced cost."); Richard Tren, 'Free the Industry, Not the Drugs' (*WJS Journal*, July 11, 2002) <https://www.wsj.com/articles/SB1026341408941203720> accessed 30 June 2017. Quoted by Colleen Chien, 'Cheap Drugs at What Price to Innovation: Does the Compulsory Licensing of Pharmaceuticals Hurt Innovation?' (2003) 18 Berkeley Technology Law Journal 853.

280 Chien (n 279).

281 Christopher Thomas Taylor, Aubrey Silberston and Z. A. Silberston, *The Economic Impact of the Patent System: A Study of the British Experience*, vol 23 (CUP Archive 1973).

the practice of allowing third parties to use patented inventions without patentee's permission does controvert the terms of limited monopoly offered to patentees, and is thus believed to have discouraged inventors from investing in further R & D. However, such an assumption was empirically tested by researchers in case studies[282] where they compared rates of patenting to other measures of inventive activity both before and after compulsory licences.[283] According to their observations, there was "no uniform decline in innovation by companies affected by compulsory licences and we find very little evidence of a negative impact."[284] Even compared with patents in the pharmaceuticals sector (where the result of cost-return is strongly associated with protection of patents more than other industries),[285] it was found that weakening patents through the use of compulsory licences does not necessarily reduce innovation in the industry. While past experience suggests that licensing categorically might not be harmful to innovation, compulsory licences as a policy option for increasing access to new technologies – especially in the industries that are less reliant on patents (i.e. climate change technology) – deserves greater exploration.

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282 See for example, Chien (n 279); F. M. Scherer, *The Economic Effects of Compulsory Patent Licensing* (New York University, Graduate School of Business Administration, Center for the Study of Financial Institutions 1977).

283 "In 1977, F.M. Scherer conducted a major study of antitrust, consent related compulsory licenses. His study focused on nearly seven hundred companies, forty-two of which had been subject to compulsory licenses. Scherer calculated the ratio of each company's R & D expenditures to its sales for the year 1975, and compared ratios between companies that had been subject to significant compulsory licensing decrees and those that had not. Scherer further modelled the relationship between compulsory licensing and R & D, and found a slight positive correlation between licensing and high R & D-to-sales ratios. On average, companies subjected to compulsory licensing actually spent more on R & D than similar firms in their industry that had not been subjected to compulsory licenses. The analysis of 1975 research and development spending patterns provides no significant indication that 44 companies subjected to compulsory patent licensing under antitrust decrees sustained less intense R & D efforts than other firms of comparable size and industry origin. If anything the opposite tendency is revealed." Scherer 47 (n 282).

284 "By available measures, the companies affected by licenses continued to perform research and development (R & D) in the therapeutic areas targeted by the license. Even in the case of forward-looking compulsory licenses that spanned several years, the decline in R & D that advocates for strong patent rights might predict was not observed." Chien (n 279).

285 "Accordingly, surveys published in 1986 and 2000 all concluded that the pharmaceutical, biotechnology, and chemical industries rely more heavily on patents than other industries." See Wesley M. Cohen, Richard R. Nelson and John P. Walsh, 'Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)' (2000) National Bureau of Economic Research Working Paper Series No 7552 <http://www.nber.org/papers/w7552> accessed 1 Jul 2017; Edwin Mansfield, 'Patents and Innovation: An Empirical Study' (1986) 32 Management Science 173; See also Levin and others (n 85).

Still, there are several underlined requirements in Article 31 that "pose important prohibitions and constraints to compulsory licensing."[286] First, compulsory licensing may proceed without any negotiation and "without regard to the location of the predominant market when licensing is permitted to remedy a practice determined after judicial or administrative process to be anti-competitive".[287] The criteria to determine anti-competitiveness are ambiguous.[288] As to market significance, refusal to grant licences can vary according to the degree of competitive threat they pose to licensors. "If a licence covers a known product in a licensor's target market, the licensor and the licensee will have to share the same market."[289] In this case, anti-competitiveness might be high. But due to a common price difference between products with and without the know-how and technical skills of patent holders, the licensor's market may not to be directly threatened. Licensors, as well as manufacturers supplying to the targeted market, usually aim at a higher end of the market because of the higher price of their products, whereas licensees are suppliers of the lower end of the market, which originally could not afford the imported products. This is an example of when licensing covers a market that is unimportant, to some extent, to the licensor. In this case, there it is likely that the licensee and licensor will not be in rivalry. Accordingly, the anti-competitiveness of this licence could be reviewed as relatively low making a judicial determination of anti-competitive behaviour less likely and the use of compulsory licencing unjustified. Clarifications of these terms as such are therefore required.

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[286] Hutchison (n 16).
[287] Artilce 31 (c).
[288] Littleton, (n 181).
[289] Chien (n 279).

Moreover, a licence for the purpose of exporting technologies will be binding. "The main limitation is that the compulsory licence must primarily serve the domestic market, and only incidentally may items be exported."[290] This is stated under Article 31(f) of the TRIPS Agreement, requiring that compulsory licences be made "predominantly for the supply of the local market, which means no more than 49.9 per cent of productions can be exported to another country (unless such exports can conceivably be justified as an "exception" within Article 30)."[291] States are then prohibited from granting compulsory licences to serve export markets[292] and might need "to waive the requirements of Article 31(f) to supply export markets with needed technologies."[293] For developing countries that have a large domestic market demand (e.g. China has a great amount of environmental projects launching each year), such compulsory licences would still be worth granting under this limitation, but for countries with relatively small domestic markets it would be an extravagance and a waste.

Even if a technology is worthy of filing a compulsory licensing application against the patent, the limited duration of the compulsory licence would become another practical economic disincentive to pursuing one. Green technologies, particularly those that relate to renewable-energy generation:

> need major manufacturers to build them, skilled installers and operators to deploy them, well-funded project developers to finance the facilities that use them – such as wind

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[290] Nuno Pires de 330, (n 268): 'The main purpose of the compulsory license must be to supply the domestic market. Only eventual or unintended (or unavoidable) surpluses may be exported'.

[291] See Frederick M. Abbott and Jerome H. Reichman, 'The Doha Round's Public Health Legacy: Strategies for the Production and Diffusion of Patented Medicines under the Amended TRIPS Provisions†' (2007) 10 Journal of International Economic Law 921 with regard to pooled procurement strategies in the pharmaceutical sector at 973-77.

[292] Unless the refusal to license is also determined to be anti-competitive: Art. 31 paragraph (k)

[293] Implementation of Paragraph 6 of the Doha Declaration on the TRIPS Agreement and Public Health para. 2.

farms and solar plants – and utilities to purchase and distribute the energy generated from them.[294]

Establishing such projects is very time consuming. Therefore, "potential compulsory licensee applicants may be discouraged by the strict time-limited nature of the licence."[295] The primary business of a number of environmental manufacturers is large equipment production and sales of the equipment. For them, to employ compulsory licensed green-tech would constitute a potential risk in future production. As a licence is "a non-exclusive licence, it does not prevent the patent holder from joining in the same market."[296] An expensive production line installed by domestic companies could be halted at the expiry of the compulsory license and probably already lose competitive advantage where the owner company has brand-name strength.[297] Moreover, significant primary costs for green-tech applications still remain as a great impediment. The actual costs of a solar, wind or biofuel power plant: construction and developing the ancillary infrastructure, or conversion and refitting an emission-control device, could amount to a huge sum. Not to mention the follow-up subsidiary/financial support required from local government (e.g. electricity tariff subsidies); even if states used compulsory licensing to bring these technologies to their local industries, the problem of capital outlay remains in place before the technologies can be effectively implemented.

There seem to be solid legal and policy reasons for developing countries to obtain climate change technologies through compulsory licensing in the face of the refusal to deal with

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[294] Lane (n 36).
[295] Hutchison (n 16).
[296] Ibid.
[297] Carlos M. Correa, 'Can the TRIPS Agreement foster Technology Transfer to Developing Countries' in Keith E. Maskus and Jerome H. Reichman (eds), *International Public Goods and Transfer of Technology under a Globalized Intellectual Property Regime* (Cambridge University Press 2005) p.249: "Canada's amendment to its patent legislation to implement the WTO Public Health decision, for example, limits compulsory licensing for essential medicines to a 2-year term."

situations. However, “this may not be as sound a solution to the problem as it may first appear.”[298] When a country does not have technology capacity enough to reverse-engineer the product or process in question, the threat of a compulsory license being issued is minor.[299] “Developing-country firms may lack the expertise to develop the technology without far more than a blueprint. In particular, compulsory licensing does not oblige the patent holder to transfer know-how.”[300] The situation may be less difficult in the pharmaceutical industry because these technologies are often constrained to ‘one drug for one illness’, and once an active pharmaceutical ingredient is known, a drug can be produced with some efficiency. Many African countries have compulsory licensing provisions in their patent laws, although the use of this provision has been rare. But with a great amount of vital know-how in hand, it is easy for a patent owner to cripple compulsory licensees from efficiently being productive in the environmental industry. More than that, the compulsory licensing provisions under TRIPS Agreement prohibit licences for primarily export markets, which discourages competitor firms from investing further.

In the fear that compulsory measures could act as an even stronger disincentive for patent owners to transfer their inventions, very few developing countries turn to this flexibility available under TRIPS. For example, to date, there has not been a single case of the compulsory licensing of a patent owned by a foreign company in China. There was one near-case about licensing the patent of Tamiflu (an avian influenza drug that has been

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[298] Hutchison (n 16).

[299] “unless it can obtain similar products from other countries where they are off-patent or available under the doctrine of exhaustion” Mario Cimoli and others, *Intellectual Property Rights: Legal and Economic Challenges for Development* (Oxford University Press 2014) p.380.

[300] Article 29 only requires sufficiently clear and complete disclosure, and best mode, of the invention to the skilled addressee in the art.

compulsory licensed in India and some other countries) where the Chinese State IPO allowed plenty of 'mercy time' for the Roche Group (the patent owner) to sign a licence contract with two Chinese pharmaceutical companies before carrying out the compulsory license-granting process.[301] Yet, no such licences have yet been issued. Even the actual use of compulsory licences is rare, such licences still require notice and prior negotiations with rights holders. Sometimes the prior negotiations themselves are enough to discourage refuse to license making the actual need of compulsory licence unnecessary.

5.4 Conclusion

Based on the above observations, it is clear that TRIPS is intended to promote innovation and the dissemination of technologies while respecting the importance of environment protection and the welfare of people in each member state. However, it has been acting less efficiently by encouraging the diffusion and wide application of more complex technologies that are needed for combatting climate change. This is partially due to the well-adopted but defective justification theories for patents as well as the history of compromise between countries in reaching an international agreement on IP issues (the TRIPS Agreement). The TRIPS mandate is thought to be fundamental and widely acceptable but its current level of objective implementation, and in particular the function of promoting TT, is seen as insufficient in many situations. Part of the explanation might lie in the discord between countries at the receiving end of TT and countries that hold most of the core technologies. However, with the consistent goal of global environment protection, it is expected that the TRIPS Agreement has the

[301] Similar situations can be seen in the Western market; for example "in the context of public health needs, both France and Belgium have enacted laws allowing the issuance of expedited public interest compulsory licences for public health purposes." See Part 2, Section 2 of Geertrui Van Overwalle, *Gene Patents and Public Health* (G. Van Overwalle ed, Brussel, Bruylant 2007).

potential to be enabled to fulfil its own objective of facilitating EST transfer and diffusion. Moreover, TRIPS is more of a mediator than a facilitator, lacking the integration of an exponent and an executant with a pragmatic mechanism that could be acting as a significant assistance to developing countries in importing and absorbing climate change technologies. The impact of these shortcomings bring to developing member states, in terms of attracting climate change TT, will be discussed in the next chapter, within which we will look at how it is reflected in cases in practice in order to get the first-hand information that may help to solve problems. Many of the problems mentioned above will be examined within one developing country (China) and will be considered within a specific industry sector (that of renewable energy).

Chapter VI: Climate Change Technology Transfer to China

6.1 Introduction

The discussions about the relevant literature and international agreements have shown the importance of climate change TT to developing countries. Previous chapters have also demonstrated that successful TT depends on enabling environments suitable for technology development, transfer, adaptation, and deployment of such technologies. It is "abundantly clear that the development of local capabilities, policies, and institutions to guide, manage and support this process is no less critical"[1] than encouraging developed countries to initiate TT. However, the development of capabilities and policies in developing countries is not an easy task due to lack of uniformity in the specific ways that international efforts might dovetail with local efforts for the goal of TT promotion. China, as a developing country, is considered to be unique because it is a big emitter which is at the transition stage from being a technology receiving country to becoming an exporter. Thus it "should not be used as a proxy for developing countries in general."[2] This thesis therefore attempts to add to the understanding of how technology capacity and supporting policies may be developed to facilitate and attract TT in developing countries individually, and China in particular.

The rise of China's manufacturing has led to an enormous emissions increase in the country. In fact, the country is now the second-largest economy in the world as well as the top consumer of energy. Therefore, it is and has been the biggest emitter of carbon dioxide (CO_2)

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[1] H. C. de Coninck and Ambuj Sagar, 'Technology in the 2015 Paris Climate Agreement and beyond' International Centre for Trade and Sustainable Development (ICTSD) International Environment Issue Paper No42 <http://www.ru.nl/publish/pages/749373/2015_-_technology_in_the_2015_paris_climate_agreement_and_beyond_-_ictsd_issue_paper_no_42.pdf> accessed 11 Jun 2017.

[2] Jim Watson and others, *UK-China Collaborative Study on Low Carbon Technology Transfer* (Final Report by Sussex Energy Group SPRU - Science and Technology Policy Research, 2011).

in the world since 2006, accounting for around 23.4 per cent of global CO_2 emissions in 2016.[3] This is one of the many challenges that China faces as its economy develops. The relatively low per capita income level is not yet able to afford the extensive application of climate change technology that is needed for environmental protection. This requires the country to wisely distribute its resources to encourage low-carbon innovation and deployment while improving the living standards of its people. Accordingly, China has in recent years carefully redesigned its national innovation system, including its innovation capabilities, its capable institutions and R & D to meet the challenges of climate change.[4] China has been continuously investing in the renewable energy sector, especially in the last two decades. Some[5] believe such growth will become a threat to the current technology owners as the emerging developing country will become a capable competitor in innovative technology sooner or later. This potentially creates difficulties for China to get access to the state-of-the-art technologies it needs from abroad. Yet the country has managed to implement its technology development to a mature level, where it is still largely relying on investments from government sources, legitimate acquisition,[6] and licensing from developed

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3 Statista, 'Largest Producers of CO2 Emissions Worldwide in 2016, Based on Their Share of Global CO2 Emissions' (*Statista – The Portal for Statistics*, 2016) <https://www.statista.com/statistics/271748/the-largest-emitters-of-co2-in-the-world/> accessed January 2017; See also Jos G. I. Olivier, Jeroen A. H. W. Peters and Greet Janssens-Maenhout, 'Trends in Global CO2 Emissions 2013 Report' PBL Netherlands Environmental Assessment Agency The Hague (2013) <http://edgar.jrc.ec.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf> .

4 Kelly Sims Gallagher, *The Globalization of Clean Energy Technology: Lessons from China* (MIT Press, Cambridge 2014).

5 Jim Watson and others, 'Low Carbon Technology Transfer: Lessons from India and China' Sussex Energy Group Policy Briefing No 9 (2010) <http://sro.sussex.ac.uk/58024/1/low_carbon_tech_transfer_briefing_-_nov_10%5B1%5D.pdf> ; See also de Coninck and Sagar (n 1).

6 For example, "in 2016, General Electric has sold its appliances business to Qingdao-based Haier." 'Chinese consumer electronics giant Haier is buying GE's appliance unit for $5.4 billion' (*Buniness Insider UK*, 15th Janurary 2016) <http://uk.businessinsider.com/haier-buying-ge-appliance-unit-for-54-billion-2016-1?r=US&IR=T> accessed July 2017 Moreover, "WESTPORT, Conn. (AP) — Shares of heavy lifting equipment maker Terex Corp. soared after the company announced it had received an unsolicited takeover offer of $30 per share from China's Zoomlion Heavy Industry Science and Technology Co." 'Penny Shares Advice - Tips and Strategies for 2017' (*Business Insider UK*, 26th Janurary 2016) <http://www.businessinsider.com/ap-terex-shares-zoom-climb-on-unsolicited-zoomlion-bid-2016-1?IR=T> accessed July 2017

countries. Such unbalanced technology improvement is resulted from the optimization of the country's economic growth without an insight of a long-term development.

The strong role of the Chinese government is also confirmed in this thesis, through its efforts at "directing strategic technology acquisition, providing R & D support, developing comprehensive policy frameworks and in systematically taking advantage of international mechanisms (especially the CDM)."[7] By looking at the "pull side" of TT, regarding the market and policy environment based on the efforts of the Chinese government, this thesis has discovered that although TT was done in collaboration with parties from developed countries, climate change technology development was in fact not supported by these countries, financially or patent-wise.[8] Therefore, considering the equity justification discussed in the preceding chapters, existing systems, including the TRIPS Agreement and UNFCCC, need to be changed so that they are more equitable and practically enforceable towards their objectives. More radical attempts should have led to a more efficient but less carbon-intensive way of development globally.

6.2 Background: A call for renewable energy

As discussed in previous chapters, energy is vital for economic development and is traditionally a major contributor (through fossil fuels) to climate change. Such a valuable resource is, however, limited and is sharply decreasing in volume. Therefore, to achieve sustainable development, "we need not only to efficiently reduce energy use but also to find

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[7] Watson and others (n 2).
[8] de Coninck and Sagar (n 1).

new energy resources to cope with the rapid global growing demand for development."[9] However, the current global economy is too dependent on non-renewable energy resources.[10] In recognition of the importance of renewable energy for sustainable development and to increase the share of renewables, the diffusion and innovation of green technology to developing countries that have vast potential for renewable energy expansion is required. This has been a primary global concern as the development of green energy incurs substantial investment costs and requires assistance from more developed countries.

For all that, countries – not only the developed but also the developing ones – have shown their resolve by announcing climate change commitments.[11] Over the past few years, investment in renewable energy (solar power, wind power, and bioenergy) has grown rapidly in China, Brazil and India. China alone "absorbed 9% of total global renewable investment in 2006 mainly to develop its wind power, methane, and dust burying."[12] As a result, successful integration of large amount of renewable recourse is now found in the existing energy infrastructure in this country. Moreover, renewable energy has proved to be reliable and possibly also an affordable power supply.[13] The maturity of the sector and experience in the area in China is the most important reason why this thesis deliberately focuses on TT

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[9] Fei Ding and others, 'Green Energy Development and Technology Transfer in China and India' (2012) 19 Journal of International Development and Cooperation 13.

[10] "considering the small share (19.1%) that renewable energy has of global total energy consumption." P. S. Ren, *Renewables 2015 Global Status Report* (REN21 Secretariat: Paris, France, 2015).

[11] See in ibid: "Together, China and the United States emitted 40% of global carbon dioxide emissions in 2014." Leigh Phillips, 'How Big a Deal Is the US-China Climate Deal?' (*Road to Paris*, 16 November 2014) <http://roadtoparis.info/2014/11/16/big-deal-us-china-climate-deal/> accessed Feburary 2017;The White House, *U.S.-China Joint Announcement on Climate Change* (11 November 2014); Bloomberg Alex Nussbaum and Eric Martin, 'Mexico Pledges to Cut Emissions 25 Percent in Climate Change Milestone' (*Renewable Energy World*, 30 March 2015) <http://www.renewableenergyworld.com/news/2015/03/mexico-pledges-to-cut-emissions-25-percent-in-climate-change-milestone.html> accessed Feburary 2017; European Commission, '2030 Framework for Climate and Energy Policies' (*European Commission for Climate Action*, 07 July 2017) <https://ec.europa.eu/clima/policies/strategies/2030_en> accessed July 2017.

[12] Ding and others (n 9).

[13] Ren (n 10).

concerning renewable energy instead of focusing comprehensively on climate change TT in all industries.

As considerable investments flow to the sector, a right mixture of renewable energy technology acquisition and the rational management of energy supply are obviously needed in China.[14] For example, continuous importing of renewable energy technology has been a primary concern to China, but the country struggles with it because the development of renewable energy incurs significant expenses directly to and around the industry. As crucial as a financial investment is to the development of renewable energy and emission reduction, much more is required to succeed. For instance, the capacity of human capital; peripheral infrastructure; and the policy environment for TT are of equal importance. Thus although China now has the world highest CO_2 emissions, it claims that it is still a challenge for the country to develop a significantly greener energy structure.[15]

Most recently, the Chinese government has discarded its once passive posture and has started attaching great importance to emission reduction and the development of renewable energy.[16] In particular, China has shown its intention to abandon its resistance to limits on carbon emissions in post-Kyoto negotiations and it wants to establish a more active international image to fight climate change.[17] This would be propitious, leading to a new commitment from the country on emission reduction, but in return China wants developed countries “to commit to more ambitious reduction targets, to share low-carbon technology

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[14] Ding and others (n 9).
[15] William Bleisch, ‘China 'unfairly seen as eco-villain'’ *BBC News* (UK, 16th June, 2009). This attitude is changing now. See Matt Hoye and Holly Yan, ‘US and China reach historic climate change deal, vow to cut emissions’ (2014) 12 CNN Edition International.
[16] Ding and others (n 9).
[17] TheGardian, ‘China Ready for Post-Kyoto Deal on Climate Change’ (*Gardian.co.uk*, 6 May 2009) <https://www.theguardian.com/environment/2009/may/06/china-seeks-climate-change-deal> accessed Feburary 2017.

and to set up a UN fund that would buy related IPRs for use across the world."[18] As the use of CDM has already demonstrated a way of encouraging climate change TT from developed countries,[19] the less developed nations like China are seeking more assistance to encourage them to further commit to international climate change cooperation. This is currently a challenge and an opportunity for both China and all the developed countries to discover a win-win solution to climate change through the enhanced application of renewable energy

6.3 The climate change situation in China

Before analyzing TT to China, this chapter looks into the country's environmental problems and its technology needs. China, which is already the largest emitter of GHGs in the world, the country's share of GHG emissions has increased dramatically in recent years.[20] As its environmental problems grow, China will struggle with issues such as poor air and water quality.[21] In recent years, "Shanghai, Beijing and other cities in China have been suffering from smogs that hark back to the London pea-soupers of the late 19th and early 20th century."[22] Meanwhile, approximately 79 per cent of electricity is still generated from coal in China,[23] intensifying its domestic environmental issues and making the country a primary

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[18] Ibid.
[19] Wytze van der Gaast, Katherine Begg and Alexandros Flamos, 'Promoting Sustainable Energy Technology Transfers to Developing Countries Through the CDM' (2009) 86 Applied Energy 230.
[20] U.S. Energy Information Administration, *Annual Energy Review 2009* (DOE/EIA-0384(2009), 2010) at 343 (stating that in 2006, China emitted 6,018 million metric tons ("MMT") of carbon dioxide ("CO2") to the United States' 5,903 MMT); see also Mckinsey&Company, 'China's Green Revolution: Prioritizing Technologies to Achieve Energy and Environmental Sustainability' 2009 <http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/chinas-green-revolution-prioritizing-technologies-to-achieve-energy-and-environmental-sustainability> at 29 ("While China's total GHG emissions have surpassed those of the United States, China's emissions are still lower on a per capita basis, and China sought to exploit that fact in international climate negotiations."); See National Development and Reform Comission of China, *Implementation of the Bali Roadmap: China's Position on the Copenhagen Climate Change Conference* (20 May 2009) (stating the Chinese negotiation position that "[d]eveloped countries shall take responsibility for their historical cumulative emissions and current high per capita emissions to change their unsustainable way of life and to substantially reduce their emissions").
[21] Christina Larson, 'The Great Paradox of China: Green Energy and Black Skies' (2009) 360 Yale Environment 17, quoted by Joel B. Eisen, 'China's Renewable Energy Law: A Platform for Green Leadership' (2010) 35 Wm & Mary Envtl L & Pol'y Rev 1
[22] Christine Ottery, 'Q&A: China's Airmaggedon' (*EnergyDesk Greenpeace*, 4 December 2013) <http://energydesk.greenpeace.org/2013/12/04/qa-chinas-airmaggedon/> accessed Feburary 2017.
[23] Behind Energy, 'Which Countries in The World Use The Most Coal to Generate Electricity' (25 Auguast 2015) <http://www.behindenergy.com/quali-paesi-del-mondo-utilizzano-piu-carbone-per-generare-elettricita/?lang=en> accessed

contributor to global warming.[24] China accounts for more than 40 per cent of the global coal consumption from 2008[25] and its coal use has even increased since then due to the needs associated with growth.[26] To meet its projected needs in 2030, it is predicted that China's needs for power generation will continue to grow.[27] Given this fact, slowing down China's emission increases could be more meaningful to mitigate climate change than environmental progress in any other countries.[28] This argument is reaffirmed by the recent Greenpeace analysis,[29] demonstrating a decrease of global coal use by at least 2.3 per cent in 2015. This is, to a great extent, due to the presence of dense smog in many parts of China in 2012–2013, and since then China has eased off its coal use, leading to a standstill in consumption in 2014 and a 4 per cent fall in 2015. This reduction amounts to more than the UK uses in an entire year. Nonetheless, the US accuses China of inaction and uses it as an excuse not to act itself on global warming.[30] Therefore, taking action in China is vital because "it will not matter whether the rest of the world endeavors to address climate change in comparison with the

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Feburary 2017; Liyu Lin, 'China's Power Generation Goes Greener with Total Capacity Up 10%' (*China View*, 7 Janurary 2010) <http://news.xinhuanet.com/english/2010-01/07/content _12771880.htm> accessed Feburary 2017, (coal-fired power accounted for 74.6 percent of the nation's 874 million kilowatts of electricity generation capacity in 2009); see also U.S. Energy Information Administration (n 20) (stating that "[c]oal makes up 70 percent of China's total primary energy consumption").

[24] See Keith Bradsher, 'China Fears Warming Effects of a Rising Consumer Class' (*New York Times*, 5 July 2010) <http://query.nytimes.com/gst/fullpage.html?res=9A02E0D81531F936A35754C0A9669D8B63> accessed Feburary 2017.

[25] U.S. Energy Information Administration (n 20) p.13 (noting that "[i]n 2008, China consumed an estimated three billion short tons of coal, representing nearly 40 percent of the world total and a 129 percent increase since 2000").

[26] National Bureau of Statistics of the People's Republic of China, *China Energy Statistical Yearbook 2014* (2014).

[27] See The 13th Five-Year Plan for Environmental Protection: "According to the unified arrangements of the central government, the "13th Five-Year Plan "will focus on promoting the establishment of a sound system to cover all pollution sources, and implement the vertical management system for monitoring and supervising environmental protection agencies at provincial level and below. It has proposed two periodic goals for the milestones of 2020 and 2030 initially."; See also Mckinsey&Company (n 20) p.37 (noting an increased demand for energy without any demand-reducing measures); see also U.S. Energy Information Administration (n 20) (noting that according to projections, "[t]he most rapid growth in energy demand from 2007 to 2035 occurs in nations outside the Organization for Economic Cooperation and Development"). Quoted by Eisen (n 21).

[28] A good quick take on this issue featuring recent data can be found in Ann Carlson, 'China's Growth in Energy Usage Truly Alarming' (*Legal Planet*, 7 May 2010) <http://legal-planet.org/2010/05/07/chinas-growth-in-energy-usage-truly-alarming/> accessed Feburary 2017.

[29] Lauri Myllyvirta, 'Coal's Terminal Decline: How a Bad Year for Coal in 2014 Has Been Followed by the Biggest Fall in Consumption Ever' Greenpeace International (2015) <http://www.greenpeace.org/international/Global/international/publications/climate/2015/Coals-Terminal-Decline.pdf> accessed Feburary 2017.

[30] Brad Plumer, 'China's Ambitious Plan to Limit Carbon Emissions, Explained' (*https://www.vox.com*, 25 September 2015) <https://www.vox.com/2015/9/25/9399055/china-climate-cap-trade> accessed December 2016.

influence of China,"[31] and it will probably increase global cooperation on climate change mitigation.

China's intention to rein in its emissions is crucially needed. In fact, China has been taking action on emission reduction already (i.e. by introducing renewable energy). As early as 2005, "renewable energy provided 8% of the China's total energy consumption and 16% of its total electricity output."[32] Moreover, China has committed in its 12th five-year plan[33] to reduce its CO_2 emissions per unit of GDP by 40 per cent to 45 per cent from 2005 levels and to use non-fossil fuels for about 15 per cent of its energy by 2020.[34] The Chinese President Xi Jinping announced that China would enact a national cap-and-trade system[35] to limit carbon emissions, starting in 2017.[36] In 2014 China pledged to peak its CO_2 emissions in 2030 or earlier and to increase its share of non-fossil fuel energy to 20 per cent by 2030.[37] The most recent 13th five-year environmental protection plan reinforced this objective by focusing on

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31 As one long-time observer of China puts it, "China is on track to overwhelm the global effort to address climate change." Challenges and Opportunities for U.S.-China Cooperation on Climate Change: Hearing Before the S. Comm. on Foreign Relations, (111th Cong 16 (2009)) (statement of Elizabeth Economy, C.V. Starr Senior Fellow and Director for Asia Studies, Council on Foreign Relations).

32 This includes hydroelectric power generation capacity. Li Junfeng, Shi Jinli and Ma Lingjuan, 'China: Prospect for Renewable Energy Development' Energy Research Institute, Beijing (2006) <http://frankhaugwitz.info/doks/policy/2006_10_30_China_RE_Mitigation_Renewables_Sector_Research_ERI.pdf> accessed Feburary 2017.

33 The 12th Five-Year Plan for Environmental Protection of China.

34 See, e.g. Eric Martinot and Junfeng Li, *Powering China's Development: The Role of Renewable Energy*, vol 175 (Worldwatch Institute 2007); See also Barbara Finamore, 'China Renews Its Commitment to Renewable Energy' (*https://www.nrdc.org*, 01 February 2010) <https://www.nrdc.org/experts/barbara-finamore/china-renews-its-commitment-renewable-energy> accessed Feburary 2017.

35 Evironmental Defense Fund, 'How Cap and Trade Works' (*Environmental Defence Fund*) <https://www.edf.org/climate/how-cap-and-trade-works> accessed Janurary 2017: "Cap and trade is the most environmentally and economically sensible approach to controlling greenhouse gas emissions, the primary driver of global warming. The 'cap' sets a limit on emissions, which is lowered over time to reduce the amount of pollutants released into the atmosphere. The 'trade' creates a market for carbon allowances, helping companies innovate in order to meet, or come in under, their allocated limit. The less they emit, the less they pay, so it is in their economic incentive to pollute less. A cap sets a maximum allowable level of pollution and penalizes companies that exceed their emission allowance. The cap is a limit on the amount of pollution that can be released, measured in billions of tons of carbon dioxide (or equivalent) per year. It is set based on science."

36 The White House Office of the Press Secretary, *U.S.-China Joint Presidential Statement on Climate Change* (25 September 2015); The programme will cover some key industries, including electricity, iron and steel, chemicals, building materials, and paper-making. Josh Margolis and Daniel J. Dudek, 'Stronger Markets, Cleaner Air- Carbon Emission Trading: Rolling out a Successful Carbon Trading System' Paulson Institute <http://www.paulsoninstitute.org/wp-content/uploads/2015/09/5-Emissions-Trading-EN-final1.pdf> accessed Feburary 2017.

37 Brad Plumer, 'The US and China just Reached a Major Climate Deal on Cutting Emissions' (*www.vox.com*, 11 November 2014) <https://www.vox.com/2014/11/11/7200909/US-china-climate-deal-cutting-emissions> accessed Feburary 2017.

promoting the establishment and improvement of the emissions permit system covering all pollutant enterprises, and the implementation authority is assigned to provincial environmental supervision through vertical management systems.[38] Environmental concerns have not only been raised in the Chinese government, but also in the people in China.[39] Xu and et al.'s survey on public opinion on climate change indicates that in China 87.6 per cent of interviewees were concerned about climate change and 45.6 per cent expressed great concerns; 96.6 per cent deemed that their government should take more measures to tackle global warming and climate change.[40] All these factors are indicating that China is very likely to continue taking emission-reducing measures[41] and may also agree to a new international climate agreement that caps its emissions in the future. However, because of its GHG emissions it might have to take more drastic actions "to slow or reverse the growth in China's GHG emissions."[42]

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[38] The 13th Five-Year Plan for Environmental Protection.

[39] Xiaojie Xu, Yoon Jung Kim and Dongchao Li, 'Chinese Policies on Climate Change and Environment Protection' Center for Energy Studies [337] (2008) The G8, Energy Security and Global Climate Issues <http://bakerinstitute.org/research/chinese-policies-on-climate-change-and-environment-protection/> accessed Feburary 2017.

[40] Ibid; See also Jon Dee, 'Top 30 Surveys on Climate Change Topics of Most Concern in China' (*www.gmichina.com*, 19 June 2007) <http://money.163.com/07/0619/15/3HC3JDE1002525CK.html> accessed Feburary 2017.

[41] "In May 2009, China demanded that developed countries as a whole... reduce their GHG emissions by at least 40% below their 1990 level by 2020, and stated that China and other developing countries need not meet emissions targets but instead should only "take proactive measures to adapt to and mitigate climate change." The 13th Five-Year Plan for Environmental Protection, (n 27).
"China sees its role as different from that of developed nations due to the historical differences between them: There's a difference between the United States position on how China should address climate change, and China's position on what it should do. It's been repeated many times, but the controversy surrounding historical vs. current emissions and gross vs. per capita emissions remains. Depending on how you read the numbers, China can either look really good or really bad. Also, there's the debate about whether China is a developed or a developing country. So, I think the challenges and the opportunities stem from that difference in stance. The US seems to believe that China should be doing as much as the US. China has indicated that—at least in this round of negotiations—no cap on emissions will be committed to." An 2009 interview with China Energy Specialists, Elizabeth Balkan and Chris Brown, quoted by Eisen, (n 21).
"The "Copenhagen Accord" reached in December 2009 did not impose emissions caps on any nations." See John Vidal, Allegra Stratton and Suzanne Goldenberg, 'Low Targets, Goals Dropped: Copenhagen Ends in Failure' (*Guardian*, 19 December 2009) <https://www.theguardian.com/environment/2009/dec/18/copenhagen-deal> accessed Feburary 2017. "Following the Copenhagen summit, China avoided the term 'associated with', but gave qualified approval to the Copenhagen Accord. Arthur Max, 'China, India Join Copenhagen Accord, Last Major Emitters to Sign On' (*Huffington Post*, 9 March 2010) <http://www.huffingtonpost.com/2010/03/09/ china-india-join-copenhag_n_491640.html> accessed Feburary 2017;At the same time, its Premier, Wen Jiabao, rejected the notion among some nations that the Accord was a platform for further negotiations toward binding emissions caps, stating " 'it is neither viable nor acceptable to start a new negotiating process' outside the framework of previous U.N. treaties." Ibid. (quoting Chinese Premier Wen Jiabao).

[42] Mckinsey&Company (n 20); Tao Wang and Jim Watson, 'China's Energy Transition: Pathways for Low Carbon Development' Sussex Energy Group , Sience and Technology Policy Research, Tyndall Centre for Climate Change Research <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.705.341&rep=rep1&type=pdf> p.3-5.

In the view of both China and the rest of the world, reducing emissions in the country has become a new environmental and political imperative. Yet it is still China's decision to choose whether and in what forms to address climate change. In China's view, those countries that had released most of the GHG emissions in history should bear the majority of mitigation responsibility. Developing countries that have not emitted as much should be less responsible for the present climate change crisis.[43] Otherwise, it would deprive the equal development rights of the developing countries to grow in the same way adopted by developed countries. This also comes from an environmental justice argument, as there is a tremendous amount of outsourcing of both production and CO_2 emissions from the developed to the developing countries.[44] China, as the workshop of the world, claims to be a victim of this fact. And censure against China because of its increasing total carbon emissions is untenable as its "emission per capita is only approaching the average level of the EU countries in the recent couple of years and it is still significantly lower than that of the U.S."[45] Therefore, although "China is committed to pursuing a more sustainable, lower-carbon future" it will not be "at the expense of economic development… It is too early, too abrupt and too blunt for the international community to impose emission caps on China"[46] if the country itself refuses or is unable to bear them. This is generally saying that a greener economy in China should be accomplished through voluntary cooperation and with assistance from developed countries

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[43] Margret J. Kim and Robert E. Jones, 'China: Climate Change Superpower and the Clean Technology Revolution' (2008) 22 Natural Resources & Environment 9.

[44] Ibid.

[45] Zhu Liu, 'China's Carbon Emissions Report 2015' Sustainability Science Program and Energy Technology Innovation Policy Research Group, Belfer Center Discussion Paper #2015-02 Harvard Kennedy School of Government, Cambridge, MA <http://belfercenter.ksg.harvard.edu/files/carbon-emissions-report-2015-final.pdf> accessed Feburary 2017.

[46] In a June 4, 2007, Ma Kai's speech at a press conference, Minister of the National Development Reform Commission, quoted by Kim and Jones (n 43).

because it lacks resources, such as the best technologies, in virtually all areas of energy production and utilization.[47]

6.4 IP protection and development in China

In keeping with the standpoint of China in committing itself to addressing global climate change, it has explicitly expressed a desire in accessing green technologies essential for climate change mitigation. In acquiring such technologies, an appropriate legal and policy environment for TT is required. While the big technology owners consider that IPRs are crucial to the economies of developed countries,[48] some imply that strengthening IP protection is also for the good of developing countries as well.[49] However, a question remains as to what extent this conclusion is true in regard to climate change TT to China. This will be looked at separately from IP protection in general within the specific context of this chapter.

China joined the WTO in 2001, pursuing the benefits of international trade. To achieve this goal, China made a series of reforms to its IP laws.[50] The WTO agreements included TRIPS[51] and China had to "bring its domestic IPR legislation up to minimum international standards in order to meet its obligations under TRIPS upon accession to the WTO."[52] Regarding technology IP protection and TT enforcement, the outcome is subject to not only the IP laws

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[47] Ibid.

[48] See Marco C.E.J. Bronckers, 'Impact of TRIPS: Intellectual Property Protection in Developing Countries' (1994) 31 Common Market Law Review 1245 p.1245-46.

[49] See, e.g., Keith E. Maskus, 'Intellectual Property Challenges for Developing Countries: An Economic Perspective' (2001) U Ill L Rev 457; see also Robert M Sherwood, 'The TRIPS Agreement: Implications for Developing Countries' 37 IEDA 491; see also Evelyn Su, 'The Winners and the Losers: The Agreement on Trade-Related Aspects of Intellectual Property Rights and Its Effects on Developing Countries' (2000) 23 Hous J Int'l L 169.

[50] Kiel Downey, 'Intellectual Property Rights and Renewable Energy Technology Transfer in China' (2012) 9 SCJ Int'l L & Bus 89.

[51] Trade-Related Aspects of Intellectual Property Rights (unamended version), Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization, signed in Marrakesh, Morocco on 15 April 1994.

[52] See generally Ramona L. Taylor, 'Tearing Down the Great Wall: China's Road to WTO Accession' (2001) 41 Idea 151, p.158-64; Also TRIPS binds its Parties to a broad set of standards for domestic IPR legislation. The Preamble to TRIPS sets forth this principle. It states that the parties to the Agreement recognize the "need for new rules and disciplines concerning... the provision of adequate standards and principles concerning the availability, scope and use of trade-related intellectual property rights... [and] the provision of effective and appropriate means for the enforcement of trade-related intellectual property rights, taking into account differences in national legal systems." TRIPS at Preamble, 320. Quoted from Downey (n 50).

but also other legislations such as contract law, the company law, and the anti-monopoly law. None of the aforementioned laws address renewable energy IP exclusively, but they are all relatively important to the Chinese IP environment in regard to the renewable energy market.

6.4.1 Contract law

The Contract Law of the People's Republic of China was adopted in 1999, two years before China joined the WTO.[53] In the "Contracts for Technology" chapter, a specific section that focuses on TT contracts is included.[54] The contract law specifies TT by creating a legal framework in which IP can be transferred.[55] It is relatively broad as the law deems any agreement that specifies rights and obligations for technology development, transfer, consultation or service shall be considered as a technology contract.[56] More specifically, it defines the scope of a TT contract in Article 342 as "contracts for the transfer of patent right, transfer of the right to apply for a patent, transfer of technological know-how and license for exploitation of patents."[57] The interesting part is that the Article articulates the transfer of know-how, which is not covered by the Chinese Patent Law. In Article 347 the contract law further states that during the implementation of know-how transfer the transferor shall, "as contracted, provide technical materials, give technical guidance, guarantee the practical applicability and reliability of the technology, and maintaining confidentiality." The law stipulates the corresponding legal obligations of the recipient as well, including the duty to maintain the confidentiality of the technology and know-how.[58] Any litigation regarding the

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[53] Contract Law of the P.R.C. (promulgated by the Standing Commission of NationalPeople's Congress on 01 Oct 1999).
[54] Ibid.
[55] Downey (n 50).
[56] Chinese Contract Law 1999 (n 53) chapter 18 article 32.
[57] Ibid, chapter 18 article 342.
[58] Ibid chapter 18 article 346 and article 348.

transfer of know-how can, therefore, refer to the contract law and its judicial interpretations, which would decrease the risk of know-how information belonging to the transferors being infringed. In that sense, this Article could act as a stimulus to encourage TT.

Although the contract law secures some of the transferors' interests by stipulating obligations of both parties, still there are retained privileges for the potential domestic technology developer and, in turn, risks for the transferors hidden in the text. For example, the ambiguously worded Article 329, states "any technology contract that illegally monopolies technologies impedes technological progress" will be considered as null and void. The 2005 Supreme People's Court Interpretation[59] explains the Article by clarifying that any "contract that prohibits research and development or improvements upon licensed technology, illegally monopolizes technology or impairs technological advancement"[60] can be considered as anti-competitive business behaviour. Ever since the implementation came out, much attention has been paid to IP rights monopolies. This guidance on what is counted as illegal monopoly or impediment creates uncertainty to a transferor because attempts to pursue marginal improvements by a competitor in the recipient country might be justified under this Article. So IP owners take extra care analyzing the "risks of being sued for conducting IP rights-related monopolistic acts when entering into a technology license deal in China."[61] This has caused them to worry about TT, and relevant investments to facilitate the TT could be made in vain if a monopoly is affirmed. In practice, such problems are likely mitigated by the

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[59] Interpretation of the Supreme People's Court concerning Some Issues on Application of Law for the Trial of Cases on Disputes over Technology Contract.

[60] Interpretation of the Supreme People's Court concerning Some Issues on Application of Law for the Trial of Cases on Disputes over Technology Contracts (16 December 2004) article 10; Chinese Contract Law 1999 (n 53) chapter 18 article 329.

[61] Dixon Zhang and Claudia Yun, 'What is the Best Way to Structure Technology Transfer Deals and What IP Issues do I Need to Watch out for?' (*www.chinalawandpractice.com*, May 2010) <http://www.fangdalaw.com/files/China%20Question%200510.pdf> accessed Feburary 2017.

relatively low absorptive capacity[62] in China's renewable energy industry[63] at this stage,[64] but with fast growth in China it does not mean that it will never become a real problem in the future.

Article 353 even puts an unreasonable burden on the transferors by making them liable "where the exploitation of the patent or utilization of the technical know-how by the transferee as contracted infringes upon the legitimate rights and interests of others."[65] This Article worries the transferors and suggests a careful drafting of TT agreements and the thoughtful choice of recipient. Thus, IP holders are meant to contract with large companies in order to minimize the risk of being sued by a third party and in turn, small businesses are expelled gradually from the industry that requires new technologies being imported.

Participants of this research are all well-known enterprises in Shandong and even in China. Therefore they are in good positions in an industry which had brought them many opportunities of cooperating with foreign companies. This is a "two-way collaboration" according to the interviewees.[66] While Chinese companies are seeking high-quality suppliers, foreign providers are looking for partners that are capable of utilizing and improving upon these advanced technologies. For example, in one of the projects, the Japanese CER buyer who is also the equipment supplier to the Chinese chemistry company was motivated to cooperate with the latter for it had the ability to solve many technical problems in their operation. The operational efficiency of the equipment provided was only 80–90 per cent,

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[62] "is the ability to recognize the value of new information, assimilate it, and apply it to commercial ends"." Wesley M. Cohen and Daniel A. Levinthal, 'Absorptive capacity: A new perspective on learning and innovation' (1990) Administrative science quarterly 128.

[63] Downey (n 50).

[64] this will be discussed later in this chapter.

[65] Chinese Contract Law 1999 (n 53) chapter 18 article 353.

[66] See for example interview with manager of the Shandong Dongyue Chemical Co. Ltd.

while with their specific strengths on wastewater treatment, flocculants for special materials, and the crystallization technology independently developed by the Chinese company, the engineers were able to improve the ratio efficiently. Therefore, sometimes foreign technology owners express their intention to collaborate with these large Chinese enterprises in the so-called "golden age" of CDM. As most Chinese companies that would consider applying for CDM projects have been doing business that relates to environmental protection already,[67] the foreign partners sometimes have to take the initiative and bring a variety of new technologies for Chinese companies to choose from in order to acquire CERs easier.

As a result, the reputation of enterprises is crucial in attracting TT from abroad.[68] Large companies have great advantages in achieving contracts with foreign suppliers. Green-tech companies from overseas are very unlikely to join any agreements with small businesses. This could be a result of the high burden that imposed on foreign companies by the Contract Law; or attribute to an impression that Chinese IP protection is inadequate to protect their IPRs; or it could be due to the poor absorption capability of small companies. Indeed, "China's piracy rate for software was 92% in 2001 resulting in a total of $1.66 billion in lost revenue for IP owners. Also, in 2001, U.S. businesses lost an estimated $1.9 billion total to copyright piracy."[69] Even in cases where EST is transferred, it is found that "the technologies [transferred] to China are usually at least five years old, or likely to soon become obsolete."[70] Many multinational companies are particularly reluctant to establish R & D institutions in

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[67] Most projects are conducted by companies that are specialized in green production already as it is a lot easier for them to establish CDM projects based on past experience and only need to add things that are specially required by the CDM.
[68] This point is confirmed in my interviews with every interviewee from the management type.
[69] Mikhaelle Schiappacasse, 'Intellectual Property Rights in China: Technology Transfers and Economic Development' (2003) 2 Buff Intell Pro LJ 164.
[70] Ibid.

China at all.[71] Those companies that do TT to China prefer "joint ventures and Wholly Foreign-Owned Enterprise, to control access to trade secrets and other knowledge-based assets. Multinational companies will often avoid fully integrating with the Chinese operation due to China's weak IP protection."[72] Smaller companies, without a well-reputed referee, are therefore unlikely even to contact the powerful technology owners. A similar conclusion is made in a UN report on CDM projects which states that TT "varies widely across project types but is more common for larger projects. Small-scale and unilateral projects are less likely to involve TT."[73] Interviewees[74] also indicated that these TT processes sometimes leads to poaching staff from more experienced companies, no matter from which country they originate. Thus, it is understandable for the IP holders to take more precautions when choosing partners. Fortunately, most of these hoppers are not key employees in their original companies. Some R & D staff get poached from abroad, originally tempted by a generous job offer, but lose confidence in their future after a while working in China. This is due to a very intricate and complex research environment in the country and it will be a challenge to the future of independent technology development in China. From such a perspective, China's weak IP protection will sooner or later affect on China's influx of foreign knowledge which is essential to the country's sustainable development.

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[71] Ibid.
[72] Ibid.
[73] Steven Seres, Erik Haites and Kevin Murphy, 'The Contribution of the Clean Development Mechanism under the Kyoto Protocol to Technology Transfer' Document for the United Nations Framework Convention for Climate Change (2010) accessed Janurary 2017.
[74] See interviews with technical and managerial group interviewees from all three of the wind projects.

6.4.2 The Anti-monopoly Law

TT into China is not only subject to the basic principles applicable to contracts but also to the Anti-monopoly Law of the People's Republic of China[75] enacted in 2007. The way that the Anti-monopoly Law deals with patents – granting a monopoly for a fixed period and regulating innovation upon existing patents – is crucial to IP owners' future business. It not only sets clear administrative protection by relevant authorities but also lays a foundation for civil and criminal protection. The Anti-monopoly Law also stipulates what constitutes abuse of IP stated in contract law.[76]

Article 55 states that the

> Law does not govern the conduct of business operators to exercise their IPRs under laws and relevant administrative regulations on IPRs; however, business operators conduct to eliminate or restrict market competition by abusing their IPRs shall be governed by this Law.

This means that the Anti-monopoly Law applies to the abuse of IPRs under two conditions: first, the abuse of IPRs[77] and rights under administrative regulations that exist; second, the act must have excluded or restricted competition or may eliminate or restrict competition. Therefore, when implemented, the authorities must identify the abuse of IPRs and eliminate or restrict consequences affecting competition. Judicial decisions will be made according to

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[75] Anti-monopoly Law of the People's Republic of China (Adopted at the 29th Meeting of the Standing Committee of the Tenth National People's Congress on 30 August 2007); see Peter J. Wang and Yizhe Zhang, 'New Chinese Anti-Monopoly Law' 2007 <http://www.jonesday.com/files/Publication/eb6dcb2a-624d-4242-b791-cc8faa3a1e52/Presentation/PublicationAttachment/4836e746-cc52-49cd-b96c-d764ae9bea1a/New%20Chinese%20Anti.pdf> accessed Feburary 2017.

[76] complementing the judicial interpretation of the Contract Law.

[77] Here it refers to abuse of of IPR in relation to competition law rather than someone breaching another's IPRs.

the existence of monopoly agreements,[78] abuse of dominant position,[79] and concentration of business operators.[80] It is worth noticing that although the Anti-monopoly Law does not include a separate chapter named after the abuse of IPRs by monopolistic behaviour, it explicitly prohibits the abuse of restrictive IPR performance in competition.[81] This could be the basis for a domestic company pursuing compulsory licensing articulated in TRIPS when a technology is not available in China.

The prohibition of IPR abuse protects the interests of innovators from difficulties they might face during R & D imposed by technologies already owned by others. For now, it is conducive to Chinese parties because according to China's current level of development many technologies are imported, and further technical development is largely dependent on IP owned by companies from another country. Take the development of wind power technology in China as an example. Before 2010, there was no price-competitive Chinese turbine supplier active in the market. According to this research, all the visited wind projects established from

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[78] Article 13-16.

[79] Article 17-19.

[80] Article 20-31.

[81] Actions listed by article 13,14, (when found in IP contract that is determined as monopoly agreement) and article 17 (Abuse of Dominant Market Position by IP owner) which can be considered as IP abuse explains "illegal monopoly" stated in Article 329 of the Contract Law in detail. "Article 13 Competing undertakings are prohibited from concluding the following monopoly agreements: (1) on fixing or changing commodity prices; (2) on restricting the amount of commodities manufactured or marketed; (3) on splitting the sales market or the purchasing market for raw and semi-finished materials; (4) on restricting the purchase of new technologies or equipment, or the development of new technologies or products; (5) on joint boycotting of transactions; and (6) other monopoly agreements confirmed as such by the authority for enforcement of the Anti-monopoly Law under the State Council. For the purposes of this Law, monopoly agreements include agreements, decisions and other concerted conducts designed to eliminate or restrict competition.
Article 14 Undertakings are prohibited from concluding the following monopoly agreements with their trading counterparts: (1) on fixing the prices of commodities resold to a third party; (2) on restricting the lowest prices for commodities resold to a third party; and (3) other monopoly agreements confirmed as such by the authority for enforcement of the Anti-monopoly Law under the State Council.
Article 17 Undertakings holding dominant market positions are prohibited from doing the following by abusing their dominant market positions: (1) selling commodities at unfairly high prices or buying commodities at unfairly low prices; (2) without justifiable reasons, selling commodities at prices below cost; (3) without justifiable reasons, refusing to enter into transactions with their trading counterparts; (4) without justifiable reasons, allowing their trading counterparts to make transactions exclusively with themselves or with the undertakings designated by them; (5) without justifiable reasons, conducting tie-in sale of commodities or adding other unreasonable trading conditions to transactions; (6) without justifiable reasons, applying differential prices and other transaction terms among their trading counterparts who are on an equal footing; or (7) other acts of abuse of dominant market positions confirmed as such by the authority for enforcement of the Anti-monopoly Law under the State Council. For the purposes of this Law, dominant market position means a market position held by undertakings that are capable of controlling the prices or quantities of commodities or other transaction terms in a relevant market, or preventing or exerting an influence on the access of other undertakings to the market."

2004 to 2009 relied on imported wind turbines from Spain, Denmark and Germany. At that time, the cost of operating the turbines ranged from 9361.98 Yuan to 10032 Yuan per kilowatt. Such costs were significantly lowered in a 2010 project to 9037 Yuan per kilowatt due to progress in the nationalization and localization of wind power equipment. However, such trends could increase fears of competition from firms transferring IP into the Chinese market.[82] This unwillingness could be determined as monopoly action because according to Article 13(4) of the Anti-monopoly Law, agreements "restricting […] the development of new technology or new products"[83] are considered to be concerted actions that eliminate or restrict competition. In an extreme case, minor advancements to the imported technology could survive restrictive clauses placed by the transferor because such clauses are prohibited by Article 13 of the Anti-monopoly Law. This may make it difficult for the transferor to prevent Chinese receivers from patenting improvements to their technologies and may well worsen grievances among IP owners, impairing future investment to the country.[84]

Except for the risk caused by the missing constraints on minor technology improvement, technology owners could be facing the loss of pricing power due to the Anti-monopoly Law. Article 17(1)[85] stipulates that if “a business operator with a dominant market position” is “selling commodities at unfairly high prices” it shall be considered as abusing its dominant market position. "Dominant market position" depends on a business operator’s “capacity to control the price, quantity or other trading conditions of commodities in the relevant market, or to hinder or affect any other business operator to enter the relevant market.” Although

[82] Wang and Zhang, (n 75) p.3-4.
[83] Chinese Anti-monopoly Law 2007 (n 75) chapter 2, article 13(4).
[84] Downey (n 50).
[85] Chinese Anti-monopoly Law 2007 (n 75) chapter 3, article 17(1).

there are no defined criteria for the "capacity," a largely occupied market share by a business operator is likely to be deemed as a determining factor. This could be a fetter to many non-Chinese companies. For example, in China's wind power market, foreign manufacturers including Vestas, Gamesa, and, GE Wind, held high market shares. And they are surely, at least were once, entities with power to manipulate pricing of wind turbine in Chinese market. However, in judicial practice, determining dominant position depends on how one defines a "market." If the wind turbine market is counted as a whole, these foreign manufacturers are not in a dominant position or only close to become so. However, when looking at the large-capacity wind turbine market, they are surely holding a great percentage of market share. According to Gosens and Lu, [86] the majority of current installations in China are turbines of approximately 1.5 MW that are mainly manufactured/assembled by Chinese companies. Only 1.9 per cent of installations have unit capacities of 2.5 MW or more, the turbines of which are mostly provided by foreign suppliers. Therefore, "the average turbine size in China remains smaller than in the US and EU markets" [87] because these imported turbines are significantly more expensive than domestically made equipment.[88] If the price of the products from abroad is thus considered as "unfairly high," which is very likely "echoing the argument from developing countries that IPR protection makes technology too expensive to acquire," [89] it could be seen as an example of monopoly conduct – a form of dominant-market position abuse. A case regarding the abuse of dominant market position in the alloy industry was initiated by four Chinese companies and upheld by the Ningbo

[86] See more detailed data in Fig. 5 in Jorrit Gosens and Yonglong Lu, 'Prospects for Global Market Expansion of China's Wind Turbine Manufacturing Industry' (2014) 67 Energy Policy 301.
[87] Ibid.
[88] Interviewees in this research hold an accordant conclusion about the higher price of the imported equipment in both the wind and biomass energy sectors.
[89] Downey (n 50).

Intermediate People's Court in 2015.[90] This is the very first case testing what constitutes an abuse of patent rights in China. It argued that the Japanese company Hitachi Metals' refusal to license its patents related to neodymium-iron-boron magnets was abusing its dominant market position, thus violating anti-monopoly laws.[91] Hitachi Metal owns most[92] of the IP associated with the sintered magnets field by holding over 600 patents globally. Hitachi has refused licences to Chinese firms except for eight selected ones. Now, four Chinese firms were actually "seeking $3.4 million in a patent antitrust lawsuit before the Ningbo Intermediate Court."[93] By refusing to license, Hitachi's behaviour affected the majority of Chinese sintered neodymium-iron-boron manufacturers and hindered them from entering overseas markets. Details of the trial have not yet been published, but with attention being placed on the technology's rare Earth alloys, similar cases regarding renewable energy technologies might have a more certain foundation in the future. While waiting on a ruling in Ningbo, it is foreseeable that the verdict could have a wide-reaching impact on actions such as compulsory licensing to be used in more sectors other than the pharmaceutical field.

Indeed, the enforcement of IPRs does not in itself undermine the market and therefore it does not violate the Anti-monopoly Law. However, the law clearly prohibits abuse of IPRs or a dominate position enabled by owning IPs in a way that disfavours the IP owners. This could be beneficial to the Chinese entities for now, when most core technologies are owned by foreign

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[90] Benjamin Bai, 'Crossing the Rubicon: When Does IP Owner Become IP Abuser?' (*Kluwer Patent Blog*, 8 March 2016) <http://kluwerpatentblog.com/2016/03/08/crossing-the-rubicon-when-does-ip-owner-become-ip-abuser/> .

[91] See Jacob Schindler, 'Hitachi Metals Case in China the Latest Sign that 'De-facto Standards' are Moving into Regulators' Crosshairs' (*iam-media.com*, 14 March 2016) <http://www.iam-media.com/Blog/Detail.aspx?g=12dbcdc1-170c-4b1a-b346-463f4257c260> .

[92] Bai (n 90).

[93] Schindler (n 91).

firms. However, it has the potential to become a huge problem when indigenous companies start to own more IPs and occupy greater market share than firms from overseas.

6.4.3 Patent Law

Patent Law is based on granting an exclusive right to innovators in exchange for the full disclosure of inventions, and thus encourages the spread of state-of-the-art knowledge. Chinese Patent Law sets out the framework for basic procedures regarding applications, examinations, re-examinations, and invalidation[94] acting as the foundation of patent protection for patent holders from home and abroad.[95] The function of the Law determines a close relationship it has to TT flows. The Chinese Patent Law was enacted in 1984, followed by three amendments.[96] Except for the 1992 amendment, the Standing Committee of the National People's Congress amended the Patent Law in 2000,[97] in preparation for compliance with TRIPS when joining the WTO.[98] Again in 2008, the Committee amended the Patent Law during China's second major set of legal reforms.[99] In August 2012, the State IPO issued a "revised draft People's Republic of China Patent Law (draft)" which has not entered into force yet.[100] This section focuses on the 2000 and the 2008 amendments, as they are the latest

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[94] See P. Ganea and others, *Intellectual Property Law in China* (Kluwer Law International 2005) p.39, quoted by Raymond M. Gabriel, 'The Patent Revolution: Proposed Reforms in Chinese Intellectual Property Law, Policy, and Practice Are The Latest Step to Bolster Patent Protection in China' (2008) 9 Asian-Pacific Law & Policy Journal 323.
[95] See Ganea and others (n 94) p.39; "Procedural law has been significantly improved in the course of the two [Patent Act] amendments, not only in order to remedy defects, but also in order to harmonise the domestic procedural law with international standards." "Where the Patent Act provides the legal framework for patent issuance and protection, the Patent Act Implementing Rules (PAIR) provide detailed information for the form and content of application documents. The PAIR interpret a number of legal provisions and provide instructions to the SIPO and local law enforcement. Further administrative rules govern interactions within administrative authorities, e.g., the Patent Examination Guidelines." Ibid p.5, quoted by Gabriel (n 94).
[96] Bai (n 90).
[97] Ibid.
[98] J. Benjamin Bai et. al, 'What Does the Third Amendment to China's Patent Law Mean to You?' (2009) Jones Day <http://www.jonesday.com/files/Publication/4bec1582-391d-497a-af19-bb314ae94433/Presentation/PublicationAttachment/ff879450-6699-4f2a-93fe-c33eb7d604cc/What%20Does%20Third.pdf> .
[99] Downey (n 50).
[100] Draft of the Chinese Patent Law revisions for public comment (published by State Council Legislative Affairs Office on December 2, 2015).

ratified versions of Patent Law and are considered to be the most significant amendments to date.

6.4.3.1 The 2000 Patent Law

The 2000 Patent Law was drafted to harmonize national law with international standards and treaties.[101] Moreover, with China becoming a member of the PCT, international patents could also be filed through the State IPO.[102] Patent holders may look for remedies regarding IPR infringement through administrative or civil enforcement.[103]

However, the seemingly standardized 2000 Patent Law had several problems hidden within its system that foreign investors could have their IP infringed.[104] For example, a patent must meet the novelty requirement in order to get issuance in China,[105] which is broadly worded.[106] Article 22[107] prohibits inventions that have been filed previously in China, have been published internationally, or have been publicly used or made known in China before the filing date from getting patent approved. Unlike the US law which has a "more than one year prior to the date of the application for patent", the Chinese 2000 Patent Law excludes viable

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[101] Louis S. Sorell, 'A Comparative Analysis of Selected Aspects of Patent Law in China and the United States' (2002) 11 Pac Rim L & Pol'y J 319 p.323. See also Peter K. Yu, 'The Second Coming of Intellectual Property Rights in China' Occasional papers in intellectual property <https://www.researchgate.net/profile/William_Brown19/publication/49851262_Intellectual_property/links/55dbc0d408aeb38e8a8b9031.pdf> , p.27.

[102] The Office has authority in "infringement matters, invalidation proceedings, and over certain matters of public interest, such as passing off another's patent as one's own." Peter Ganea, Thomas Pattloch and Christopher Heath, *Intellectual Property Law in China*, vol 11 (Kluwer Law International 2005) at ix; "The second revisions to the Patent Act in 2000 made invalidation decisions of the Patent Re-examination Board (PRB) subject to review by a People's Court." Ibid p.62; "The Intermediate People's Court of Beijing No. 1 is competent to review PRB decisions in the first instance." Ibid p.63; see also Jiang Zhipei, 'Patent Litigation in China' (1999) 9 Fed Cir BJ 479, p.479-81 (discussing "the location of the SIPO and PRB within geographical limitations of the Intermediate People's Court of Beijing No. 1"). Matthew L. Goldberg, 'The Viability of Stimulating Technology-Oriented Entrepreneurial Activity in China, Taiwan, Japan, and South Korea: How Regulations and Culture Encourage the Creation, Development, and Exploitation of Intellectual Property' (2005) 1 Int'l L & Mgmt Rev 1; see generally Patent Cooperation Treaty, June 19, 1970, 28 U.S.T. 7645, 1160 U.N.T.S. 231.

[103] Ganea and others (n 102) p.289, quoted by Gabriel (n 94).

[104] Schiappacasse (n 69) p.128.

[105] Goldberg (n 102) art. 22; See Ganea and others (n 102) p.10-20 quoted by Gabriel (n 94).

[106] See Tiancheng Jiang, *China and EU Antitrust Review of Refusal to License IPR*, vol 3 (Maklu-Pblishers 2015) p.147.

[107] Article 22: "Novelty means that, before the date of filing, no identical invention or utility model has been publicly disclosed in publications in the country or abroad or has been publicly used or made known to the public by any other means in the country, nor has any other person filed previously with the Patent Administration Department Under the State Council an application which described the identical invention or utility model and was published after the said date of filing.".

inventions from being patented, including one-year new technologies which is not novel (know to the public or disclosed at exhibition). Also patents already filed in another country are still patentable under the 2000 Patent Law. This is because there are insufficient limitations on defining “prior art”.[108] Thus inventions that are excluded from patentability under other countries’ patent laws may be considered novel in China.[109] At the same time, a malevolent company could file the patent right before the original inventor and get away with it via the loophole.[110]

Furthermore, the Chinese government retains great control over holders exercising their patent rights.[111] For example, when Chinese companies pursue joint ventures with foreign companies, any patent licensing to the companies from abroad must be approved by the state.[112] Although the law does not clarify what criteria shall be applied to obtain approvals,[113] such an intervention has the ability to deter investors from considering business with Chinese companies. Government power to require compulsory licences[114] will also

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108 Ganea, Pattloch and Heath p.10 quoted by Gabriel (n 94).

109 For example, the United States expressly limits and defines prior art. 35 U.S.C. § 102(b) (2000) (“A person shall be entitled to a patent unless...the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States.”); See discussing Draft Amendment to art. 22. ABA, ‘Coments of American Bar Association’s Section of Intellectual Property Law and International Law on Draft Amendments to the China’s Patent Law’ AMERICAN BAR ASSOCIATION (ABA) <https://www.americanbar.org/content/dam/aba/administrative/intellectual_property_law/advocacy/advocacy-20150427-comments.authcheckdam.pdf> accessed Apr 2017) p.27-29.

110 “Notably, it is also apparent that foreign applicants could capitalize on this loophole by filing for inventions patented by third parties in other countries.” Goldberg (n 102).

111 Ibid p.6.

112 Patent Law of the P.R.C. (2000 revision) (Promulgated by the Standing Comm. Natn’l. People’s Cong., Aug. 25, 2000, effective July 1, 2001) Article 10; see Goldberg (n 102) p.7.

113 Goldberg (n 102).

114 Ibid, art. 48-50, (Article 48. Where any entity which is qualified to exploit the invention or utility model has made requests for authorization from the patentee of an invention or utility model to exploit its or his patent on reasonable terms and conditions and such efforts have not been successful within a reasonable period of time, the Patent Administration Department Under the State Council may, upon the request of that entity, grant a compulsory license to exploit the patent for invention or utility model.
Article 49. Where a national emergency or any extraordinary state of affairs occurs, or where the public interest so requires, the Patent Administration Department Under the State Council may grant a compulsory license to exploit the patent for invention or utility model.
Article 50. Where the invention or utility model for which the patent right has been granted involves important technical advance of considerable economic significance in relation to another invention or utility model for which a patent right has been granted earlier and the exploitation of the later invention or utility model depends on the exploitation of the earlier invention or utility model, the patent administration department under the State Council may, upon the request of the later patentee, grant a compulsory license to exploit the earlier invention or utility model.

affect IP holders receiving desired licensing fees and they may be forced to allow others to exploit their patents.[115] Article 48 states that:

> where any entity which is qualified to exploit the invention or utility model has made requests for authorization from the patentee of an invention or utility model to exploit its or his patent on reasonable terms and conditions and such efforts have not been successful within a reasonable period of time, the Patent Administration Department Under the State Council may, upon the request of that entity, grant a compulsory licence to exploit the patent for invention or utility model.

Such broad wording of the Article requires the owner to exploit the patent in a limited period when the inventors do not intend to exploit a patent in China within a few years. For example when:

> a foreign inventor who files a patent application in China at the same time he files a patent in his home country[116] the inventor may not have the funding to exploit the patent in China because the invention may not become commercially successful in his home country yet.[117]

This is worth notice that the retention of government control in compulsory licence falls to both domestic and foreign inventors. Thus it is not considered as protectionism in favour of

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Where, according to the preceding paragraph, a compulsory license is granted, the Patent Administration Department Under the State Council may, upon the request of the earlier patentee, also grant a compulsory license to exploit the later invention or utility model.) The 2000 Patent Law of P.R.C. (Promulgated by the Standing Commission. National People's Congress, Aug. 25, 2000, effective July 1, 2001) available at http://www.chinadaily.com.cn/bizchina/2006-04/17/content_569573_4.htm; See also Goldberg (n 102) p.6.

[115] Goldberg (n 102) p.6-7.

[116] A foreign inventor would have to file in this sequence because a foreign disclosure, or patent application, would be a complete bar to a patent in China.) See ABA) p.8.

[117] It should also be noted that the 2006 Draft Amendments to arts. 49, 51, and A3 bring the Patent Law in line with arts. 30 and 31 of TRIPS. See ibid) p.55.

Chinese companies.[118] However, the government requires foreign applicants to use government-approved patent agencies to file a patent in Article 19[119] of the 2000 Patent Law.[120] This could constitute a barrier to TT because banning foreign applicants from filing patents directly by themselves does not help reduce transaction costs. Also, it is may be inconsistent with Article 3 of TRIPS: the national treatment requirement asking member states to treat foreign applicants as "no less favorable as...its own nationals."[121] Article 19 uses different words ("shall" and "may") when stipulating patent agency requirements on foreign and domestic inventors. This could be seen as a less favourable treatment because "foreign entities have a burden to use approved patent agencies while domestic inventors do not."[122] Meanwhile, though these provisions seem to be favouring local firms in patent competition by requiring additional restrictive conditions from foreign companies, actually the burden of facilitating TT is shifted back to domestic enterprises indirectly in the end because they are responsible for removing these obstacles for their foreign partners in practice. To quell foreign parties' fears of risks, any pre-project works such as an administrative examination or getting governmental approvals are executed by Chinese enterprises. These activities incur considerable costs, which are assumed by the Chinese buyer.

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118 Joint Submission of the American Bar Association's Section of Intellectual Property Law, Section of International Law, and Section of Science & Technology Law on Draft Amendments to the Patent Law of the People's Republic of China, at 1 (2006) p.6, 8, 17-21 (Draft Amendments to arts. 16, 19, 22, 48-50, 55, A3).<http://www.abanet.org/intlaw/blanketauthority/PRCpatentlawchanges.pdf>

119 Article l9. Where any foreigner, foreign enterprise or other foreign organization having no habitual residence or business office in China applies for a patent, or has other patent matters to attend to, in China, it or he shall appoint a patent agency designated by the patent administration department under the State Council to act as his or its agent. Where any Chinese entity or individual applies for a patent or has other patent matters to attend to in the country, it or he may appoint a patent agency to act as its or his agent. The patent agency shall comply with the provisions of laws and administrative regulations, and handle patent applications and other patent matters according to the instructions of its clients. In respect of the contents of its clients' inventions-creations, except for those that have been published or announced, the agency shall bear the responsibility of keeping them confidential. The administrative regulations governing the patent agency shall be formulated by the State Council.

120 See ABA) p.4, 23-25.

121 The TRIPS Agreement, art. 3

122 Gabriel (n 94).

A final issue[123] with the 2000 Patent Law is its "broad defenses and exceptions for infringement but niggardly with compensation."[124] For example, Article 63(1) stipulates:

> where, after the sale of a patented product that was made or imported by the patentee or with the authorization of the patentee, or of a product that was directly obtained by using the patented process, any other person uses, offers to sell or sells that product[125]

shall not be deemed an infringement of the patent right. Such provision does not require importers to only import from countries where the product was legally produced in order to avoid infringement of IPRs.[126] Thus it is possible to get an illegally manufactured device outside of China and then import it back into the country for sale,[127] meaning that piracy outside China could be indulged. This is against Article 28(1) of TRIPS where importing patented goods without authorisation is prohibited. And it is potentially harmful in cases where many consumable parts of imported renewable energy equipment require replacements purchased from abroad. However, those that purchased from patent holders are priced several times or even more than ten times higher than domestically produced parts. Therefore, energy plants prefer introducing indigenous components to combine with imported core components in production. For example, the digital control of the generating equipment – the mechanical and electrical equipment as well as chemical equipment – is mainly made in China in the biomass energy industry.[128] In the wind energy sector, instead of importing from the original manufacturer, damaged components due to wear and tear are

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[123] Ibid.
[124] See ABA p.11, 69-71.
[125] See ibid) p.29.
[126] See ibid) p.70.
[127] Ibid).
[128] Interview with managers of the four Biomass energy plants.

dismantled, reported and sent to the headquarters of these Chinese firms. With the help of specialized engineering experts, the headquarters will provide a consolidated solution to part-damage of the same kind and authorize a Chinese or a manufacturing plant in another country to repair or refurbish these components. Such a resource is available for all subordinate companies. A large cooperation like the Guoneng (National Bio Energy Co. Ltd.), having more than 30 subsidiary factories, is saving significantly by relying on refurbished consumables. According to the interviewees,[129]

> Reprocessing of these components depends on foreign patented technologies to varying degrees, while none of them are licensed. Having them made elsewhere is to avoid high cost of parts from original overseas manufacturers incurred by patented technologies.

Moreover, the maximum statutory fine for patent infringement is limited to only 50,000 Yuan (4,500 pounds),[130] which is hardly a deterrence to well-financed infringers and to those who benefit from piracy. The cost of litigation, especially for foreign patent holders, is high and compensation is not particularly promising and may also be slow to obtain. Therefore, a sharp rise in maximum recoverable damages and statutory fine are needed, and it may offset the expense of protecting patent rights and compensate for damages due to continuing illegal operations.[131]

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[129] Interview with manager and technical staff from China Resources (Holdings) Co. Ltd participated in wind project

[130] Goldberg (n 102) Article 58. Where any person passes off the patent of another person as his own, he shall, in addition to bearing his civil liability according to law, be ordered by the administrative authority for patent affairs to amend his act, and the order shall be announced. His illegal earnings shall be confiscated and, in addition, he may be imposed a fine of not more than three times his illegal earnings and, if there is no illegal earnings, a fine of not more than RMB 50,000 Yuan. See ABA p.11, 64-65.

[131] Geoffrey T. Willard, 'An Examination of China's Emerging Intellectual Property Regime: Historical Underpinnings, the Current System and Prospects for the Future' (1995) 6 Ind Int'l & Comp L Rev 411 p.430 (stating that cultural and political influences of Communism affect intellectual property rights in modern China).

6.4.3.2 The 2008 Patent Law

Nonetheless, the 2000 Patent Law is an amendment designed to basically align with the TRIPS requirements.[132] However, external pressures continued to mount against it afterward. Coercion by developed countries has always been a tool to push less developed countries to improve their IP laws.[133] Accordingly, in 2006 both the US and the EU indicated that they would bring investigation proceedings at the WTO to try to rectify the piracy of patents in China.[134] In order to avoid these legal challenges and to serve its own interests, China amended its Patent Law in 2008. Adding the goal of "enhancing innovation capability" to the basic objective of IPR protection for inventions (encouraging inventions and their diffusion; facilitating patent applications as well as meeting the needs of socialist modernization), the 2008 amendment[135] is the current act that regulates patent and relevant IP issues. Several improvements have been made to the 2000 Patent Law, as follows.

(a) The absolute novelty standard

Article 22[136] of the 2008 Patent Law amended the 2000 novelty standard[137] for patentability with an absolute standard to cover "prior art" and define it as "publicly known art anywhere

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[132] Gabriel (n 94).
[133] Yu (n 101) p.28-30; Robert C. Bird, 'Defending Intellectual Property Rights in The BRIC Economies' (2006) 43 American Business Law Journal 317 p.329-44.
[134] "As early as September, 2006, the United States was considering mounting a case in the WTO attacking China's lax IPR enforcement." Richard McGregor, 'Beijing Asks for More Time to Combat Piracy' (*Financial Times*, 06 September 2006) <http://www.europeanchamber.com.cn/en/national-news/114/beijing_asks_for_more_time_to_combat_piracy> accessed Feburary 2017; in October, 2006, Peter Medelson, the European Union Trade Commissioner, challenged China to "crack down on the piracy of European patents and trademarks, or it will face legal challenge at the World Trade Organization." See Michael Burr, 'China's IP Protections are Improving, but Enforcement Remedies Remain Weak' (*InsideCounsel*, November 2006) <http://dev.insidecounsel.com/ assets/article/729/China.pdf.> accessed December 2016 (stating that the commissioner of the State Intellectual Property Office, Tian Lipu, wants to increase innovation in China).
[135] Bai (n 98) chapter 1 article 1.
[136] Article 22: "Novelty means that the invention or utility model concerned is not an existing technology; no patent application is filed by any unit or individual for any identical invention or utility model with the patent administration department under the State Council before the date of application for patent right, and no identical invention or utility model is recorded in the patent application documents or the patent documentations which are published or announced after the date of application."
[137] This discussion of the significance of the 2008 amended Patent Law in general draws on analysis by J. Benjamin Bai et. al (n 98).

in the world before the filing date." Thus, when assessing the novelty of an invention, one should consider not only publication but also public use or knowledge outside of China. Under the 2000 Patent Law, inventions and designs used publicly outside China could still be considered as novel and thus not subject to invalidation proceedings. In contrast, the 2008 Patent Law improved this standard so that evidence of overseas public sale, public dissemination, and public knowledge is relevant and eligible proof to disqualify novelty.[138] The change helped close the loophole for "patent hijacking", i.e. "the patenting in China of another's invention witnessed at a public event (such as a trade show) outside of China."[139] Foreign firms may invoke this broadened wording of prior art to challenge patents successfully registered in China that they allege conflict with their own.[140] Indeed, this change has deterred a lot of patent applicants in China that intended to rush patent registry solely generated from foreign experiences.[141] However, the "amendment does not state whether and to what extent this absolute novelty requirement would be made retroactive to previously granted patents or pending applications."[142] Therefore, its effect on the validity of some of the existing problematic patents in China is unclear.

(b) Inventions based on genetic resources

A special point to note here about the 2008 Patent Law is its provisions that relate to "genetic resources."[143] The Law retains great government control by stipulating that "no patent will

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138 Ibid.
139 Ibid.
140 Downey (n 50).
141 this in indicated by the staff in charge of technical department of Shandong Dongyue Chemical Co. Ltd
142 This discussion of the significance of the 2008 amended Patent Law in general draws on analysis by J. Benjamin Bai et. al (n 98).
143 Prior to the 2008 amendment, the Patent Law did not contain references to "genetic resources." Bai (n 98) Article 5, 26.

be granted for an invention based on genetic resources if the access or utilization of the said genetic resources is in violation of any law or administrative regulation."[144] These administrative regulations include, for example, the Administration of Import and Export of Technologies,[145] the Administration of Registration of Technology Import and Export Contracts Measures,[146] the Catalogue of Technologies Prohibited or Restricted from Import,[147] and related Supreme Court interpretations regarding technology contracts.

And more than that, for inventions based on genetic resources, the amendment requires that "the applicant shall state the direct source and the original source of the genetic resources in the application documents. If the applicant is not able to state the original source, it or he/she shall state the reasons."[148] This provision imposes a burden on the inventors to provide the direct and original source of the genetic resources and proof that these were lawfully obtained.[149] The genetic resource disclosure requirement potentially affects renewable energy TT because such patents are commonly involved in the biofuel industry. For example, technologies developed to produce low-emission biofuels[150] will be required to disclose the source of genetic resources, or at least explain why they cannot be disclosed.[151] With abundant genetic resources in China, the extra information disclosed will help potential

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[144] Patent Law of the People's Republic of China (as amended up to the Decision of December 27, 2008, regarding the Revision of the Patent Law of the People's Republic of China) article 5.

[145] Regulations on Administration of Import and Export of Technique (Promulgated by the State Councilon 10 December 2001 and effective as of 1 January 2002) English version available at <http://en.pkulaw.cn/display.aspx?cgid=38107&lib=law >

[146] Measures of the Administration of Technology Import and Export Contracts Registration (Degree No. 3 [2009] of the Ministry of Commerce of the People's Republic of China); United Nations, 'Chapter 1 Declaration of the United Nations Conference on the Human Environment' in *Report of the United Nations Conference on the Human Environment, Stockholm 5-16 June 1972* (UN Doc A/CONF.48/14/Rev.1 1972). English version available at <http://english.7139.com/2609/18/39020.html >

[147] United Nations (n 146).

[148] Chinese Patent Law 2008 Article 26.

[149] J. Benjamin Bai et. al (n 98).

[150] "For example, at the 2009 Bio World Congress on Industrial Biotechnology, in July 2009, biotechnology firms gathered to discuss how genetic engineering and biotechnology could be used to produce second- generation biofuels." See, e.g., United Nations (n 146), quote by Downey (n 50).

[151] Bai (n 98) chapter 3 article 26.

competitors to explore similar products. No requirement is found in the patent laws of Europe, Japan, or the US equivalent to such tough disclosure rules for inventions relying on genetic resources are unique[152]. However, this risk for investors may not affect the development of renewable energy in China as a whole because biofuels occupy a relatively small share of the market. According to the World Energy Outlook 2007's Reference Scenario estimation, biofuels will account for only "2% of road fuel consumption" in China by 2030.[153] But importantly it will deter or could deter biomass companies from TT to China in the future.

If China intends to attract more TT and relative investment, it has to envisage the potential risk that the current legal system is imposing on investors and therefore construct a fairer and free domestic market for business.

6.5 IP law enforcement in the renewable energy sector

While Chinese IP correlative laws on the books still send out a few negative signals to potential investors, sufficient protection in practice plays a no-less-important role, or even a greater role in attracting investment. Despite certain defects discussed above, as a whole the Chinese government has used its adoption of stronger legal regimes facilitating TT to indicate its will to shift towards a more business-friendly environment.[154] But how and to what extent the reformed IP system is affecting TT flows and their dynamic in the renewable energy sector is another separate subject. For example, a better-enforced IP and IP-relative law environment might have increased FDI and multinational cooperation activities, while these

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[152] J. Benjamin Bai et. al (n 98) at 3 (noting that no such requirement exists in American, European, or Japanese patent law)

[153] International Energy Agency, 'World Energy Outlook 2007: China and India Insights' INTERNATIONAL ENERGY AGENCY (2007) <http://www.worldenergyoutlook.org/media/weowebsite/2008-1994/WEO_2007.pdf> accessed Feburary 2017 p.299.

[154] Ligang Song, Ross Garnaut and Cai Fang, *Deepening Reform for China's Long-term Growth and Development* (ANU Press 2014).

activities do not necessarily equal higher levels of international TT. This is due to a mature associated effect in the receiving country required for adequate TT, including good adaptation, wide application, affordable commercialization, independent innovative potential, and so on.[155] Therefore, this thesis endeavours to exam the level of TT reflected in several different IP law enforcement aspects, showing that the proportional relation between stronger IP law and ITT is weak and inconclusive, even in mid-income countries like China.

6.5.1 Patent growth

Some sectors of China's economy, such as the renewable energy industry, are very much dependent on technological advances. Noticeable growth in the renewable sector can be found in the years after 2000. China also became one of the top four countries to have the most electricity generated from renewable sources.[156] The country has been the top renewable energy commodity producer since 2005.[157] This significant advance has been reflected in patent growth as well, in the same period of time. For example, patent holders in the "BRIC" countries increased by 33 per cent from 1998 to 2008 in number with almost all of that growth occurred in China.[158] Patent data have been used as indicators of sufficient TT in many empirical studies[159] on climate change technology development.[160] Growth in the

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155 Amanda Watson, 'Does TRIPS Increase Technology Transfer to the Developing World? The Empirical Evidence' (2011) 20 Information & Communications Technology Law 253.

156 The data is collected from 1980 to 2010 statistics, and four countries include Canada, the United States, Brazil, and China. The data is provided by the U.S. Energy Information Administration. At the time of writing this article, the U.S. Energy Information Administration did not provide data for years beyond 2010. See The US Energy Information Administration, 'Total Renewable Electricity Net Generation' US Department of Energy, Washington, DC 2010 <http://www.eia.gov /cfappsipdbproject/iedindex3.cfm?tid=6&pid=29&aid=12&cid=BR,CA,CH, US,&syid=1980&eyid=2010&unit=BKWH> accessed July 2015. See in compare with The US Energy Information Administration, 'Electric Power Monthly with Data for April 2017' US Department of Energy, Washington, DC 2017 <https://www.eia.gov/electricity/monthly/pdf/epm.pdf> accessed June 2017.

157 Downey (n 50).

158 Copenhagen Economics and The IPR Company, *Are IPR a Barrier to the Transfer of Climate Change Technology* (Copenhagen Economics Informed Decisions, 2009).

159 See Ivan Haščič et. al, *Climate Policy and Technological Innovation and Transfer: An Overview of Trends and Recent Empirical Results* (2010); N. Johnstone and Ivan Hascic, 'Indicators of Innovation and Transfer in Environmentally Sound Technologies: Methodological Issues' OECD Environment Working Paper, Working Party on National Environmental Policies ; OECD, *Invention and Transfer of Environmental Technologies, OECD Studies on Environmental Innovation* (OECD Publishing, Paris, 2011); EPO and ICTSD UNEP, *Patents and Clean Energy: Bridging the Gap Between Evidence and Policy (Final Report)*

number of patents registered, in theory, should indicate a better environment for investment in technology-based industries in a country, along with a greater capacity for independent technology development. Indeed, since the 2008 Patent Law, Chinese companies have been filing for utility-model patents at a rate of more than 300,000 per year. The utility-model patent[161] is a special patent type created by the Chinese Patent Law which is less rigorous and less expensive than invention patents because it does not require a substantive review process and provides just ten years of protection (compared to 20 for invention patents)."[162] The advantage of the utility model is its quick review process,[163] which shrank from approximately four and a half months in 2012 to three months in 2015.[164] This is mainly because the review does not require a utility model to have substantive features and represent the state of the art. Although such low criteria will inevitably cause a considerable

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(United Nations Environmental Programme, European Patent Office, International Centre for Trade and Sustainable Development, 2010).

[160] Pauline Lacour and Catherine Figuiere, 'Environmentally-Friendly Technology Transfers from Japan to China: An Empirical Analysis using Patent Data' (2014) 3 Juournal of Innovation Economics and Management 145.

[161] "Utility models are a form of patent-like protection for minor or incremental innovations. They tend to protect the functional aspect of a product (examples of utility models apply to the functional aspects of toys, watches, optical fibres, machinery, etc). Utility models are very common in the mechanical, optical and electronic fields and played a role in the industrial development of countries like Germany and Japan, as well as South Korea and India." U. Suthersanen, Utility models and innovation in developing countries (UNCTAD Project on IPRs and Sustainable Development, Issue paper No 13, 2006).
The main differences between utility models and patents are, according to WIPO, the following:
"The requirements for acquiring a utility model are less stringent than for patents. While the requirement of "novelty" is always to be met, that of "inventive step" or "non-obviousness" may be much lower or absent altogether. In practice, protection for utility models is often sought for innovations of a rather incremental character which may not meet the patentability criteria.
The term of protection for utility models is shorter than for patents and varies from country to country (usually between 7 and 10 years without the possibility of extension or renewal). In most countries where utility model protection is available, patent offices do not examine applications as to substance prior to registration. This means that the registration process is often significantly simpler and faster, taking, on average, six months. Utility models are much cheaper to obtain and to maintain. In some countries, utility model protection can only be obtained for certain fields of technology and only for products but not for processes."
'Protecting Innovations by Utility Models' (WIPO)
<http://www.wipo.int/sme/en/ip_business/utility_models/utility_models.htm> accessed May 2017.

[162] Basil Moftah and Thomson Reuters, 'The New Patent Dynasty' (*The Patent Lawyer, CTC Legal Media*, 2013)
<http://ip.thomsonreuters.com/sites/default/files/new-patent-dynasty.pdf> accessed Feburary 2017.

[163] "China differs from many Western jurisdictions by providing patent protection for utility models, which protects the shape, structure, or the combination of shape and structure of a physical product (methods and compositions can only be protected by invention patent) for a term of 10 years (compared to 20 years for invention patents). Obtaining a utility model patent, sometimes colloquially called 'mini-inventions', requires a lesser degree of 'inventiveness' (i.e. the degree of innovation over known technology) than needed to obtain an invention patent. Utility models are inexpensive and quick to obtain, on average within 9-12 months, and are well suited to protecting products with shorter product life-spans." The Development Solutions and the European Chamber, 'IP Strategies for EU 'Cleantech' SMEs in China' China IPR SME Help desk 2012
<http://www.china-iprhelpdesk.eu/sites/all/docs/publications/EN_IP_Strategies_for_EU_Cleantech_SMEs_in_China.pdf> accessed Feburary 2017.

[164] EPO, *IP5 Statistics Report 2012 Edition* (European Patent Office, Japan Patent Office, Korean Intellectual Property Office, tate Intellectual Property Office of the People's Republic of China, United States Patent and Trademark Office, 2013).

part of the utility model to be low quality, it does nurture many small R & D companies nowadays in China that rely on selling registered utility models. This shorter protection period could also have encouraged a faster metabolism for green-technology development, as many green technologies are registered under this category (e.g. Patent CN 203312804 U: Renewable energy portfolio grid system).[165] This device under Chinese IP law could be one of the explanations for the rapid growth of patent applications in China. However, it is a double-edged sword because it might have caused the quality of these Chinese patents to sink lower than those granted in other countries.[166] Such an argument can be affirmed through a comparison between patents registered domestically in China and those filed internationally. The number of patents filed abroad from China grew from 13,005 in 2008 to 33,222 in 2013, whereas overall patenting including domestic applications has increased from 239,663 in 2008 to 629,612 in 2013.[167] Although the ratio of patents filed in other countries by Chinese firms to domestically registered patents remained at almost the same level, the proportion of patents filed abroad remains small. As for patents filed in 2013, 80 per cent were filed domestically.[168]

Foreign companies intending to invest in China need to establish their patent portfolios according to Chinese law in order to avoid finding themselves at an IP disadvantage in this market, or being victims of patent infringement.[169] Sufficient attention should be paid to the

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165 Solar cells, wind power generation unit and a biogas power units are connected to the DC bus and the system controller, the system controller detects and calculates the power output by the wind power generation unit and solar unit, and adjust the power output of biofuel power generation unit.

166 This is indicating a need of TT remains in China though the Number of patent application appears to be large.

167 Reuters (n 162).

168 Ibid.

169 Georgia Chiu and Skip Fisher, 'China as Innovator? Recent Thomson Reuters Report Examines Trends in Chinese Patent Filing & Litigation' (*LimeGreen IP News*, 15 Janurary 2015) <http://www.limegreenipnews.com/2015/01/china-as-innovator-recent-thomson-reuters-report-examines-trends-in-chinese-patent-filing-litigation/> accessed Feburary 2017.

use of utility models as well as to invention patents. Meanwhile, Chinese companies are much more familiar with utility model patents and taking advantage of them to fight their foreign competitors. Pre-empting registration, combining utility models with invention patents is the trick that Chinese companies use to deal with clean technology based on legacy technology. For example, in the well-known 2009 Chint vs. Schneider case, the registered utility model patent (ZL97248479.5) owned by Chinese company Chint was used to sue the French company Schneider and its distributors over patent infringement. "The Chinese company was able to settle the case through arbitration for USD 23 million using a utility model."[170] This is considered a successful fight back by an individual Chinese company against an acquisition threat from its foreign competitor, but also a warning to foreign investors of the powerful use of the utility model by Chinese firms.

Regardless of the growth of patent registrations, the patent quality has to be looked at to build up a more comprehensive understanding of IP development in China.[171] In the renewable energy sector, technology development appears to have improved significantly in China.[172] According to Lee et al., "by 2009, China held significant shares of worldwide patents in various renewable energy technologies, including over 10% of worldwide patents in wind power, biomass, and concentrated solar power (CSP)."[173] Such numbers, if then adjusted by the geographic origin of the parent companies to exclude patents owned by foreign

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[170] EPO (n 164); Relevant Patent -the "low voltage and small circuit breakers", is widely used in the construction industry and domestic air switch products. This patent is available for alternative products to the traditional electrical protection device- fuse. As early as in November 1997 CHINT group has filed to the State Intellectual Property Office of China for a utility model patent registered as "ABB S2IM S800S-C ".

[171] Bob Stembridge, 'Chinese Patenting: Report on the Current State of Innovation in China' Thomson Reuters <http://fordhamipconference.com/wp-content/uploads/2012/02/TR-China-Patenting-Report.pdf> .

[172] Downey (n 50).

[173] Bernice Lee et. al, *Who Owns Our Low Carbon Future?* (Intellectual Property and Energy Technologies: A Chatham House Report, 2009).

subsidiaries, show that Chinese companies held only about 5 per cent to 8 per cent of global patents in those types.[174] However, countries in the areas of renewable energy patenting, with a high volume of installed capacity, are not necessarily scoring high on technology/patent quality. China has the highest installed capacity for solar PV but does not figure in the top owners of patents in this area.[175] Although there is an increase in patenting in China, there are significant gaps between the top technology holders in the developed countries and their Chinese rivals. Chinese firms were granted a much smaller proportion of patents in the three big patent offices (US, Japan and the European Patent Office) than in China.[176] According to WIPO data 2015, "US applicants filed the most applications abroad (224,400), followed by those from Japan (200,000) and Germany (105,600). Chinese applicants filed only around 36,700."[177] This could be an indication of the unusually high volume of low-quality patents that China has, giving under its low standard for utility patent application.

Patenting activity in China in 2014 outstripped the USA and Japan combined. China's patent office received almost one million applications. Despite such an explosion of Chinese patents, it is important to keep in mind that in terms of patent application per capita, China is still lagging behind several developed countries with high innovative capability. "Per capita measures provide necessary context to date, and in the case of patent filings, arguably better

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174 Ibid.

175 See Sarah Helm et.al, *Renewable Energy Technology: Evolution and Policy Implications - Evidence from Patent Literature* (WIPO Global Challenges Report: An Overview of Issues Relevant to Debates about Solutions to Global Challenges, such as Climate Change, Public Health and Food Security, 2014).

176 Pointed out by Ahmed Abdel-Latif, from the International Centre for Trade and Sustainable Development. See Julia Fraser, 'WIPO Report Indicates Unprecedented Rise In Renewable Energy Tech Innovation' (*Intellectual Property Watch*, 13 June 2014) <https://www.ip-watch.org/2014/06/13/wipo-report-indicates-unprecedented-rise-in-renewable-energy-tech-innovation/> accessed Feburary 2017.

177 WIPO, *Global Patent Filings Rise in 2014 for Fifth Straight Year; China Driving Growth* (WIPO 14 December 2015).

reflect penetration rates of invention capacity than absolute patent filings."[178] According to the 2014 WIPO and World Bank statistics database, China ranks number nine of the top 20 origins regarding their resident patent applications per million per population.[179] The Republic of Korea had the highest resident applications-to-population ratio, followed by Japan, Switzerland, and Germany.[180] China's resident applications-to-population ratio is below Denmark's whose population is less than 0.5% of China's, and below seven others.[181] China's patent applications-per-million capita is only about a quarter of that of Japan and half of the US, which lends a stark contrast to its vast total applications in comparison with those two countries.

The increase in Chinese patent applications may be due to its design of patent laws, but may also be at least partly explained by the financial incentives offered by different levels of the Chinese government to increase the use of clean technology. The Chinese national IP regime started to incentivize green patent application by local firms from as early as 1999 but the rapid growth in clean-energy technology patents in China did not occur until 2004–2005.[182] The lag in-between might indicate a lack of financial incentives and market-oriented policies, like the Chinese Renewable Energy Law or the five-year plans with their targets for reduced energy intensity over. These factors were more influential as inducements for innovation in the clean energy sector than was IP protection.[183] Other than favourable domestic policies,

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[178] Dan Prud'homme, 'A Statistical Analysis of China's Patent Quality Situation and Larger Innovation Ecosystem' in Dan Prud'homme (ed), *Dulling the Cutting Edge: How Patent-Related Policies and Practices Hamper Innovation in China* (European Union Chamber of Commerce in China Publications 2012).
[179] WIPO, *World Intellectual Property Indicators 2014* (WIPO Statistics Database, October 2014, 2014).
[180] Ibid.
[181] the Top eight regions in terms of resident patent applications per million population: Republic of Korea, Japan, Switzerland, Germany, United States of America, Finland, Sweden and Denmark
[182] Gallagher (n 4).
[183] China has joined the WTO in 2001, and amended IP law to meet requirements of TRIPS were available even earlier. However, such IP law reform did not make much difference in incentivising technology development and TT to the country. Ibid (n 4).

preferential government policies introduced to take advantage of international environmental agreements are also playing a key role in the increase of green patents. For example, between 1990 and 2008 the number of climate change mitigating patents under the PCT in this field increased 33 times. Among them, the number of environmental patent applications by Chinese inventors has been growing the fastest.[184] Patents filed for technology in energy production from renewable resources, in particular, increased 20-fold from 1990 to 2009. In contrast, the total patent filings increase only by about four times.[185] "The growth rate of environmental innovations is more significant than that of all technological fields combined."[186] This could indicate that the Kyoto Protocol in 1997 was perhaps a bigger stimulant than the Chinese Patent Law 2000.[187]

However, using the information in the PATSTAT database,[188] the OECD has found that "Chinese domestic companies are more competitive in the midstream[189] and downstream[190] parts of the industry chain while they still rely on foreign technologies for the upstream part, which requires more investment and technological capabilities."[191] With a significantly growing number of patent applications, China's technological development will be confronted with a considerable amount of existing less-innovative patents and low technology capability in the upstream industry. Such a sceptical view is confirmed by results from interviews

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[184] Patents are classified by priority date and according to the inventor's country of residence. Fractional accounts are applied to patents which have several inventors. OECD (n 159).

[185] 'World Patent Report: A Statistical Review - 2008 edition' (*WIPO*) <http://www.wipo.int/ipstats/en/statistics/patents/wipo_pub_931.html> accessed May 2017.

[186] Figuiere (n 160).

[187] Ibid.

[188] It is a worldwide patent statistical database, known as EPO European Patent Office PATSTAT.

[189] For example, in the energy industry the midstream sector involves electricity transportation (i.e. cables and construction of these products).

[190] Downstream sector is highly related to the final products purchased by end users. In the wind power industry, for example, the refining of assembling blades, engine and the construction of wind tower shall be considered as downstream sectors.

[191] Figuiere (n 160).

conducted in this research. Let's take the wind energy sector as an example: on the macro-national level, Chinese activity in renewable power technologies has risen sharply in recent years.[192] In 2011, "global wind power patent applications by applicants from China totalled 2600, compared to 3044 for EU-15[193] applicants and 1234 for US applicants."[194] However, only 52 per cent of all wind patents registered at the Chinese Patent Office belongs in the invention patent category.[195] The remaining were utility-model and design patent types, which lack rigour with respect to their novelty assessment. Most of the interviewees[196] had expressed that a certain amount of the so-called independently developed wind turbines were actually products assembled from hardware that had been imported. In addition, a Chinese policy aiming at encouraging innovation in China requires that 70 per cent of wind energy installation has to use indigenous equipment.[197] As a result, a pattern of fabrication using parts made in foreign factories is embedded in the soil of China's political environment. This observation is supported by Gosens and Lu[198] who identify a much lower number of patent applications by Chinese wind turbine manufacturers than by their foreign competitors.

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[192] Patrick Bayer et.al, 'Global Patterns of Renewable Energy Innovation, 1990–2009' (2003) 17 Energy for Sustainable Development 288 p.288-295.

[193] the 15 EU countries include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

[194] Analysis of online databases from European Patent Office (EPO) (2012), State Intellectual Property Office (SIPO) (2012) by Gosens and Lu, (n 86) p.301–318.

[195] Ibid.

[196] Interview with wall three managers recruited from wind projects.

[197] The "National Development and Reform Commission notice of relevant requirements on wind power construction management" issued in 2005 articulates: "wind power equipment localization rate shall reach more than 70%, wind project that does not meet the requirements of the localization rate of equipment will not be approved." Because of this policy, from 2006 onwards, China's endogenous wind power installed capacity reached a approximate 100% increased rate annually. During the time, the Chinese government also provided financial subsidies and other favourable policies to further support the development of its domestic wind power equipment manufacturers. The abolishment of the "70% localization rate", although not officially announced in written document, has been made to known by the end of 2009 to the relevant provincial authorities. And it has actually been implemented. It has been implemented for 5 years, "the 70% localization rate of wind power equipment" policy has become history. Liu Yanjun, the Chinese spokesman of the world's largest Danish wind turbine manufacturer Vestas, points out that currently Vestas products available in the Chinese market are produced 80% locally in China to satisfy the policy. The bespoke V60-850 kilowatts turbine for China is manufactured 90% in China. Therefore, the abolishment of the "70% localization rate" is very important to those who want to enter the Chinese market as it is making the entry easier. But still, more advanced equipment such as the 3 MW turbine parts are not fully absorbed by the domestic suppliers/manufacturers. The need of import remains high, for example, most core components of Sinovel 3 MW wind turbines are imported from the United States.

[198] Details see Fig 3 of Gosens and Lu (n 86).

Despite the limited independent technology capacity of Chinese wind turbine manufacturers, they are still keen on filing patents meaning that they intend to pursue a decent-looking patent portfolio. This is because the more patents possessed, the better position a company will be in during project tenders because owning many patents is considered as a qualification of reputable suppliers. It is much easier for companies with a good "reputation" to get favourable policies from the state and local government, which has, on the other hand, left smaller and start-up companies to face a difficult situation.[199]

In fact, patent growth in numbers only indicates a rough trend of technology development, as more applicants are getting protection from being infringed by potential imitators. Neither does it necessarily reflect the amount and effectiveness of TT from developed countries to China nor the technology-capacity growth as a whole. In addition, in some cases inventions may be protected by strategic measures used by technology owners, such as trade secrets, production or operation know-how, and well-planned cross-filing.[200] Many companies from developed countries are selective about which inventions are to be filed in China. They only patent inventions that they absolutely must market in China, at a minimum level, to avoid publicly disclosing too many technological details.[201] Only blueprints and other technical information that is closely relevant to the end product sold in China is being patented. More upstream technologies and even channels to purchase materials for consumables and components to the imported equipment are undisclosed thus mainly protected as a business

199 indicated by interviewee from the government officer group that has participated in one of the three wind projects.

200 Ivan Haščič and Nick Johnstone, 'CDM and International Technology Transfer: Empirical Evidence on Wind Power' (2011) 11 Climate Policy 1303.

201 Ros Davidson, 'Wind Manufacturers Act to Defend Intellectual Property Rights' (*Wind Power Monthly*, 26 January 2012) <http://www.windpowermonthly.com/article/1114292/wind-manufacturers-act-defend-intellectual-property-rights> accessed Feburary 2017.

secret.[202] The core components used on wind turbines in China are basically imported, as there are currently no comparable indigenous alternatives available in the market. For example, the stable performance of a wind turbine is mainly dependent on the quality of its wind blades. The engine motor and spindle are of secondary importance. First, imported wind blades are manufactured under fastidious production procedures and the material used provides minimum deformation rate, which will adapt to a variety of wind speeds. Second, these blades are highly concentric between the spindle and the outer circle. Third, they have a high precision of balance, with only a 0.4 to 1.0 deviation. These three features are so advanced that none of the domestic turbine manufacturers are able to compete in their manufacture. Chinese wind farms reported that replacement components provided by joint ventures and local suppliers had a much higher failure rate in operation.[203] Frequently requested mechanical parts, such as electricity relays, are usually demand for highly specialized steel components used in axle and yaw bearings.[204] Therefore, they are entirely dependent on imports because domestic manufacturers are unable to provide products good enough to be applied.

6.5.2 R & D development in renewable energy

As patent growth does not necessarily indicate the success of the amended Chinese IP law, neither does it mean sufficient TT is flowing into the country. Two things stand out in explaining the weak linkage between IP law reform and the increase of TT. First, the Chinese

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[202] According to statement from interviewees of this research.

[203] All manager and technician interviewees from wind projects pointed out this problem.

[204] LI Junfeng et. al, 'China Wind Energy Outlook 2012' Chinese Wind Energy Association 2012 <http://www.gwec.net/wp-content/uploads/2012/11/China-Outlook-2012-EN.pdf> accessed Feburary 20127; And see Jingyi Han et.al, 'Onshore Wind Power Development in China: Challenges Behind a Successful Story' (2009) 37 Energy Policy 2941 p.2941–2951.

government is determined to encourage the domestic innovation rate with big commitments from itself. For example, between 2004 and 2008, the funding for science and technology activities in China increased by 111 per cent.[205] As a result, expenditure on R & D grew by 135 per cent and increased as a share of GDP from 1.23 per cent to 1.54 per cent.[206] In 2014, government investment in renewable energy R & D even leaped to $1.7 billion.[207] This could be a solid reason explaining the patent inflation in China.[208] Indeed, in order to narrow the gap between China and the industrialized countries in terms of technological intensity, the Chinese government has been providing more and more resources to R & D activities, especially in the environmental sector, since the middle of the 1990s.[209] Therefore, the increase in environmental patents in China could reveal the authorities' concerns for environmental protection (more than the strengthened IP and global effort perspectives) for encouraging the diffusion of renewable energy technologies. Although the Chinese government devotes considerable financial resources to environmental technology R & D, human resources in this field remain low.[210] In 2008, R & D labour per thousand of the total employment in China, was still at least 3 units below other developed countries.[211]

Second, the Chinese government has implemented policies which encourage FDI to maximize spill overs of foreign knowledge and TTs.[212] For example, between 2000 and 2010, the

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[205] National Bureau of Statistics of China, *China Statistical Yearbook 2009* (China Statistics Press, 2009) p.820.
[206] Ibid.
[207] Prud'homme (n 178).
[208] See Roman Kilisek, 'Higher R&D Investment in Renewable Energy Technologies Critical for Clean-Energy Innovation & Climate Action' (*Breaking Energy*, 13 May 2015) <http://breakingenergy.com/2015/05/13/higher-rd-investment-in-renewable-energy-technologies-critical-for-clean-energy-innovation-climate-action/> accessed Feburary 2017
[209] Figuiere (n 160).
[210] Ibid p.145-169.
[211] For example, researchers and R & D personnel only reached respectively 2.1 and 2.9 per thousand of total employment in China. In contrast, the numbers are 10.2 and 13.9 in Japan. OECD, *Growth, Technology Transfer And Foreign Direct Investment (Oecd Global Forum On International Investment,* (OECD Global Forum on International Incestment, Mexico City, 26-27 November 2001, 2011).
[212] See Figuiere (n 160); This argument will be discussed in detail in the later part of the chapter.

number of foreign-invested R & D centres increased from fewer than 200 to more than 1,300.[213] A proportionate relationship between FDI and patent application is even applicable domestically among provinces. In China, according to Cheung and Lin,[214] provinces with more FDI have more domestic patent applications. "They attribute this to a form of spill over from foreign investment – namely, a demonstrative effect on domestic enterprises."[215] FDI through joint ventures and wholly foreign-owned companies is provided with a tax rebate on capital goods imports and other tax exemptions. But in return they are subject to some requirements, such as the adoption of "advanced technologies to develop new products; save energy and natural resources; improve existing products and/or replace imported products; provide technological and organizational training; and pursue some economic activities that favour technological upgrading."[216] Government at different levels also has "local policies or regulations on land or tax concessions to attract foreign investment and technology."[217]

Accordingly, R & D investment from abroad increased substantially in China. More foreign multinational R & D centres were established in the country. This indicates a positive trend of China's innovative capacity development alongside its patent growth. For example, "at the end of 2011, there were over 1,400 foreign-invested R & D centres in China,"[218] and more collaboration between Chinese and foreign companies occur in R & D.[219] A survey finds that

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[213] The Business Times 2011, quoted by *Deepening Reform for China's Long-term Growth and Development* (Ligang Song, Ross Garnaut and Cai Fang eds, ANU Press 2014)

[214] Kui-yin Cheung and Lin Ping, 'Spillover Effects of FDI on Innovation in China: Evidence from the Provincial Data' (2004) 15 China economic review 25.

[215] Ibid; See also Song, Garnaut and Fang (n 154).

[216] The law governing wholly foreign-owned enterprises was implemented in April 1986. Figuiere (n 160).

[217] Zhang and Yun (n 61).

[218] Liu Yajun, 'Greater Convenience for Foreign Investors' *China Daily* (9 December 2011) <www.chinadaily.com.cn/business/10thWTO/2011-12/09/content_14240801.htm> .

[219] Companies from EU, US, Japan and Korea invest in China. See Sylvia Schwaag Serger, 'Foreign R&D Centers in China: Development, Drivers, Spillovers' Swedish Institute for Growth Policy Studies (ITPS) and Research Policy Institute, University of Lund (2007) <http://www.oecd.org/science/inno/39244157.pdf> accessed Feburary 2017.

2.2 per cent of EU companies' outward R & D investment is designated to go to China.[220] As a result, while China is becoming an increasingly attractive place for R & D investment from abroad, the number of patent applications within the region is growing as well. Song et.al confirmed that R & D intensification in China is one of the primary driving forces of China's patent boom.[221]

However, the potential of such investment to promote China's technology capability is limited, as the amount of these investments is relatively low at present. According to the same survey mentioned above, on average, the "EU firms' R & D investment in China is not projected to rise by more than 3% (to about 5% of total R & D expenditures) in 2013."[222] More importantly the R & D collaboration that is in place does not necessarily involve breakthrough and core technologies. According to Wu and Pangarkar, FDI flows to mainly low-tech industries in China.[223] A similar conclusion is found in another study that points out that technologies transferred to China are usually "at least five years behind global standards or transfer technologies that would be obsolete in the near future."[224] Some studies[225] argue that this reluctance is likely attribute to perceived weak IPR protection in China. In fact, this could be due to companies' natural instinct to keep their core R & D in headquarters or

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220 European Commission, *The 2010 EU Survey on R&D Investment Business Trends* (Joint Research Centre: IRI - Economic of Industrial Reserach and Innovation Directorate General Research, 2010) p.5.
221 Song, Garnaut and Fang (n 154).
222 European Commission, *The 2010 EU Survey on R&D Investment Business Trends* (n 220) p.13.
223 Jie Wu and Nitin Pangarkar, 'Rising to the Global Challenge: Strategies for Firms in Emerging Markets' (2006) 39 Long Range Planning 295.
224 For example, see Keith E. Maskus et. al, 'Intellectual Property Rights and Economic Development in China' (1998) 504 The National Bureau of Asian Research Working Paper. In the research, interviews have been done "with managers of a range of foreign enterprises operating in China, who noted they at large do not develop breakthrough technologies in China given concerns over misappropriation of IP and patent infringements. Almost all respondents reported that they transferred technologies that were at least five years behind global standards, or transferred technologies that would be obsolete in the near future, unless certain means could be utilised to protect the technology particularly well. Additionally, concern over weak patent protection in China prevented foreign enterprises from fully integrating their Chinese operations, whereas they typically divided production processes among production sites to avoid revealing the full nature of their operations in any one site."
225 See for example Peter Bruun and David Bennett, 'Transfer of Technology to China:: A Scandinavian and European Perspective' (2002) 20 European Management Journal 98; See also Kazuhiro Asakawa and Ashok Som, 'Internationalization of R&D in China and India: Conventional Wisdom versus Reality' (2008) 25 Asia Pacific Journal of Management 375.

other more IP-mature areas instead of dispersing their highly innovative efforts elsewhere, in order to prevent unnecessary competition. It is possible that entities with the most advanced and high quality patents in the world deliberately not to develop breakthrough patented products in potential competitors' countries regardless of the level of IP protection, and perhaps especially in China. This might be attributed to the country's large-scale economy and the acquiescent, preferential government support that is available to domestic firms and which assists them in commercializing imported technologies, making them affordable quickly once they are transferred. Foreign firms may be reluctant to develop such products in China given concerns over the competency of development by Chinese firms and the potential risk of lost sales in other markets abroad. From this perspective, IP protection provided by the legal system is acting as a harbour for the anti-competitive and diffusion-hindering behaviour of technology owners.

As a result, in the renewable energy sector, although China is one of the world's highest producers in the field of renewable energy and possesses the relevant equipment[226] (for example more than half the global output of solar photovoltaic (PV) panels),[227] its indigenous companies are still more engaged in the midstream and downstream industry chain (the production of modules and cells) and owns fewer core technologies.[228] The situation is amplified in the wind energy sector. Rapid growth in Chinese wind turbine manufacturing is reflected by a 44 per cent share of the market by domestic providers in 2012. Such an increase is due to clearly favouring and significant financial support from the Chinese

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226 Figuiere (n 160).
227 with 57% of global output in 2011. Ibid.
228 Ibid.

government. According to the GWEC Global Wind Report,[229] the Chinese government requires 70 per cent of all installed projects in the country to have "domestically produced content."

A possible reason for this increase in foreign invested R&D could be the economic recession of 2008 in China, with the government desperate to stimulate domestic demand instead of relying on export to keep the economy growing. In 2005 the Notice of the National DRC on the Relevant Requirements for Wind Power Construction Management was promulgated.[230] The Notice requires localization rate of wind power equipment installation to reach more than 70 per cent. Wind farms unable to comply with the localization requirement will not be approved to proceed. From 2006 this has increased the Chinese wind power capacity by nearly 100 per cent annually.[231] Subsequent government policies regarding subsidies and other assistance gave more support to the development of domestic wind power manufacturers. Abolition of the 70 per cent localization requirement[232] was relayed to each province in China in 2009 for implementation. Such protectionism, enacted for only five years, forced foreign firms to establish joint ventures with domestic industries under the restrictive quota requirement and encouraged many purely foreign-funded factories to set up in China. This is referred to as FDI in many articles[233] and considered to be an important mechanism of TT.[234] Such TT among affiliated firms is a mechanism that "usually involves large resource commitments and

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229 GWEC, *2012 Global Wind Report* (Annual Market Update 2012, Global Wind Energy Council (GWEC), Belgium, 2013).
230 Notice of the National Development and Reform Commission on the Relevant Requirements for Wind Power Construction Management (发改能源[2005]1204 号) (in Chinese)
231 OECD, *OECD Science, Technology and Industry Outlook 2014* (OECD Publishing, Paris, 2014).
232 although not officially announced, but included in governmental documents
233 Watson and others (n 2).
234 Keith E. Maskus, *Encouraging International Technology Transfer* (UNCTAD-ICTSD Project on IPRs and Sustainable Development Issue Paper No. 7 2004).

provides a high degree of control over the technology that is transferred."[235] In fact, leading manufacturers such as Vestas, GE, and Repower all have subsidiary factories in China. Indirectly, these FDIs facilitated Chinese indigenous turbine manufacturers in developing smaller capacity wind turbines by learning from the market leaders from overseas. Vestas' Chinese district spokesman Yanjun Liu pointed out that the localization rate of wind power installation in China had reached 80 per cent already.[236] But neither the purely indigenous nor the foreign-funded manufacturers are exempted from depending on foreign technologies for the consumable parts, which is characterized by strong barriers to entry.[237]

Therefore, on the surface, the 70 per cent localization-rate policy encouraged TT to China, while in fact it motivated companies to enter the industry more carelessly. In the primary stage of the use of political incentives to encourage wind power, many defective policies were established. Some private investors initiated wind turbine projects on purpose to occupy a piece of land granted by the favoured policies, and many poorly qualified manufacturers attempted to produce wind turbines. As a result, even in the small city of Weihai, there are three turbine manufacturing enterprises now. Businesses supplying turbines can be found in even a small city such as Rongcheng. Currently the company has only two sample units installed in Inner Mongolia as a pilot, and more than 20 turbines waiting in the warehouse for purchase. This is an unhealthy dynamic and a waste of resources. In theory, R & D activities should correspond to the sales volumes of Chinese manufacturers and FDI received. According

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[235] See general Slavo Radosevic, *International Technology Transfer and Catch-up in Economic Development* (Edward Elgar Publishing 1999); Sharmila Vishwasrao, 'Royalties vs. Fees: How do Firms Pay for Foreign Technology?' (2007) 25 International Journal of Industrial Organization 741; João Leitão and Rui Baptista, 'Inward FDI and ICT: Are They a Joint Technological Driver of Entrepreneurship?' (2011) 10 International Journal of Technology Transfer and Commercialisation 268.
[236] The V60-850 kW turbines tailor-made for wind farms located in China has even reached a localization rate of 90%.
[237] Figuiere (n 160).

to the interviewees, although the Chinese wind turbine suppliers currently have the majority of the market share, the most advanced components for 3 MW and higher wind turbines cannot be manufactured in China. Chinese wind turbine manufactures, even the sales leaders Sinovel and Gold Wind, rely on licences to assembly core components such as the rotor and gearbox that are imported from the US[238] and Germany.[239] More than half of the existing Chinese turbine manufacturers are still heavily dependent on assembling under licences from foreign manufacturers.[240] Production of these factories is mainly "supporting systems that account for a small proportion of the total costs of the entire wind turbine."[241]

The indigenous companies: Xiangtan Electric,[242] Sany,[243] and Envision,[244] on the other hand, have better technology capabilities because they used to be large heavy machinery and power-generation equipment manufacturers. As such, they have a certain experience of electricity generator engineering and a base point from which to conduct further R & D activities. For example, Envision, which has set up "R & D centres in Denmark, China, Japan and the US, as well as collaboration centres at a number of Chinese universities", endeavours to independently develop turbine design.[245] With stronger imitation and reverse-engineering ability, these Chinese manufacturers intend to develop wind turbine design as a whole. Therefore, they tend to collaborate with licence issuers or other manufacturers to carry out

238 The California based company: Wintec Energy.
239 The German company: Repower System AG.
240 Watson and others (n 2).
241 Jingyi Han et.al, (n 204).
242 Xiangtan Electric Manufacturing Group, Dongfang Turbine Co. Ltd.
243 The company's name in Chinese is "三一电气风电投资公司".
244 The company's name in Chinese is "远景能源".
245 see Appendix A for details Gosens and Lu, (n 86) p.301–318.

collaborative research.[246] These firms are very likely to become powerful competitors to the current technology owners, although not yet.

Despite R & D growth among Chinese entities, there are still notable gaps between these domestic manufacturers and the international industry leaders. For example, although the Xiangtan Electric has long-term experience of power machinery production, they are still lacking the capability of building a high-quality generator for wind power. These generators are specially required for low frequency (10–20 rpm) which is unfamiliar to Xiangtan Electric who used to provide ones designed for thermal power plants, which are high-frequency generators (3000 rpm). Additionally, many affiliated facilities are required and these new turbine manufacturers, in a weaker market position, find it harder to profit from sales. Regarding Xiangtan Electric, although it rang up more than 10 billion Yuans in yearly sales, its net profit is only tens of millions per year. To narrow these gaps as soon as possible some Chinese firms are trying a new modality of TT, namely company acquisition: purchasing foreign firms to get their IPR. For example, Goldwind has acquired the German company Vensys Energy AG to strengthen its R & D abilities.[247]

Such short cuts to improving R & D are more evident in the Chinese biomass energy sector. The majority of the approved CDM biomass projects are initiated by Guoneng.[248] As early as 2003, the president of Guoneng began to investigate biomass energy technology in Denmark in order to introduce biomass power generation project to the Chinese market. After a month

[246] "For example, Sinovel and Windtec co-designed 3 MW offshore wind turbines for the Shanghai Donghai Bridge offshore projects, and Mingyang and Aerodyn co-designed Super Compact Drive 3 MW turbines. Collaborative R & D is more effective in technology transfer because of the intensive exchanges it demands during the process". Watson and others (n 2).
[247] Ibid (n 2).
[248] National Bio Energy Co. Ltd.

of on-the-spot investigation in Denmark, Guoneng decided to introduce biomass boiler technology from BWE, one of the most reputable companies in the area. Some core parts were imported with royalties also paid to BWE, and Jinan Boiler Group Co. Ltd was contracted to assemble and install boilers. Each boiler was then sold for 60 million Yuan, 1.5 times higher than a domestic boiler, which was remarkably expensive at the time. Thirty per cent of the sale price was paid for the license, accounting for presumably half of the profits. Even so, due to encouraging policies on renewable energy projects and financial support from international resources, such as the CDM, Guoneng has developed rapidly in both capital and operational strength. Although taking a limited share of the profits, five years later in 2008, Guoneng's sister company LoonG was able to acquire another equally qualified Demark biomass boiler company – Bioener. In the first stage, LoonG acquired a full set of biomass furnace technology, introduced through licensing, and soon after LoonG convinced Bioener to export some core technology engineers to work in China and enticed these employees with stock shares in the Chinese enterprise. Using the opportunity of the global recession in 2008, LoonG acquired Bioener, thereby all succeeding installed boilers in Guoneng projects became indigenously produced. Until this acquisition, China, at least one Chinese firm, has updated its technology to the most advanced level.[249]

6.5.3 Transfer of know-how

Undeniably, the role China is now playing in the global renewable energy market cannot be underestimated, particularly in the solar power sector and the biomass energy sector where it has acquired advanced international manufacturing companies, fully absorbing the

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249 Summary of the interviews conducted in all biomass projects.

technology and innovation for its large domestic market. Except for Chinese firms' proactive efforts, TT to China, especially in less tangible forms, is rather immature at present. For example, most of our interviewees[250] were sceptical about the operational performance of wind turbines produced domestically and acknowledged that "the quality gap between these indigenous equipment and imported turbines are significant."[251] Moreover, in comparison with the global market leaders, such as Vestas, GE, and Siemens, the Chinese manufacturers are weaker when it comes to independent technology and innovation, because they have rather lower patent registration numbers in this area of technology and use less state-of-the-art technology in their turbine models.[252] Such deficiencies are due to a shorter history of turbine design in China, something which would have built a solid foundation of know-how on top of patents.

Know-how is of vital importance even when a patent licence has been acquired. Although the patented technology is supposed to be repeatable under defined experimental conditions, the environment, skills of workers and raw materials used by another experimenter will be different during processing. Therefore, without technical know-how, results may not be ideal. TT even fails completely in some extreme cases. Also, many experienced foreign manufacturers are strict with operational requirements, ranging from temperature control to environment and quality control. For example, in alloy production, a minor difference in raw materials will lead to varying amounts of impurities in the alloy and the ceramic powder made from them. In turn, entirely different products could have been made with the same formula.

[250] Participants from two of the wind projects indicate this. Yet interviewees from the one established in Wulian expressed that it is acceptable for the Chinese companies are only new to the wind turbine manufacturing industry and one shall have faith in their future improvement.
[251] Interviewee with technician recruited from Shandong Weihai 69 MW Wind Power Project.
[252] Gosens and Lu (n 86).

As a result, products based on patented formula licensing, even using imported source materials, could have a low pass rate under quality assurance requirements. Abundant details and possible variables could be beyond the imagination of Chinese manufacturers. Experience and assistance from foreign experts are thus an indispensable part of a successful TT. Information regarding the construction of the production line, process control, personnel training, product testing and so on, is crucial to achieving the acceptable performance of finished products at a better-qualified rate. Interviewees[253] implied that some highly advanced technologies require particular precision while others need less. For example, the alloys used in aircraft engines are designed with extreme accuracy; such technology is simply impossible to acquire without essential know-how being transferred. In comparison, the same alloy if used to build human joints does not require the same degree of precision in its formulation. For highly fine and sensitive technologies, it is almost impossible to commercialize them through reverse-engineering.

In the field of renewable energy, technology directors sent from foreign manufacturers have played a prominent role during the construction of wind farms in China.[254] These experts introduced detailed technical standard operational procedures meticulously, even down to trivial minutiae such as the driving route of the cranes hired. In the beginning, many domestic wind farms did not use this production method and had inflexible ways of doing things. But later experience proved the significance of such know-how when properly applied and how it ensured the performance of equipment during operation with better safety and stability

[253] Interviews with a R&D staff from a world leading wind turbine manufacturer and technical director of the Provincial power grid.
[254] Especially indicated by a managerial interviewee from the Animal Manure Management System (AMMS) GHG Mitigation Project.

during operations. In fact, the failure rate of these imported power generators is relatively low and requires only a regular maintenance shutdown every 2,000 hours. Such stable operation performance provided the wind farms with complete control over production.

In the biomass power sector, a project[255] that employs a biogas power generation methodology has chosen German generators (now acquired by GE). Danish experts recommended by the CDM investor provided information, including the screening of raw materials; a series of quality control tests and so on; together with strict operational standards. As a result, this imported device can provide 8,000 stable full-load hours per year. Compared with other Chinese biomass power plants using domestic equipment, such operational performance is peerless. Eventually, the biomass power plant established a specialized team comprised of Chinese nationals, including maintenance, operator, management, and technology staff, which enables them to run well, independently, and to be capable of innovating and patenting. The technical director of the company revealed that she was sceptical and at first hesitated about introducing a lot of monitoring devices recommended by the experts but eventually she and her team were convinced of the necessity for this equipment in keeping them informed of the running status of their company. Although technology know-how was sometimes considered to be expensive and unnecessary, it is now getting more attention by the Chinese for the value it has on long-term operation and efficiency improvements.

Another example that reflects the importance of know-how is found in the areas of installation and customer service. Interviewees tell of how the "quality difference between

[255] The Animal Manure Management System (AMMS) GHG Mitigation Project.

imported turbines and domestic ones made under license is considerable."[256] For example, a common gearbox failure was discovered in the first batch of wind turbines produced by Goldwind after a few years of putting them in operation. Many wind farms throughout the country were queuing for repairs and it took more than half a year to get it fixed. Shanghai Electric began to develop turbines relatively later than the other Chinese manufacturers and it purchased foreign gearboxes. However, they cleaned the gearbox two times instead of five times as required by the foreign supplier before installation, resulting in an oil leakage which held up the operation of the wind farm. In contrast, the Danish company Vestas accumulated a substantial amount of know-how. As part of its presale service, Vestas demanded that it undertake a micro-site selection for the wind farms. Even though some Chinese buyers prefer conducting the work by themselves, Vestas insisted on doing so in order to ensure proper turbine performance during operation. Site selection demands a lot of experience and knowledge in the area. For example, some operators had installed a turbine at the edge of the cliff expecting better wind resources, whereas the up-flow winds at the cliff-edge affect turbine blades that are designed to cope only with parallel air flow. The lack of such services provided by Chinese wind turbine manufacturers resulted in higher failure rate.

The transfer of know-how is generally insufficient, at least partly due to a less established legal environment to protect and encourage such TT. There are several different versions of know-how interpretation in the Chinese context. The term can be understood together with many other concepts such as "technical secret," "trade secret," "industrial and commercial secret," "proprietary technology," "non-patent technology," and so forth; and sometimes

[256] interview with manager participated in the Shandong Haiyang Qiuershan Wind Power Project, and similar opinion can be found in interviews with management group interviewees from all three wind projects.

these terms are interchangeable. Most scholars use the term "proprietary technology" as a substitute for know-how. While “know-how,” "trade secrets," "proprietary technology" and "non-patent technology" are all used in legal texts as general concepts of law, the Chinese laws and regulations interpret these concepts differently, with various legal effects. Article 10 of the Chinese Countering Unfair Competition Law[257] defines a trade secret as:

> technical information and operational information which is not known to the public, which is capable of bringing economic benefits to the owners of the rights, which has practical applicability and which the owners of the rights have taken measures to keep secret.

Meanwhile the Regulations on Administration of Technology Import Contracts[258] uses “proprietary technology” and defines it as technology that is “provided in the forms of drawings, technical data, technical specifications, etc., such as technological processes, formulae, product designs, quality control and management skills”; and the Detailed Rules for the Implementation of the Regulations on Administration of Technology Import Contracts[259] interprets know-how as “technical knowledge for manufacturing a product or applying a technology as well as for product designs, technological processes, formulae, quality control and management, which is neither publicized nor under legal protection of industrial property rights.” These overlapping and broadly worded definitions all touch upon the connotations of the term know-how, however, making the use of the term rather confusing. Know-how is not

[257] Leitão and Baptista (n 235).
[258] Anti Unfair Competition Law of the P.R.C. (Adopted by the Third Session of the Standing Committee of the Eighth National People's Congress On September 2nd, 1993) article 2.
[259] Regulations of The People's Republic of China on Administration of Technology-Introduction Contracts (Promulgated by the State Council on May 24, 1985).

yet a well-established legal term, for it is a rather intangible estate and still vaguely stipulated by the current Chinese law. Therefore, in most cases, know-how is only successfully transferred to Chinese firms, voluntarily and proactively,[260] by more experienced companies, properly shielded under the legal system. Such ambiguity makes know-how transfers difficult to assess and therefore harder to pursue during litigation when there is a know-how leakage; and this deters transferors. Although nowadays foreign renewable technology pioneers have to compromise in order to business with Chinese buyers,[261] they are still capable of getting potential partners to the negotiating table for they have demonstrated strong control over credible technologies that require specific know-how to be fully actualized. Technology holders are usually able to find key factors and provide solutions in niche areas which enable local licensees to manufacture products efficiently. Indeed, a large part the secret of success in operations is linked to know-how related to implementing or using the technology.[262]

Despite in cases where know-how transfer seems successful (e.g. the biomass furnace company acquisition), the improvement of China's domestic absorptive capacity in general is inadequate in facilitating TT at large.[263] Even, in the renewable energy sector, sufficient support to fully absorb the most advanced technologies has not been developed. A detailed discussion of the technology absorptive capability in China is included in Annex III of this thesis.

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[260] Indeed, that some of the 'know-how' regarding the maintaining and operating the equipment would be stipulated in the TT contract, and that the transferor would be paid for 'services' such as Vestas' pre-site selection. when the transferor offered to do this, there would be less problem with the licensed product. However it is clear that the licence did not include the manufacturing of wind turbine. This would be subject to negotiation individually in each contract between a foreign manufacturer and a Chinese competitor, which is not covered in this thesis. Nevertheless, interviewees recruited by this research are the customer of these Chinese manufacturer as well, and their experience of using the end product provided by Chinese manufacturers reflect the lack of know-how transferred to that equipment making firms.

[261] Interview with manager from the Shandong Wulian Dongfeng Phase I Wind Power Project

[262] The Development Solutions and the European Chamber (n 163).

[263] Haščič and JohnstoneI (n 200).

6.5.4 IP litigation

With an increased register rate of patents and a series of reformed laws to protect IP, in theory it should be easier and more predictable for foreign investors to seek remedies through litigation in China. Sepetys and Cox note that "from 2001(the year that China signed TRIPS) to 2008, there was a 50% annual increase in the number of IPR court cases involving foreign firms in China."[264] In general, the number of patent infringement cases accepted by the People's Courts has increased significantly from 2006 (less than 3,000) to 2015 (more than 10,000).[265] An aspiring trend of IP litigation in China is also seen from the late 2000s because the value of damages awarded by the courts has become more predictable as the outcome of an IPR lawsuit is easier to be estimated by foreign companies.[266] However, the amount of compensation in IPR cases still tends to be low and therefore it is argued that low damages fail to significantly deter infringers.[267] Sepetys and Cox also identify a median value of damages awarded for IPR infringement related cases in China in 2006 and 2007 was close to $15,000 (around 11,600 Pounds),[268] which is about only 15 per cent of damages claimed by plaintiffs.[269] Nevertheless, a positive phenomenon for foreign investors is that foreign patent plaintiffs have a 75 per cent win rate against Chinese defendants versus a 63 per cent win rate for domestic plaintiffs.[270] And in the cases with foreign plaintiffs, damages awarded are 28

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[264] Kristina Sepetys and Alan Cox, 'Intellectual Property Rights Protection in China: Trends in Litigation and Economic Damages' NERA EcoNoMIc CONSULTING (2009) <http://www.nera.com/extimage /PUB IPR ProtectionChina_0109_final.pdf.> .
[265] Conor Stuart, 'Recent Trends in Patent Litigation in China' (*NAIP Portal*, 26th May, 2017) <http://en.naipo.com/Portals/0/web_en/Knowledge_Center/Feature/IPNE_170526_0703.htm> accessed Mar 2017; See also Weinian Hu, *International Patent Rights Harmonization: The Case of China* (Routledge Taylor and Francis Group 2017); Chiu and Fisher (n 169).
[266] Sepetys and Cox, (n 264) p.6.
[267] Ibid p.6.
[268] Ibid p.8.
[269] Ibid p.8.
[270] Chiu and Fisher (n 169).

per cent higher than the figure for cases with Chinese plaintiffs.[271] This might due to the fact that foreign firms are more inclined to pursue litigation and the have more experience in such lawsuits which is useful in winning IPR cases.[272] Such reault from these researchers challenges the widely held view that China practises protectionism.

From the statistics of IP litigation, it is clear that the IP law reforms that China undertook in preparation to accede to the WTO have encouraged the use of IP litigation in both foreign and domestic firms. However, laws and reforms have had a rather muted impact compared with the political force of the Chinese government on every important issue. Therefore, their contribution to facilitating TT and promoting technology development in the country is relatively insignificant. Especially in the renewable energy sector, so far relatively little patent litigation is seen compared to more mature sectors such as the software and mobile phone industry.[273] At present, intense competition mainly exists between companies in developed countries. For example, the titans of the wind energy market are already well underway, and a patent battle is seen in patent lawsuits such as the ones brought by GE against the Vestas.[274] Competition between Chinese domestic and foreign companies in the renewable energy market is not as fierce. But as the market expands and the allure of profits increases, companies will become more aggressive in business and arm themselves with large patent portfolios to grow market share or revenues. The AMSC (US) vs. Sinovel Wind group[275]

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271 Sepetys and Cox (n 264) p.13.
272 Ibid p.4.
273 Rodger Sadler and others, ‘Plan Your Clean Energy IP Strategy’ [2010] No 202 Managing Intell Prop 48. This article provides tips for companies seeking to enter the market in this increasingly essential sector.
274 See discussion in Chapter V. In 2008, “GE brought suit against Vestas in a U.S. District Court, alleging that Vestas is infringing on the 705 patent, which governs GE’s intellectual property pertaining to zero-voltage ride through.” Dan Shreve, ‘GE’s Patent Lawsuit Against Vestas Raises the Stakes for America’s Wind Industry’ (7th August, 2017) <https://www.greentechmedia.com/articles/read/ge-sets-its-sites-on-vestas-in-latest-ip-infringement-battle> accessed July, 2017.
275 The Beijing First Intermediate People's Court 2011. Case cited in Chinese: 美国超导公司、美国超导 WINDTEC 有限责任公司、苏州美恩超导有限公司与华锐风电科技（集团）股份有限公司、苏丽营、辛理夫、赵海春侵害商业秘密纠纷一案

(China) case is one example of the trend. Cooperation between the two companies began in 2005, with AMSC providing Sinovel with central control components, software, and design for turbine manufacturing. In June 2011, after the discovery of the theft of IP, AMSC pursued law enforcement authorities in Europe and carried out investigations against its business partner.[276] In 2011, AMSC launched several cases against Sinovel, seeking a total of over 1.2 billion US dollars of the contract breach and damages.[277] On the other hand, Chinese entities are learning to protect their indigenous IP in order to gradually secure competitiveness in the future. For example, in the China Environmental Project Tech, Inc. vs. Fujikasui Engineering Co. Ltd. case,[278] more than 7.4 million dollars were awarded to the Chinese holder against a Japanese water treatment company and a Chinese power plant. The disputed patented technology is for reducing sulphur-dioxide emissions in electrical power generation.[279]

In more extreme circumstances, a patent can be used as a weapon in competition. Technology owners can file applications maliciously. Such actions could harm another competitor or even harm the innovative environment for the whole industry. Some studies show that more than 50 per cent of foreign innovators with patents filed with China State IPO have the sole intention of suing their Chinese competitors for patent infringement.[280] Some industry

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(American Superconductor WINDTEC Co., Ltd., Suzhou Meen Superconductor Co., Ltd. sue Sinovel Wind Power Technology (Group) Co., Ltd., Su Liying, Xin Lifu, Zhao Haichun infringement of trade secret dispute)

[276] In 2008, a supply contract were signed between AMSC and Sinovel with the former providing core parts that will be incorporated in Sinovel's wind turbine of SL1500 and SL3000 model. However, Sinovel stopped paying AMSC claimed that it has provided unqualified products required by the contract. Later, AMSC brought a serious of lawsuit against Sinovel asking for a compensation of about 0.5 billion Chinese Yuan. In front of the Beijing First Intermediate People's Court in 2011, AMSC claimed that Sinovel has "violated the multi-year supply agreement under which AMSC provided Sinovel with electrical components for its wind turbines." Leslie Hook, 'AMSC to sue Sinovel in Beijing court' (Financial Times, 4th November, 2011) <https://www.ft.com/content/b5e190c8-05db-11e1-a079-00144feabdc0> accessed July 2017. The court supported the claims by AMSC of 37,800,000 Yuan. And the Sinovel has appealed to the Chinese Supreme court which has made a final rule maintaining the civil ruling of the Beijing First Intermediate People's Court.

[277] AMSC, 'AMSC Launched Several Litigations Against Sinovel' (http://www.amsc.com, 2014) <http://www.amsc.com/sinovel/index_chinese.html> accessed Feburary 2017.

[278] China, Fujian High Court, 2008.

[279] Sadler and others (n 273).

[280] Prud'homme (n 178).

leaders with large patent portfolios particularly enjoy employing this kind of legal but aggressive patent strategy. GE, the largest turbine maker in the US, holding 36 per cent of high-relevance US wind patents and which has filed more than 900 wind patents globally "is adept at 'bracketing off' key technology by developing multi-patent 'fences' around those technologies."[281] This approach can prevent competitors from developing their own technologies in order to protect the core status held by GE with its exclusively advanced IP and technologies. For example, GE intentionally bought a broad and costly technology to circumvent a patent – the 039 variable-speed patent[282] covering vital technology needed for wind turbine manufacturing, to serve its patent strategy. It was actually used to sue Mitsubishi Heavy Industries (MHI) in 2008 for alleged infringement by MHI's flagship 2.4 MW turbine. Such a "blocking patent" clearly consolidated GE's share of the wind market and could be crucial in reshaping the US or even the international wind industry.[283] With other less important technologies, it is still worth filing according to the above patent strategy. Especially in China, given the cheaper and easier procedure available for utility models application than invention patents, it is even more convenient for foreign technology holders to apply for these types of patents when they intend to conduct malicious prosecution actions in China's renewable energy market.[284]

In fact, the trump card of pursuing patent litigation is less used in practice. From a manufacturer's perspective, in recent years, a complaint to the suspect company or the relevant administrative authorities followed by reaching a settlement through negotiations is

[281] Davidson (n 201).
[282] Expired in February 2011.
[283] Davidson (n 201).
[284] Prud'homme (n 178).

usually more efficient in business, avoiding the expense and burden of a trial and the risks to future cooperation opportunities with Chinese companies.[285] The judicial path usually takes a longer period of approximately two years and results in unsatisfactory compensation rates as discussed earlier. The whole process is very complex and requires careful planning under the assistance of a patent lawyer and local agents.[286] Moreover, pursuit of the payment of royalties or IP infringement compensation through litigation requires careful investigation to demonstrate that the technology at stake is covered by a registered patent owned by another. In practice, it is often difficult, as many infringers and imitators will not declare that their equipment contains patented technologies. For example, according to the interviewees, a Chinese biomass boiler manufacturer has been in production using technology reverse-engineered from an imported BWE boiler. Products made by this company were also presented in tenders for biomass energy projects established in Shandong. One of the most critical technologies employed by BWE is a specialized "mechanical grating furnace grate" technology which was not acquired by the Chinese at the time. As this technology was already in the public domain, getting the technology by reverse engineering does not constitute an infringement. Also there is a "seal technology" and an "exhaust purification technology" that are still protected by patents.[287] Technically, as long as the Chinese boiler is proven to meet certain exhaust standards, and its combustion efficiency reaches the level equal to that of the patented technology, the existence of infringement is suspected. However, this Chinese manufacturer never disclosed these test result during tender or in all of its advertisements.

[285] The Development Solutions and the European Chamber (n 163).
[286] Delegation of the European Union to China and Euraxess Links China, 'IPR in China: Guidance for Researchers' (2014) <https://ec.europa.eu/research/iscp/pdf/sfic/ipr-in-china-guidelines_en.pdf> .
[287] Interview with technical staff from Shandong Electric Power Group Corp.

Therefore, it is difficult for BWE to provide definite proof to support the claim. Consequently, many cases are settled through negotiation and mediation. And the owners are less able to recoup their investment.[288] Therefore, when litigation is not absolutely necessary, a valid IP holder is not inclined to resort to courts in order to enforce his IP rights. Instead, a threat to sue could work better in reaching a settlement between parties in a conflict.

All in all, while the dispute settlement measures in China are tailored to fit TRIPS standards and the litigation route is more available for foreign technology owners to protect their intellectual possessions, the judicial method itself is still deterring IP holders in pursuing it in practice. Less formal steps, such as negotiation and mediation are considered to be the first choice to the technology owners because these are a part of Chinese business conventions. In fact, "not all infringement is deliberate, and not all infringers are aware of the gravity of what they are doing." [289] It might be due to a cultural misunderstanding or the lack of correct knowledge about IPRs in China. Without proper consideration of the status quo in China, many IPR cases are actually solved through informal dispute resolution after finally going to court.

6.5.6 IP understanding and education

Another factor that indirectly determines the law in action is how people understand and respect knowledge-based rights. It is important to note that this impact will take years because the digestion of IP obligations is to be phased in over time. In that case, the long-term effect of IP law in China will depend on the level of "IP education" in the country.

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[288] The Development Solutions and the European Chamber (n 163).
[289] Delegation of the European Union to China and Euraxess Links China (n 286).

It is undeniable that China's IPR standards have improved to an international level despite some defects in the reformed IP laws. Meanwhile, a change in the perception of China becomes evident in results of surveys such as the 2010 survey by the US-China Business Council, in which a majority of participants felt an improvement in China's IP enforcement.[290] But the degree to which Chinese practitioners understand IPRs and the way they handle IP has lagged behind those improvements, with many people still regarding IP theft and staff poaching as inevitable.[291] A disagreement between developed countries and China over IPR protections is basically focused on the enforcement of TRIPS standardized IP laws. However, such a seemingly simple issue is differentiated by multiple cultural aspects such as political, economic, and historical incompatibilities, which have acquiesced in the underlying incentives for IP infringement.[292] For example, the Chinese understand IP under a culture of collectivism, and by instinct put more value on dedication than individual rights. This cultural/social background has resulted in legal challenges for a foreign company doing business with China. China's accession to the WTO has resulted in a series of amendments made to the IP law and relative law regarding trade, "but even today it is common to see technology being stolen either by the employees of the outsourced firm in China or by a Chinese competitor in the country."[293] To Chinese entities, market place is a field to battle. Therefore in general, the copycat culture is a weak legal pitfall but considered in Chinese society as an acceptable or tacit business strategy. To some extent, the Confucian philosophy is adopted predominately in China's society and such cultural background encourages

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[290] Says Simon Zhang, the Shanghai-based head of clean tech at Inter-China Consulting. Quoted by Davidson (n 201).

[291] this is especially indicated by the manager interviewees however none of my interviewees from the legal department expressed this way.

[292] Steven P. Feldman, *Trouble in the Middle: American-Chinese Business Relations, Culture, Conflict, and Ethics* (Routledge 2013).

[293] Karthik Jayaraman, 'Doing business in China: A risk analysis' (2009) 1 Journal of Emerging Knowledge on Emerging Markets.

individuals to dedicate any invention to the society with respect to the community's harmony and development. Consequently, such culture has made China the world's biggest counterfeit products maker in the world.[294] The vague wordings of the Chinese laws, which may also attribute to the Confucius way of understanding IP, leave plenty of room to interpret provisions with Chinese characteristics.[295] Thus there is a fear that this will allow manipulation of the law by lawyers against foreign companies.[296] The Confucian ideology values the "rule of man" more than the "rule of law." Hence some patent infringers see patent violations as "part of the greater good for the country as they copy Western [technologies] and sell them at affordable prices to Chinese [companies]."[297] Foreign companies are normally aware of the situation in China when they decide to outsource manufacturing or investing in the country, especially when there is a costly developed technology at stake. One way of preventing these legal challenges is to have a strong connection with the local social society, even so avoid outsourcing critical technologies to China might be the approach of lowest risk. From this point of view, the Chinese way of conditioning business is victimizing its own market by deterring foreign business partners.[298]

On the other hand, "the economic argument for IPR is not cut and dried. A balance is always required between the motivated entrepreneur and his access to public information.

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[294] H. Chee and C. West, *Myths about doing business in China* (Palgrave Macmillan UK 2007).
[295] For example, the Regulations of The People's Republic of China on Administration of Technology-Introduction Contracts (Promulgated by the State Council on May 24, 1985) uses the wording of "The relevant units" in describing the agent that will be in charge of administrative and implementation issues regarding technology import contracts. However, it does not point out which agent in particular has the authority. Therefore, there remains great uncertainty in the result of an application of import contract. Such wording is an evidence proving that the government retains great power representing the collective interests of the society.
[296] Doing business in China: Accessing the Chinese business environment for Norwegian enterprises - Masters Thesis at BI - GRA 69971, Hedvig Grande Estensen, 2007, quoted by Jayaraman (n 293).
[297] Ibid (n 293).
[298] Feldman (n 292).

Reasonable people can disagree as to where exactly the line should be drawn."[299] Therefore, judgement cannot be made on a developed country standard condemning failure in IP enforcement in China. One country should have its own standard valuing IP and its enforcement. Moreover, China, as a latecomer in the technology development ranks, has seen the history of how other precedent countries have behaved during their developing stage. Virtually all developing countries and developed countries when they were in their growing phase, tended to be IPR violators. As well as the US, more recent cases such as in Taiwan, Singapore, and South Korea have demonstrated a "grey technology development" in history,[300] where infringements of different degrees are considered to be a common phenomenon. And now in China, according to the observation of the interviewees, "infringement is unavoidable and necessary in getting new techs."[301] Such behaviour is especially common among Chinese renewable energy generator manufacturers. One of my interviewees even indicates that some biomass boiler companies have been using technologies without a licence from the owners of the IP for the first few years of production.[302] Some interviewees[303] believe that developing countries will never be able to compete with the developed nation competitors in most areas of IP if they follow such unaccommodating international accords created by developed countries in the first place. Conversely, in this research, most interviewees also showed respect for the importance of IPRs as a general legal concept, especially the lawyers. The managers, when asked directly

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299 Ibid.

300 Mike W. Peng and others, 'An institution-based view of global IPR History' (2017) Journal of International Business Studies 1, states that the history of IPR development in the US is also the history of the country turning from a leading violator to a leading advocate of IPR.

301 Manager interviewee from the Shandong Wulian Dongfeng Phase I Wind Power Project

302 Technician interviewee from the Shandong Shanxian 1x25MW Biomass Power Plant Project

303 Manager interviewee from the Shandong Wulian Dongfeng Phase I Wind Power Project and manager interviewee from the Shandong Haiyang Qiuershan Wind Power Project

about their opinion towards IPR also provided positive answers by trying to demonstrate that they are not associated with IP infringement, which I assume is true because no IP litigation was discovered regarding these companies. Such contradictions indicate a double-standard in the understanding of IPRs among businessman, depending on the role they are looking at for themselves: transferor or transferee.

Nevertheless, as the companies visited are in fact end-consumers of renewable energy technology, they are discharged from paying royalties. Thus they are less at risk of being sued by the transferor through IP litigation. But except for the less possible infringing behaviour by reverse-engineering, a more frequently mentioned act that is suspected to be an infringement is staff poaching. Interviewees [304] indicate that poaching staff from more technology-advanced companies happens not only with equipment manufacturers but also end-users. Those employees specialized in the most in-demand areas are often attracted by competitors promising vastly inflated salaries to lure them away. An interviewee[305] talked of such rife and unscrupulous recruitment in a dispassionate manner, reflecting how regular such headhunting and poaching is in everyday practice. For example, in AMSC vs. Sinovel technology Ltd. ("Sinovel") case,[306] there was enough evidence found to confirm that the former employees of AMSC have been revealing confidential information to Sinovel which constituted the crime of commercial espionage and the misuse of data. There were even illegal contracts signed between Sinovel and employees of AMSC along with relevant chat records and e-mails disclosing IP information given to Sinovel which was applied to a turbine

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304 Interview with manager and technician participants from Shandong Wulian Dongfeng Phase I Wind Power Project and interview with technical director from the Provitial Grid.
305 Interview with R & D staff recruited from a world leading wind turbine manufacturer.
306 AMSC (n 277).

designed by the company later on. A more straightforward example is found in this thesis.[307] At the initial stage of wind power development in China, most turbines installed were imported. In those years, wind farms were not only burdened by equipment purchasing but also spending a lot on maintaining the equipment. As the imported replacements were priced excessively high, wind farms would consider staff poaching when the warranties expired as the easiest way to discover authentic channels for getting cheaper components is from information revealed by former employees of the leading turbine makers. As buyers, these wind farms were acting fearlessly when threatened by IP litigation raised by sellers regarding staff poaching, because they could use a refusal to purchase in the future as a tool to deter turbine sellers from suing them. Emerging domestic turbine manufacturers were doing the same more discreetly and secretly at the time. Gradually, as larger Chinese companies such as Goldwind became more mature, the smaller start-up manufacturers in China began to recruit staff from these Chinese domestic turbine makers. Such a problem results from many factors combined, such as the absence of a non-competition clause in the employment contract and a disadvantageous position occupied by turbine manufacturers in the "buyer's market" in recent years. Even so, none of the interviewed power stations have an independent legal department or an in-house lawyer. Legal issues including IP-relevant factors are dealt with by their parent companies, and minor disputes such as conflicts between the company and local residents during construction are resolved under the guidance of external law firms.[308] This indicates that legal issues regarding IP infringement are rarely faced by power generation

[307] evidence provided by manager and technician interviewees recruited from the three wind projects. In order to protect the interviewee for releasing such sensitive information, I will not give the project name to indicate any particular interviewee.
[308] For example, when one of the biomass project was under construction, residents nearby claimed compensation on potential effect of the local environment. Agreements were signed between the company and more than 1000 residents with approximately 500,000 Yuan paid in total to settle the dispute. Interviews with participants from the Animal Manure Management System (AMMS) GHG Mitigation Project.

plants, and behaviours in terms of staff poaching are not taken seriously as they are in fact offending legitimate interests of others. This might be subtle at this stage where China's technology absorptive capability and independent technology development ability is limited, but it could be a hidden peril to China's future technology improvements when the country becomes more of a technology provider, if it does not evolve a better culturally adapted regime to deal with the issue.

More than this, none of the interviewed companies knew much about TRIPS requirements and they know less about TRIPS flexibilities, such as compulsory licences. Even when explanations were provided about what a compulsory licence is, they showed little interest in it. Instead, some interviewee indicated their worries that such a method could break the "pleasant relationship between Chinese and foreign investors/transferors and may in turn harm future cooperation with them."[309] Such a fogeyish attitude is possibly ingrained in Chinese culture and therefore deep-seated in their way of thinking. The deeper reason maybe to do with issues of trying to see relationships with foreign firms simply in terms of traditional (non-government influenced) commercial arrangements; or there may simply not have been much time to understand the benefits of these provisions to the company or to China. But whatever the reason, it seems a bottom-up way of initiating compulsory licences is not yet suitable for Chinese firms, at least in the renewable energy equipment manufacturing sector.

6.6 Market factors versus IP protection

A subtle conclusion seems to be drawn from this discussion: with China having a set of world-class laws for IP protection on the books, IP holders were still concerned about its high

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[309] Interview with manager from Shandong Gaotang 30MW Biomass Power Generation Project.

IP-infringement rates.[310] At the same time, TT to China was insufficient to meet the increasing need for emission reduction technology in the country. Indeed, the reputation of IP protection in China was abominable. According to a report released by the US International Trade Commission,[311] China's piracy of American products cost the US over $300 billion in business. Moreover, the number could be even higher since the available data is inadequate in volume or scope. Developed countries such as the US censure how China fell short to ensure that IPR protection would produce real consequences because many technology owners might have lost faith and lost interest in investing in the country.[312] This indisputable failure of enforcement in China is a result of a fear of slowing economic growth by the Chinese government as well as the weak administrative and judicial systems in the country.[313] However, the majority of these infringements relate to consumer products and minor to business-to-business products. The complexity of the latter may make breaches of IP less significant. "Those wishing to encourage Chinese adherence to international standards and its own laws must come armed not only with institutional suggestions but also economic arguments"[314] based on evidence available in each specific sector.

It is unquestionable that IP is currently at the heart of today's renewables industry. Innovations are obviously neither freely shared publically nor easy to access. For example, in

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[310] Keith E. Maskus et. al (n 224).

[311] The Commission on the Theft of American Intellectual Property, *The IP Commission Report* (The National Bureau of Asian Research (May 2013), 2013).

[312] IBT Stuff Reporter, 'How Much Does the US Lose to China's Piracy? $48 Billion' (*International Business Times*, 18 May 2011) <http://www.ibtimes.com/how-much-does-us-lose-chinas-piracy-48-billion-644062> accessed Feburary 2017; See also Peter K. Yu, 'Piracy, Prejudice, and Perspectives: An Attempt to Use Shakespeare to Reconfigure the US-China Intellectual Property Debate' (2001) 19 BU Int'l LJ 1; see also Amanda S. Reid, 'Enforcement of Intellectual Property Rights in Developing Countries: China as a Case Study' (2003) 13 DePaul-LCA J Art & Ent L 63 (noting that it has also been calculated that U.S. businesses lose as much as $1.9 billion a year to copyright infringement in China alone).

[313] See Alexander C. Chen, 'Climbing the Great Wall: A Guide to Intellectual Property Enforcement in the People's Republic of China' (1997) 25 AIPLA QJ 1.

[314] Schiappacasse (n 69).

the wind industry the "major players like GE, Siemens and Vestas are spending millions of dollars building and maintaining IP portfolios to drive profit and gain the strategic upper hand."[315] This is to say that TT is no longer an act of charity from the IP owners but an investment decision made on risk and return calculations.[316] However, factors linked to the terms of return on investment in the Chinese renewable energy market are considered prior to TT, with equal or perhaps more importance, as changes in China's IP laws and enforcement occur. The relative size of the domestic market also matters because it determines the possible extent of revenue and therefore the possible extent of investment in R & D.[317] With a large population of 1.3 billion[318] and one of the world's highest economic growth rates,[319] the expansion of China's domestic market with high demand of goods and services should be ideal for any investor.[320] Also because of the growing need for sustainable technologies and the energy consumption required in China to produce the required volume of goods, big market opportunities are provided to foreign suppliers (especially renewable energy technology IP owners). In fact, the country is now one of the world's largest recipients of FDI.[321] China's focus on encouraging the growth in renewable energy sector provides a clear incentive for the pooling of related patents and follow-on innovations. For example, the country aims at installing thirty gig watts of wind power capacity by 2020, supplying thirteen to thirty million homes, necessitates equipment and facilitating infrastructure with larger

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[315] Davidson (n 201).
[316] Downey (n 50).
[317] Gosens and Lu (n 86).
[318] IBT Stuff Reporter (n 312).
[319] See Vikram Nehru, Aart Kraay and Xiaoqing Yu, *China 2020: Development Challenges in the New Century* (World Bank: PREM Sector Department (EASPR), 1997) (China's growth fell in 2000-2001 to about 7%, but compare China's high growth rate in the 1990s to other high growth countries like Taiwan at 6.3% and Singapore at 5.2%, or the US at1.5%); but see Joel R. Paul, 'Do International Trade Institutions Contribute to Economic Growth and Development' (2003) 44 Va J Int'l L 285 (notes that China's purported high growth rates have been challenged, leading to estimations of a -2% to 6% actual GDP).
[320] Taylor (n 52) p.159.
[321] Schiappacasse (n 69).

generating capacities.[322] Therefore, among wind farm projects, the landscape is going to feature large-scale turbines in order to generate more than 1,000 MW of electricity per project which will be sold to the grid.[323] Such a great business opportunity, created by the considerable amount of installation needed, reflects that the development model adopted by China is currently based on its economic scale rather than its technological advances.

The examination of anecdotal evidence and qualitative interviews in this research led us to conclude that concerns over IPR are not a significant barrier to renewable energy TT to China. As a matter of fact, IP holders ignored the undesirable IP environment, and insisted on business with the country. This suggests that profits from turnover will overcome IPR holders' fear of allowing Chinese companies to use their wares. Empirical evidence has also proved that the size of a domestic market determines the development of manufacturers from that country to a certain level,[324] which explains China's case well. High growth potentiality in China's renewable energy market and possible profit incentives for developed country companies to partner with Chinese companies could overcome potential barriers that poor IP protection can possibly created. Then again, one might ask: if access to IP is available under measures other than promising IP protection, i.e. generous market returns and the potential opportunities it generates, and inventors are paid accordingly sufficient, what is the point to abide by the onerous IP rules? Such question reflects that IP law improvement is not

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[322] Zhaohua Li, 'Cashing in on China's renewable energy boom – Alison Leung' (*China Digital Times*, July 14, 2006) <http://chinadigitaltimes.net/2006/07/cashing-in-on-chinas-renewable-energy-boom-alison-leung/> accessed Jul 2017, quoted by Federico Caprotti, 'China's Cleantech Landscape: The Renewable Energy Technology Paradox' (2008) 9 Sustainable Dev L & Pol'y 6.

[323] See, e.g., Caprotti (n 322).

[324] Marian Beise and Klaus Rennings, 'Lead Markets and Regulation: A Framework for Analyzing The International Diffusion of Environmental Innovations' (2005) 52 Ecological Economics 5; Joanna Lewis and Ryan Wiser, 'Fostering a Renewable Energy Technology Industry: An International Comparison of Wind Industry Policy Support Mechanisms' (2005) Lawrence Berkeley National Laboratory 1844.

functioning as a positive and effective TT facility as well as expected. As a result, ceaselessly complying with international IP standards would be devalued gradually and out of accord in the context of the climate change crisis.

China has been an exception in the generally proportionate relationship between the level of IP protection and the number of technologies transferred. For example, according to a US International Trade Commission survey,[325] many US firms reported "losses associated with IPR infringement in China, including losses in sales, profits, and licence and royalty fees, as well as damage to brand names and product reputation."[326] However, with protection of IPRs remaining difficult for companies entering the Chinese market, where access to government approvals can affect the patent licence and other forms of TT; where joint ventures are also common and often required,[327] China's growing demand for energy with the need for an increased share of renewable energy in recent decades, has become an irresistible temptation even so. As a result, a considerable amount of renewable energy TTs came into the Chinese market despite the above restrictions, and emissions in China declined in 2014 for the first time since 1999, registering a drop of around 130 Mt (1.5 per cent).[328] The promise of billions of customers and end-users has been a strong attraction for foreign business to invest in China, which inevitably involves some innovation-related information being transferred at the same time. There are high-tech transfers from foreign companies to Chinese firms as well, even though these are largely not the most ground-breaking types of technology,[329] neither

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325 The Commission on the Theft of American Intellectual Property (n 311).
326 United States International Trade Commission, *China: Effects of Intellectual Property Infringement and Indigenous Innovation Policies on the U.S. Economy* (Investigation No 332-519, USITC Publication 4226, May 2011).
327 Davidson (n 201).
328 International Energy Agency, *Energy and Climate Change* (World Energy Outlook Special Report, 2015).
329 Prud'homme (n 178).

are the majority of them TTs to China. But with the large scale of application and potential experimentation with new renewable energy technologies that they have developed, foreign IP holders are likely to increase patent filings in China. The expansion of China's energy industry sells itself to investors and raises their propensity to file patents in the country. The defaults on strong IP protection as the only incentive to TT may, therefore, "be offset by the market power of the industry to encourage [companies] introducing new technologies to China."[330] The weak impact of IP protection on promoting TT becomes apparent when compared with irresistible benefits from the Chinese market; it is seen as self-abnegation by developed countries such as the US government. While it is thought that China's laws have "not produced meaningful protection for American IP, nor is there evidence that substantial improvement is imminent,"[331] American government responses to Chinese IPR violations are restrained because it gains considerably from occupying a share of the Chinese market. This explains the silent tendency among developed country executives on IP issues in China. The fear of losing access to China's booming market necessitates them putting up with IP risks.[332]

On the contrary, excessive IP protection may abet the laziness of potential innovators to pursue more advanced technologies in a shorter period. According to an interviewee,[333] although a longer monopoly period is comforting, 20 years (the length of patent protection) without significant technology breakthrough would be a sign of waning in the relevant

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[330] A. G. Hu, 'Propensity to Patent, Competition, and China's Foreign Patenting Surge' (European Policy for Intellectual Property Conference, Bern, Switzerland) p.34. Hu provides evidence that "Chinese firms are more likely to imitate the technology of Japanese, Korean, and Taiwanese firms more so than German and US technology." This could be partly due to "Chinese firms are more of direct competitors with the aforementioned Asian countries, and at large one might suggest their technology is comparatively less advanced and fundamental in nature." (p.23) As a result it is easier for Chinese companies to fully absorb such technology if transferred to them.

[331] The Commission on the Theft of American Intellectual Property (n 311).

[332] Feldman (n 292).

[333] Interview with R & D staff of a world leading wind turbine maker.

company or even the industry. Thus, a modest slackening of IP protection might put some pressure on the innovators, stimulating technology development and shortening commercialization cycles. However, an alternative argument is that innovation would occur regardless. If there were lengthy IP protections, competitors would seek to make a more efficient version as this could take more market share in the future. Companies that sit on their patents tend not to survive in a world where innovation continues apace. This issue regarding the proper duration of IP protection should be looked at by future researchers from the perspective of both the transferor and the transferee, with supporting empirical evidence.

Other than the profit inducement, there naturally exists the growing need for low-cost manufacturing from the developed countries, which drives businesses to seek cheaper labour as well as raw materials from developing countries. This outsourcing of energy and labour leads to the hardship of Chinese workers looking for better paying jobs in large manufacturing companies. In return for work carried out in a tough environment with long working hours and few company benefits by the developing country's employees, people and firms in developed countries enjoy continuously falling prices of goods and products. From this perspective, the risk of IPR infringement that harms technology owners is less considered, for they too benefit from a less regulated market.[334] This dilemma is a good example showing the complex relationship between China and many other developed countries intending to invest in the country, as the market provides both positive and negative outcomes.[335] Thus, contradictory actions can be found in the developed countries' responses. For example,

[334] By introducing technology legally or illegal from abroad, the Chinese and other developing countries were able to incorporate these technologies to their indigenously produced products, which is with lower quality but a lot cheaper than the ones made in developed countries.
[335] Feldman (n 292).

although listed by the US Special 301 Report, China also received American support to join the WTO.[336] By joining the WTO, China is enjoying the most-favoured-nation treatment and other benefits required by the WTO from all member states, including the US. Reasonable precautions taken before entering the Chinese market are of course needed as they are with any market. Some developed country companies even indicate satisfaction with the current IP situation in China, claiming that the arrangements are sufficient. For example, in December 2012 Siemens established two joint ventures with Shanghai Electric Group and the representatives of the company stated that they felt well protected by the Chinese patent system.[337] It is likely that having compared the significant return on investment and the effect of IP law reform, it becomes evident to the investors that the former clearly outweighs the later.

The renewable energy market growth in China is also providing a breeding ground for the emerging climate change technology industry because it is a capacious environment in which to test and improve newly invented technologies and to accelerate the product commercialization cycle.[338] A more intensive competition for market share between indigenous and foreign companies will prevail over the negative effect of poor IPR protection and encourage manufacturers to innovate under increasing pressures, which will have a positive impact on the global expansion of climate-friendly technologies.[339] For example, many former monopoly foreign turbine enterprises like Vestas have to confront the crisis of

[336] Ibid.
[337] Davidson (n 201).
[338] Beise and Rennings (n 324); Jan Fagerberg, 'User-Producer Interaction, Learning and Comparative Advantage' (1995) 19 Cambridge Journal of Economics 243; Michael E. Porter, 'The Competitive Advantage of Nations' Free Press, Macmillan, New York 564.
[339] Interview with Provincial Power Grid technical director. And also indicated by the R & D staff from a world leading wind turbine manufacturer.

losing a dominant position in the Chinese market. This is generally due to huge price differences between imported turbines and the domestic ones.[340] A wind farm equipped with turbines all imported from overseas companies may need more than 1 billion Yuan (116 million Pounds) of investment flowing into the project. Such a difference is so palpable that it cannot be ignored by any investor. Before 2010, the Chinese wind turbine manufacturing industry was still in its infancy regarding quality, compared to the foreign leaders. Imported equipment had the great advantage of lower failure rates and higher full-load hour availability. However, with the rise of the domestic wind industry and improvements in its own technology, the gap has narrowed. The advantages of imported turbines are attenuating gradually and are obscured by the price advantage of domestic turbines over time. According to an interviewee,[341] back in 2008 the wind market was virtually a seller's market. Wind farms sometimes were not able to purchase from Vestas even when they had enough fund. This is because the annual production target of Vestas allows it to sell very limited number of turbines globally. Whenever they completed this sales target, the company refused to sell more, no matter how much money was offered by the buyers.[342] Also, Chinese energy companies were forced to accept many onerous and harsh clauses at that time because they were so keen to quickly establish a wind project supported by Chinese policies. Contracts included very specific terms describing working conditions that shall be provided for workers sent by Vestas.[343] While these conditions might seem onerous by Chinese standards they are

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[340] Information gathered from interviews with managers, CDM project managers from all three wind projects studied.

[341] Interview with manager from the Shandong Haiyang Qiuershan Wind Power Project.

[342] Interview with manager from the Shandong Haiyang Qiuershan Wind Power Project.

[343] Such as "employees sent by Vestas to the Chinese wind farms providing technical guidance on equipment installation, must be provided with well-conditioned accommodation (the best local hotel) with specific room temperature and high-speed broadband. A route between the hotel and the wind farm had to be selected according to a certain comfort level requested by the foreign employee and agreed in written forms. In addition, hourly wage was 800 Yuan (about 100 pounds) which was more than ten times higher than local technicians. Working daily hours was fixed for 10 hours, with a maximum two-hour extra shift paid at 1600 Yuan

not as burdening to European or US companies, and any staff employed from outside the country would expect limits on working hours and their accommodation to be paid for. But such terms were inconceivable to Chinese investors and were very difficult for them to comply with.

In contrast, a significant growth in the maturity of domestic equipment had made a great change, converting the entire renewable energy market into a buyer's market after 2010. For example, now whenever a component fails (even off-work times) these foreign manufacturers are willing to send maintenance personnel to quickly restore the operation of the wind farm.[344] It can be seen that promoting competition among upstream enterprises (turbine manufacturing) is significantly beneficial to the growth of downstream green production (energy generation plants) for it has released the new clean-energy project developers from difficulties caused by suppliers. On the other hand, with more investors encouraged to develop the renewable energy market, China will be able to provide a rather large domestic market with more advanced technology for end-users. These manufacturers and investors could improve the adaptability of both imported and independently developed technologies.

Moreover, innovation may be induced by demand conditions, i.e. when domestic users sufficiently scrutinize the technological quality of different (turbine) suppliers and select their supplier accordingly.[345] When IP holders are under continuous pressure to develop technology with a better cost/performance rate, with healthy rivalry, the whole industry will

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per hour. Overtime work cannot be arranged on Sundays in any occasion." Interview with manager from the Shandong Haiyang Qiuershan Wind Power Project.

344 Interview with manager from the Shandong Haiyang Qiuershan Wind Power Project and with manager from Shandong Weihai 69 MW Wind Power Project

345 Fagerberg (n 338); Porter (n 338).

evolve faster and foreign manufacturers could also benefit from the global knowledge growth. Therefore, in the context of a mutually benefitting relationship established between developed countries and China, an unchangeable one-fits-all international standard of IP protection is lopsided, especially in the embryonic stage of renewable energy conversion in China. As to the question of how much rights protection is actually needed to encourage innovation and how to value the innovator's rights against community rights, one should give full respect to the legitimate cultural and economic differences between countries, because "it is clear that the ethics of Chinese IPR infringement is a complex and multifaceted issue."[346] Indeed, even if the Chinese government is committed to curtailing infringement, it may not be able to fulfil the pledge without accepting certain harms to the country. The price could be a reduction in both employment and economic growth, and more perilous effects on the stability and sound development of the country.

6.7 Price of green technology

Based on the discussion above, the suspicion that unsatisfactory IP protection deters investment to China seems untenable. As a matter a fact, although foreign suppliers have little faith in Chinese IP protection, they are somehow used to such situations and prepared for its impact. In other words, China has not been seriously threatened by foreign companies refusing to give their technology to local firms due to low IP-implementation levels in the country. In this case, it is an even weaker argument that IP enforcement according to Western standards is necessary for facilitating green TT in comparison with the strong market

[346] Feldman (n 292).

incentives available in today's China. It seems that local manufacturers[347] are therefore enjoying a great deal of the fruits of non-legitimate duplications[348] based on technologies transferred to local suppliers.[349] Unfortunately, from a technology receiving and application perspective, current end-users of renewable energy technologies would simply switch back to fossil fuel energy/contaminating production where it is easier and much less time/capital-consuming than the greener way of production. With the significant cost of green technology (including buying, maintaining, applying, facilitating and administrative costs), should the focus still be placed on enforcing strong IP protection in the context of imminent climate change?

6.7.1 Price of renewable energy technology and power generation equipment purchase and maintenance

Historically, the price of green TT to China was considerably expensive. This is because, in the infant stage of environmental technology development in China, most equipment and components needed to be imported from abroad. This was due to the immaturity of domestic renewable energy technology. The average price for an imported biomass furnace was 65 to 70 million Yuan, which is 1.5 times higher than domestically manufactured equipment in that infant stage.[350] Compatible components for such imported furnaces cost four times more than indigenous mechanical parts. In the wind sector, imported equipment constitutes up to

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[347] Especially companies that supplies consumable parts to renewable energy equipment. See Interviews with all three manager from the wind projects.

[348] With technology owners charging considerably that is too high for developing countries to afford, companies in China tend to acquire them by imitation or reverse-engineering (which are non-legitimate) acquisition (which is legitimate), bypassing IP limitations, and gradually taking over market share that used to be dominated by the original company.

[349] Companies that design and produce the main body of the equipment.

[350] Roughly from 2005 to 2010. Interview with manager from Shandong Gaotang 30MW Biomass Power Generation Project

70 per cent of the construction expenses of a wind farm.[351] Cost per kilowatt of the imported turbines is around 10,000 Yuan while domestic turbines' power generation costs 30 per cent less at about 7,000 Yuan per kilowatt.[352] Foreign turbine manufacturers normally provide a 5-year warranty but when the warranty has expired a large wind farm will have to pay 30–50 million Yuan per year to maintain this equipment.[353] This is due to compatible accessory parts and consumables costing more than ten times higher for imported ones than those available at home.

As a result, if operated well without interruption, on average it is estimated to take 10-15 years to recoup the full amount of investment paid for equipment purchased from abroad, the related construction and pre-project works. Such term is, according to the interviewees, not short but acceptable to firms that have financial assistance from the national policies.[354] Soon after, with the localization rate required by the government, more foreign companies entered into the market by investing in factory construction in China. Moreover, the technology capacity of Chinese suppliers also increased promptly to meet the increasing local demand. This led to a second stage of renewable energy technology development when the cost of green-tech equipment declined, premiums on IP were been reduced to affordable levels, and end-users could expect reasonable returns under current market conditions. This

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[351] In the wind sector the price drop from the level at the infant stage to now has not been so significantly as in the biomass sector. Interview with technical director from the Provincial Power Grid.

[352] The national average: "The pricing of foreign brand turbines range from 8000 to 10000 RMB per KW in the foreign developed market, but only cost 5000 to 8000 RMB per KW in the Chinese market. This is due to that Chinese indigenous manufacturers have been able to offer turbines at even lower prices than their foreign competitors, range from 3800 to 6000 RMB per KW." European Wind Energy Association, *Pure Power: Wind Energy Scenarios up to 2030* (March 2008); International Energy Agency, *IEA Wind TCP 2015 Annual Report* (Executive Committee of the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems of the International Energy Agency, August 2016); Joanna I. Lewis, *Green Innovation in China: China's Wind Power Industry and the Global Transition to a Low-Carbon Economy* (Columbia University Press 2013).

[353] Interview with manager and CDM manager from Shandong Wulian Dongfeng Phase I Wind Power Project.

[354] Interview with managers from the Shandong Gaotang 30 MW Biomass Power Generation Project and the Shandong Kenli Biomass Generation Project.

was mainly due to the effort by the Chinese government to encourage international TT into the domestic renewable energy industry. For example, China's earliest wind turbine manufacturers were two joint ventures between foreign and domestic manufacturers, created as part of a government programme.[355] "Between 2003 and 2009, TT was promoted by making wind farm development permits conditional on a minimum percentage of locally manufactured content."[356] The National DRC and international environment funds, such as the GEF, were also providing financial support for indigenous manufacturers to develop independent multi-MW wind turbines.[357] Domestic turbines also have the advantages of being better adapted to China's local circumstances, having short delivery terms and convenient, cheaper costumer service. Therefore, according to the International Trade Administration data, "there were over 80 wind turbine generator manufacturers and 200 wind [energy project] developers" by 2008 with domestic firms occupying more than 75 per cent of the market share.[358]

However, the achievement of a relatively short diffusion and duplication period (only a few years) cost greatly according to the interviewees.[359] In the biomass furnace manufacturing industry, although "royalty costs for energy patents [represent] a small percentage of the total investment cost,"[360] more than 50 per cent of profit gained from biomass boiler sales were paid to the foreign licenser before the Chinese manufacturer accomplished acquisition

[355] See the 'Ride the Wind' program of 1997 and the State Planning Commission 1997. Gosens and Lu, supra note 86
[356] NRSC: Cancellation of Requirements Concerning Localization Rates of Wind Power Project Equipment Purchases.
[357] World Bank, *China - Renewable Energy Scale-up Program* (Implementation Completion and Results Report, 24 June 2012).
[358] Energy and Security Group, *Clean Energy: An Exporter's Guide to China* (US Department of Commerce, International Trade Administration, 2008).
[359] Interview with manager from the Shandong Weihai 69 MW Wind Power Project and technical director from the Provincial Power Grid.
[360] World Business Council for Sustainable Development, 'Towards a Low-Carbon Economy: a Business Contribution to the International Energy & Climate Debate' WBCSD, March 2009 <http://www.wbcsd.org/Clusters/Climate-Energy/Resources/A-business-contribution-to-the-international-energy-climate-debate> accessed Feburary 2017.

of a technology owner's company.[361] These core technologies include automatic loading system, vibrating grate technology and desulphurization technology. The limited profit margin is, in fact, restraining further independent development of domestic manufacturers. In comparison, in the wind turbine manufacturing industry, all Chinese wind turbine manufacturers started operations under licensing from abroad or based on partnership with a mature foreign turbine designer from the outset.[362] And soon after many of them declared that they had independent wind turbine designs and they started to be called "leaders" in the international market. Take Sinovel and Goldwind, the top two Chinese wind turbine manufacturers as examples. Sinovel imported technology from the German company Fuhrlander under licence in 2005 and established a cooperative development with American firm Windtec two years later. In 2009, it released its own independently developed wind turbine. In 1998 Goldwind got a licence from a US company, Jacobs Wind Electric, and exploited independent technology on the gearless Vensys wind turbine in 2008.[363] However, despite a number of domestic manufacturers claiming that they are capable of designing wind turbines independently, my interviewees were sceptical. All of the interviewees recruited from wind farms indicated that most of domestic wind turbine manufacturers are assembling components purchased from abroad rather than designing and producing turbines. This indicates that a large share of income made by the domestic turbine makers are paid to foreign companies from whom chemical parts are imported. Nevertheless, a demand for core

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[361] interview with technical director from the Provincial Power Grid and CDM manager from Shandong Shanxian 1*25MW Biomass Power Plant Project.
[362] Gosens and Lu (n 86).
[363] Xujuan Chen, 'Patent Analysis on Manufacturing Technology of Wind Power Generation Equipment' (2009) 9 Inner Mongolia Technology and Economy 43.

technologies and components[364] from overseas, such as the highly specialized steel components used in axle and yaw bearings remains high.[365] Many core technologies, like frequency converting technology[366] are still owned by old firms like Vestas until now. The independent technologies claimed by these Chinese wind turbine suppliers are mostly guides to the techniques of assembling components. This is confirmed by the fact that no Chinese manufacturer has been able to license its independent turbine design technology to a foreign company. Without independent core technologies domestic companies are not able to profit well from production. Not to mention that prices paid for turbines produced by the local Chinese companies have been much lower than those for imported ones.[367]

A better TT example is seen in the biomass energy sector where the technology producing main parts and essential auxiliary equipment of biomass furnaces is obtained through acquisition after being under licence for years and has helped the market reach a satisfactory localization rate. Yet the knowledge needed for production and improvement of the pre-treatment device and feeding system is still falling behind most advanced foreign leaders.

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364 LI Junfeng et. al (n 204); Jingyi Han et.al (n 204).

365 Gosens and Lu (n 86).

366 "The wind turbine generator system requires a power conditioning circuit called power converter that is capable of adjusting the generator frequency and voltage to the grid." Md Rabiul Islam, Y. G. Guo and J. G. Zhu, 'Power converters for wind turbines: Current and future development' in A. Méndez-Vilas (ed), *Materials and Processes for Energy: Communicating Current Research and Technological Developments* (Formatex Research Center 2013).

367 Interviews with managers and CDM managers from all three wind projects.
But lower price indicates that comparatively low technology is used in China's wind energy installations. According to my interviewees, there is clearly a large gap in quality between Chinese manufacturers and the world leading companies, as discussed in a former section. So if buyers are able to make choices freely (without government influence and the institutional defects of HR in China), wind farms prefer to use more expensive imported turbines that promise steady performance over domestic brands. In recent years, many Chinese manufacturers faced an overcapacity issue but the resultant price competition could not offset their disadvantages in producing low-quality products with high maintenance costs against the more costly imports with lower maintenance costs. Let's go back in time to when the Chinese wind turbine industry was emerging. In comparison with the significant expenditure needed for developing and designing the turbines independently, licensing was a much cheaper and easier way for a start-up business to get off the ground. In order to enter the market as quickly as possible and take over market share, there was little time for the less- or zero-experienced companies to craft their technology to perfection. This tradition has continued and grown through development of the Chinese renewable energy industry and possibly will expand to further influences. An increase in the use of domestically produced equipment can reduce the construction costs of power stations due significantly to "the reduction in purchasing price, transportation costs, and custom tariffs." (Jingyi Han et.al, n 204) After all, domestic wind turbines are about 30 per cent cheaper than imported turbines. However, the abolishment of the 70 per cent localization rate policy suggests that the future potential for additional cost reductions in this respect is limited. (ibid n 204) In the long term, a large amount of installation of immature domestic renewable energy equipment will have higher maintenance fees. And the cost will be even more when the warranty expires and replacement of core parts is needed.

This has subsequently affected the stability of the equipment's operation, and directly influences the production of biomass power plants. However, Chinese companies must solve these problems independently as straw material in China is very different in variety from those available in foreign countries. Plenty of finance was spent on innovation with the imported furnaces to adapt them to the Chinese fuel available and the improvement of equipment performance in the first two or three years (which is the so-called "running-in period"). Such cost is inherently attached to almost every TT to China adding to the price that is already high.

In addition, from the second to the fifth year, equipment is performing at its best because it is still new, has high stability and personnel are proficient in its operation. Therefore, yield rate during this period of time is relatively good. After five years, all equipment enters a period of fatigue. Devices start to wear down and demand regular maintenance and this causes downtime. A conglomerate company, which develops several projects in different places, will receive reports of component failure from projects established contemporaneously and it will be able to deal with the requests for supply/import of replacements in the same period. Therefore, it will take immense expense and intense work cumulatively. In the wind sector, some wind farms saved on costs during initial investment because they installed domestically supplied turbines. Still, they eventually need to spend more time and money to maintain these turbines than imported ones. This is due to the immature domestic wind technology, which has resulted in more frequent breakdowns during operation. According to Han's research, the "average full-load hours per year of wind turbines in China (1787 h) are much lower than in Western countries such as the United Kingdom (2628 h), Australia (2500 h) and the United States (2300 h)."[368] He provides an extreme case of Huarui having three wind turbines installed in Boligenshan Wind Farm in 2003. And these turbines designed with 2000 full-load hours can operate merely 300 hours a year.[369] A similar situation has been discovered in the interviewed projects, as domestic turbines require replacement of "large components" more often, which will stop production of the wind farm from time to time. Large components include the engine room and the gearbox, which need to be installed by Caterpillar crane. Such a crane is assembled from a number of lorries and equipment, requiring convoys to be hired and a huge amount of transportation fees to be paid on top of the cost of the component (300 thousand Yuan on average). Furthermore, in the long term, power plants installed with immature equipment will have to pay conversion expenses[370] when the maintenance fee exceeds the small profit. To keep their means of production updated (and possibly to comply with newly promulgated policies),[371] power companies might be forced to switch to more advanced and stable equipment. While production cost reductions achieved by the instalment of new facilities are not always enough to offset the initial upfront conversion costs.

Nevertheless, it is noted that "China has been able to take advantage of certain kinds of technology at a lower cost than others."[372] Because of the size of the Chinese market and significant prices differences between domestic and imported technologies, the cost of

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[368] Ibid (n 204).
[369] Ibid.
[370] Chris Joseph, 'The Disadvantages of Going Green for a Corporation' (*www.Chron.com*) <http://smallbusiness.chron.com/disadvantages-going-green-corporation-3318.html> accessed Feburary 2017.
[371] For example, the SASAC (State-owned Assets Supervision and Administration Commission) used to require a 8% rate of return has been increased to 12% from 2014.
[372] Copenhagen Economics and The IPR Company (n 158).

renewable equipment is being driven down.[373] Accordingly, the disadvantaged situation of Chinese end-users with weaker bargaining power in relation to developed suppliers has been changed. Interviewees indicate that they are now in a better position in negotiations and provided with more reasonable deals and services from the leading manufacturers who used to "play hard." It is true that "in an environment of the mania for investment in China's renewable energy market, competition and diversity will make it impossible for monopolistic pricing."[374] But again, certain types of technologies, especially the core ones and most recent ones, are still and will be for a long time controlled by developed leading manufacturers. For example, although China's wind turbine rotor blade production accounts for 25 per cent of the world's total,[375] access to turbines with a capacity over 1.5 MW is mainly dependent on imports.

In theory, the excessive expense involved with expanding the usage of renewables could be offset from more profitable sectors through macro-control of the economy. For example, with a large capacity of Chinese solar power companies,[376] revenue income from exporting solar panels could be used to subsidize wind and biomass power stations when importing equipment.[377] However, such a strategy may be barred by counterproductive policies adopted by developed countries that profess environmentalism and international cooperation on climate change. Actions such as increasing trade tariffs on photovoltaic panels imported from China by the US and the EU are hindering China's exportation of renewable energy

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[373] Downey (n 50).
[374] Ibid.
[375] Gosens and Lu (n 86).
[376] Energy and Security Group (n 358).
[377] In fact, most large energy companies re engaged with more than one type of renewable energy projects. Interview with manager and CDM manager from Shandong Wulian Dongfeng Phase I Wind Power Project regarding the China Resources (Holdings) Co. Ltd.

equipment.[378] This "will only slow the rate at which costs decrease and will decelerate the world's retreat from fossil fuels."[379] As a result, the decrease in the cost of renewables was delayed and the carbon reduction targets ascertained in the Kyoto Protocol were not fulfilled after the first commitment period (2008–2012).[380] According to the interviewees,[381] even in China where favourable policies are available, renewable energy technologies are only affordable to companies that are getting financial support from abroad or from the state government. However, with the first implementation period of the Kyoto Protocol expiring in 2012,[382] a lot of CER buyers ceased their contracts with Chinese companies. Many Chinese entrepreneurs have lost interest in utilizing green tech and stopped applying for CDM projects, as both are time- and money-consuming. Only a few demonstration CDM projects still have the intention of running renewable energy plants because financial support provided for such projects are guaranteed and sufficient. In 2012, when the Chinese government issued the Interim Measures for the Administration of Voluntary Greenhouse Gas Emission Reduction Transactions, there was a minor rebound in green-tech applications within the Chinese domestic market. But in general the enthusiasm in applying renewables has declined

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[378] "Europe's solar industry has condemned an EU vote to impose another round of duties on Chinese imports, just weeks before a US trade panel is due to rule on similar tariffs." Arthur Neslen, 'Solar industry says EU tariffs on Chinese imports will raise panel prices' (*The guardian*, 8 September 2017) <https://www.theguardian.com/environment/2017/sep/08/solar-industry-says-eu-tariffs-chinese-imports-will-raise-panel-prices> accessed July 2017.

[379] John A. Mathews and Hao Tan, 'Economics: Manufacture Renewables to Build Energy Security' Nature: International Weekly Journal of Sience (2014) <http://www.nature.com/polopoly_fs/1.15847!/menu/main/topColumns/topLeftColumn/pdf/513166a.pdf> accessed Feburary 2017.

[380] Ibid.

[381] manager interviewees from all wind and biomass projects.

[382] First commitment period: 2008-2012; "In Doha, Qatar, on 8 December 2012, the 'Doha Amendment to the Kyoto Protocol' was adopted. The amendment includes: New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020; During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first." Quoted from Metro-link Express for Gandhinagar and Ahmedabad (MEGA), *Environmental Impact Assessment Study for Ahmedabad Metro Rail Project (Phase-1)* (Urban Engineering, Oct 2014).

out of a fear of costly IP and follow-on expenses. The narrative around IP in relation to renewable energy technology needs to change.

6.7.2 Cost to maintain patents

Although the cost of equipment and service is much higher with imported technologies,[383] it still seems almost affordable to large Chinese companies. On the other hand, such capital resource outflow comes at the price of leaving less capital domestically needed for patenting and maintaining renewable energy technologies. And as China is in a transition period from technology receiver to provider, it could result in fatigue in connection with increasing green production and R & D development in the foreseeable future. In fact, keeping and maintaining a valid patent portfolio is proven to be expensive enterprise in itself. Entities that are already major players in the wind industry, like Vestas, GE, Siemens and Gamesa are allocating considerable amount of capitals in building and maintaining IP portfolios.[384] It is estimated that for every megawatt installed, GE will have to spend $25,000 licensing wind patent suits in the US. And by 2020 the cost of GE maintaining just its US wind IP portfolio will be as much as $31 million.[385] Such a whopping price could be even higher for IP successors, as the current industry leaders will only compromise their competitiveness in exchange for an outstanding profit. Most Chinese companies are virtual latecomers in the global renewable energy business. How IP fits into the overall business strategy for an emerging firm is depends on its start-up or developing position in the market.[386]

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383 Jingyi Han et.al (n 204).
384 Davidson (n 201).
385 Ibid.
386 The Development Solutions and the European Chamber (n 163).

Factors regarding the maturity of the independent technology capacity of a company are also important in maintaining patents. The old industry leaders are the key players in investing in exploring new and untested technologies, as they own many mature core technologies and are experienced with applying off-patent ones already. Such companies are keen to increase opportunities to license and cross-licensing to other companies by barring new players from entering the market. Interviewees[387] have indicated that only these world leaders are capable of protecting technologies with trade secrets because they are sophisticated enough to conceal the key parts required to unblock the technology within a "black box." "This could be done by supplying specialized equipment or by having a trusted contractor perform the installation because the technology will need to be taught and practiced by the licensee."[388] In contrast, Chinese businesses are not yet able to use IP to achieve these objectives. They would be more interested in maximizing revenue and extending their IP portfolio through licensing and other forms of imitation, which are sometimes out of their control. At this stage, a considerable share of profits is taken by foreign licensers/exporters. Therefore, Chinese manufacturers may be even struggling to budget sufficiently to actively detect counterfeiters and pursue compensation through litigation.[389]

Moreover, to survive the competition and become so-called "industry leaders" globally, companies will have to look at anything they can do to get ahead, filing cutting-edge patents broad enough to exclude competitors' inventions or through the acquisition of IP developed by competitors. For example, the Chinese energy technology company LoonG acquired

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[387] Interviews with R & D director from Shandong Dongyue HFC23 Decomposition Project and the R & D staff from a world leading Turbine maker.

[388] The Development Solutions and the European Chamber (n 163).

[389] According to technicians from all three wind projects and one biomass projects, detecting patent infringement is actually a very technical and difficult job requires a team of knowledgeable experts and funding.

Bioener – one of the top two Denmark biomass boiler manufacturers. However, possessing a single patent does not automatically allow a manufacturer to commercialize technology. In fact, it requires the acquisition of "a particular variant of a broader technology, already patented"[390] and latent capacity regarding both financial and intellectual abilities to explore, innovate and renew this invention. In that case, LoonG taking over Bioener is an entirely different case from a stronger merging between technology leaders, both from developed countries. For example, GE purchased Converteam to enhance its technology for full-power conversion and permanent-magnet generators. Also the 039 patent, later acquired by GE and originally filed by a US firm – Enertech Windpower, has enabled GE to block Enercon (the innovative German turbine maker) from applying it own technology in the US until 2010.[391] Such wind power-related IP clashes of the 1990s even included "allegations of industrial espionage involving the US National Security Agency."[392]

Therefore, for upcoming Chinese manufacturers, it will be costly to keep and innovate upon imported technologies. Harsh terms and potential litigation coming from the original technology owners would hinder the fast, independent development of renewable energy technologies by Chinese companies. For example, in the aforementioned AMSC vs. Sinovel case,[393] when the two parties started to develop wind turbines cooperatively, a declaration of ownership of independent IPRs by Sinovel was included in the agreement. But in exchange, Sinovel agreed to use core components of the electronic control system provided by AMSC in all of its turbines, which secured great sales for AMSC for several years. Data shows that in

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[390] Delegation of the European Union to China and Euraxess Links China (n 286).
[391] The patent expired in February 2011. Davidson (n 201).
[392] Ibid.
[393] See Section 6.5.4

2010 alone, purchases by Sinovel from AMSC reached 20 billion Yuan (about 2.2 billion Pounds). Since 2011, with the increasing proportion of wind power in the national grid, the grid required wind turbines to introduce low-voltage ride-through technology (LVRT). The LVRT capability is the ability to deal with grid faults. It has a great impact on the power system stability of wind farms and therefore became an important indicator used by the grid connection test.[394] Sinovel thus developed its own technology to improve the PM transducer in order to pass the LVRT testing required by the national grid, and ceased purchases from AMSC. This led to the subsequent dispute between AMSC and Sinovel, and IP litigations were launched as a result.[395]

The AMSC-Sinovel dispute reflects the increasing competition between domestic wind power enterprises and foreign companies. This is a tough transition phase for Chinese former-licensees who are becoming competitors in the international market because of many hidden problems they encounter when they first start to cooperate with foreign licensors. In Sinovel's case, at the beginning of cooperation with AMSC, Sinovel entered into a contract specifying AMSC as its sole frequency-converter supplier. This led to a vicious circle, with Sinovel's overreliance on AMSC products, and without competitive pressure it established a "lazy" psychology of slow technological upgrades in AMSC and more import reliance of their Chinese partners. In order to continuously use the imported technologies and innovate upon

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394 "The grid connection test is conducted to verify the safety of the electrical grid when an inverter performs the conversion of the variable DC output of the Photovoltaic (PV) modules or wind turbines into a utility frequency AC current that can be fed into the commercial electrical grid. Because each country has its own specifications for rated voltages, the grid connection test is an important measure to ensure that the inverter can meet the all requirements of the targeted markets." 'Grid Connection Testing' (*Bureau Veritas*) <http://www.bureauveritas.com/home/about-us/our-business/cps/our-services/testing/grid-connection> accessed May 2017.

395 See Section 6.5.4

them to adapt to local situations in China, Chinese renewable energy equipment manufacturers and end-users will have to seek means that proactively break this vicious circle.

At present, the Chinese wind turbine companies' independent R & D capability is still low for they are unable to produce or design an integrated multi-megawatt wind turbine[396] without procurement from foreign suppliers. For example, the direct-drive technology employed by Goldwind is originally from the Germany company Vensys; XEMC's production is dependent on technology from the Netherlands company Zephyros; Dongfang Electric and Zhejiang Windey imported their technologies from Repower (Swiss). Some Chinese enterprises have been authorized by the original technology owners to incorporate these technologies in later developed wind turbine manufacturing but often there were conditions required by the foreign technology owners to protect their potential market share in China (e.g. a long-term sales contract signed). Currently, the global wind power giants have control over the majority of China's domestic wind power technologies and industry chain. In these cases, it is necessary for the Chinese renewable energy facility designers and manufacturers to identify foreign companies' patent strategies and have a clear understanding of their IPRs to avoid the risk of patent infringement and to establish a local advantage. However, this would be redundant if the contract between foreign company and the Chinese company ties the Chinese company to the foreign companies' products. Currently, the patented technologies employed by China's domestic renewable energy manufacturers are mainly from three sources: indigenous independent technology, technologies developed by R & D cooperation

[396] The machine consists of host, blower, analyzer, powder and filter components.

with foreign companies, and licensed technology owned by foreign companies.[397] At first, when domestic firms were not able to compete with foreign enterprises, there were no obvious differences between the three sources, but once the Chinese companies became more capable, the latter two sources of technology become problematic areas with a high incidence of patent disputes. Chinese firms' lack of independent IPRs can easily lead to IP litigation. The monopoly rights of patents are therefore putting burdens on China's independent renewable power technology development and innovation. In the meantime, as discussed earlier, the industry leaders are not willing to sell products containing their most advanced wind power technology to China, requiring Chinese firms to spend more money to renew and replace equipment in order to keep their technologies updated. Also, they will need to employ a more sophisticated technology strategy to secure sales in the future.

Other than the above difficulties, the sustainable development of renewable technology in the long term requires related human resources to be developed in the area. To facilitate technology innovation, government, universities, and enterprises will have to make greater efforts to promote education, so as to train and equip qualified personnel. This will result in even more expense in cultivating talents across society. As the history of renewable energy industry development has been short, experienced and skilled workers and researchers are scarce. It will take a lot more time and resources for them to grow to maturity in order to have domestic capability to adapt to China's special natural environment, develop techniques, and establish industry standards.

[397] Technicians and managers from all three wind power projects.

6.7.3 Cost to apply – facilitating the appliance of new technology (smart grid)

For companies in the downstream of the renewable energy industry, such as those related to energy generation plants, there is less need for storing up patents. This is to say that the information required to produce electricity-generating machinery is not necessary, while the knowledge required to use the machinery effectively is rather important. For example, during a wind farm construction period, know-how to do with anemometry and installation techniques is of vital importance for the eventual performance of the turbine. Subsequently, in wind power generating, "power companies need not only physical assets like rotors and generators, but also intangible assets, such as the knowledge of how to maintain, repair, and improve upon those physical assets."[398] On top of equipment purchase, software for data collection systems and knowledge on how to effectively interpret and analyze the data are vital. A smart electricity grid connecting consumers and generating plants is also essential, and that means extra cost on infrastructure and knowledge-based assets.[399] For a power plant, in particular, three elements are of the highest importance – the aforementioned components and service purchase price; fuel resources and feed-in tariff; and access to public facilities (i.e. the power grid). Development of above aspects requires considerable investment and expensive maintenance as well.

6.7.3.1 Fuel resources and feed-in tariff

In China, most power plants are subsided by large state-owned/invested power conglomerate/consortiums (State Owned enterprise- SOE)[400] that are mainly in charge of

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[398] Downey (n 50).
[399] See Arnulf Grübler, *Technology and Global Change* (Cambridge University Press 2003).
[400] "Historically, the most important developer has been Longyuan. This state-owned enterprise (SOE) was established in 1993 with a mission to develop renewable energy. In 2002, Longyuan was incorporated as a subsidiary of Guodian, one of the so-called

project construction and running. At the same time all power plants are directly controlled by the government – in particular through the provincial/national DRC. For example, in the wind sector, collectively, the top five power enterprises (Guodian, China Power Investment, Datang, Huadian, and Huaneng) "operate 58% of China's wind farms (as of the end of 2011). Other SOEs, mostly utilities under central or provincial government control, operate the remaining further 32%."[401] One of the most powerful measure is the pricing of renewable electricity that government can employ to control the industry.

Before 2007, all large-scale renewable energy projects were settled through concession tenders to reduce the purchase price of the renewables.[402] Projects established under concession bidding are required to provide electricity at the price offered at auction. The company that offers the best price per kWh on the terms provided would win the right to proceed with the project and thus is entitled to every benefits provided for the company to produce electricity on the site; developers are subsequently tied up by the small profit margin restricted by the price offered to win in the project/concession tender. However, some manufacturers reduce their offered price merely to overbid others for ancillary rights attached to the tender. This happens even when, in actual routine operation, it proves economically impossible to run the power plant appropriately at this offered price.[403] On the surface, this concession model is an equal platform for suitable developers that are capable of generating renewable power at different prices, with all the power companies allowed to participate in

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'Big 5' power companies (the others being China Power Investment (CPI), Datang, Huadian and Huaneng). These are state-owned enterprises (SOE) under the control of the central government." Gosens and Lu (n 86).

401 Ibid (n 86).

402 from 2003

403 Jingyi Han et.al (n 204).

the renewable energy industry by bidding for projects.[404] However, in fact, small private companies have insufficient financial resources to compete with large state-owned power companies. At the same time, SOEs in China are required by the national DRC to have a certain amount of energy generated from renewable energy resources.[405] In order to fulfil such requirement, SOEs are under very ambitious as they are enormous pressure to win their bids regardless the low-price offered was not going to cover real costs required for a project.

To overcome the shortcomings of the concession approach, from 2007 onwards a uniformed benchmark tariff[406] was applied to all large-scale renewable energy projects. China's 2006 Renewable Energy Law becomes the main resource for the renewable energy pricing standards,[407] and it endeavours to increase the renewable energy share in the Chinese energy market.[408] The law's renewable energy pricing mechanisms are based on "feed-in" tariff

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[404] Ibid.

[405] "In the Mid-Long Term Plan of Renewable Energy Development, NDRC announced Renewable Portfolio Standard (RPS) mandates in power generation sector. For the whole sector, the share of electricity generated from non-hydro renewable energy resources should reach 1% of total electricity generation by 2010 and 3% by 2020. For any power producer with installed capacity greater than 5 GW, the mandatory share is raised to 3% by 2010 and 8% by 2020." Ibid (n 204); Gosens and Lu (n 86).

[406] Current wind power and biomass power on-grid price: In the end of July 2009, the National Development and Reform Commission issued the "Notice on improvement of wind power on-gird tariff policy " (Development and Reform Price [2009] No. 1906), refined the policy on wind power tariff. The document stipulates that according to the different quality of wind energy resources and local constructive conditions, wind resources are divided into four kinds, and the on-grid prices are set correspondingly. The on-grid benchmark price for the four types of wind power are 0.51 yuan / kWh, 0.54 yuan / kWh, 0.58 yuan / kWh and 0.61 yuan / kWh. Projects that are approved since August 1, 2009 -based wind power projects will be applying this unified benchmark price depending on their location and wind resource type.
In 2006, the National Development and Reform Commission and the State Electricity Regulatory Commission issued the "Interim Measures for Renewable energy generated electricity on-grid price and cost sharing management" ([2006] Document No. 7). Electricity from Biomass power generation project are priced by the State Council department in charge of electricity pricing, price are ascertained differently based on benchmark price suggested by provincial governments. Since 2005, the benchmark on-grid price for renewable energy generated electricity is the sum of price for desulphurization coal generated electricity and the renewable energy electricity subsidy price. Standard subsidy price is 0.25 yuan / kWh. Such subsidy price will be enjoyed by the power generation projects for 15 since the date of commissioning. After 15 years of running, the subsidy price will terminate. Biomass power generation projects conducted through tender, enjoys an on-grid price determined during tender, but the winning price shall not exceed the benchmark price of biomass power in that region. From the beginning of 2007, straw combustion projects are given a temporary subsidy price of 0.1 yuan / kWh.
In order to encourage technology innovation, the "Interim Measures for Renewable energy generated electricity on-grid price and cost sharing management" also made it clear that "since 2010, the subsidy price enjoyed by newly approved power generation projects will be reduced by 2% compare with price enjoyed by projects approved in the previous year." In addition, in July 2010, the "National Development and Reform Commission notice on the improvement of agricultural and forestry biomass power price policy" (development price [2010] 1579) stipulates that benchmark price for biomass projects are unified as 0.75 yuan / kWh (before tax).

[407] See Renewable Energy Law of P.R.C. (promulgated by the Standing Commission. National People's Congress, Feb. 28, 2005, effective Jan. 1, 2006); See also Caprotti (n 322).

[408] See e.g. Chinese Renewable Energy Law 2006 (n 407) Article 14

models,[409] but the link it has established between pricing at source[410] and grid in-taking obligations is problematic.[411] According to the National Energy Administration, the State DRC and the State Electricity Regulatory Commission: "after power generators are put into commercial operation, the on-grid tariffs set by the competent price department of the government shall uniformly apply to the amounts of on-grid electricity of the power generators."[412] The electricity benchmark price is dependent on the calculation of the generation cost and reasonable profit margin decided by the DRC,[413] and in turn a designated profit margin is included for electricity purchased from the power plant. Therefore, any purchasing agreement signed between the power grid and power companies is manipulated by the government's attitude towards each energy sector. In practice, the price offered by the winning bid before 2007 is still to be executed today. But the local government has to make sure that the price is no higher than the benchmark price stipulated by the state, which according to my interviewees only guarantees low profits for renewable power plants.[414] For

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409 Zijun Li, 'China's Renewable Energy Law Takes Effect; Pricing and Fee-Sharing Rules Issued' 18 Worldwatch Institute; see also 'China Passes Renewable Energy Law' (*Renewable Energy World*, March 9, 2005) <http://www.renewableenergyworld.com/articles/2005/03/china-passes-renewable-energy-law-23531.html> accessed Feb 2017. Quoted by Caprotti (n 322).

410 Chinese Renewable Energy Law 2006 (n 407) Article 19: The on-grid electricity prices for projects of electricity generation by using renewable energies shall be determined by the administrative department of price of the State Council in light of the conditions of different areas and the characteristics of electricity generation by using renewable energies of different types, and according to the principle of helping promote the development and utilization of renewable energies and the principles of economy and rationality, and be adjusted in a timely manner by the same department in light of the development of the renewable energy resource utilization technology. On-grid electricity prices shall be published.
The on-grid electricity price for a project of electricity generation by using renewable energies for which public bidding is held under Paragraph 3 of Article 13 hereof shall be the price as fixed through bidding, provided that the price may not be higher than the that as set under the preceding paragraph for a project of the same type.

411 Junfeng li et. al, 'A Study on the Pricing Policy of Wind Power in China' Published by Chinese Rnewable Energy Industries Association, Greenpeace and the Global Wind Energy Council <http://www.greenpeace.org/eastasia/Global/eastasia/publications/reports/climate-energy/2006/study-pricing-policy-of-wind-power-in-china.pdf> accessed Feburary 2017.

412 Chinese Renewable Energy Law 2006 (n 407).

413 To advance the development of the renewable energy industry and ensure the rational distribution of renewable energy power price surcharges, and, based on the ibid (n 407). and the Convention on Biological Diversity, 1760 UNTS 79; 31 ILM 818 (1992), this Commission has formulated, upon research, the UNFCCC, 'Decision 7/CP.7 Funding under the Convention' in *PART TWO: ACTION TAKEN BY THE CONFERENCE OF THE PARTIES* (United Nations Framework Convention on Climate Change, 7th session, FCCC/CP/2001/13/Add.1, 21 January 2002 2002).

414 interview with managers from Shandong Gaotang 30MW Biomass Power Generation Project and Shandong Kenli Biomass Generation Project.

example, currently the average construction cost of wind farms is about 10,000 Yuan/kW[415] and a biomass power plant is constructed at a cost of 10,000 to 15,000 Yuan/kW for the generators, and other devices are expensive.[416] In operation, it costs about 0.60–0.64 Yuan/kWh for wind projects and around 0.70–0.79 Yuan/kWh[417] depending on the straw purchase price of the year for biomass projects. In comparison with the benchmark feed-in tariff at 0.4469 Yuan/kWh, the grid is purchasing from wind and biomass projects at 0.7 Yuan/kWh and 0.75 Yuan/kWh, which are significantly higher than those for fossil fuel generated energy but insufficiently to cover all the costs borne by these renewable energy plants.

All biomass projects are pursuing better thermal conversion efficiency in operation in order to reduce production costs and increase profit at the current tariff. As a result, some projects are running well as long as CDM funding and government subsidies are in place. However, as it takes up to 0.8 kilograms of straw for one-kilowatt generation, power plants need to stock 150 thousand tons or more to ensure the proper operation of the plants in the tax year. In fact, the cost of straw fuel is dependent on the type of crops (wheat, maize or cotton) it comes from and the agricultural output of the season/year. When the straw market is fine, straw is available at 150–280 Yuan per ton plus expenses for setting up purchase stations and transportation.[418] As straw production is seasonal, it is impossible to purchase in winter. So when harvest time comes, power plants must make time to collect straw. Usually, if the acquisition happens a month or even two weeks later than harvest time, all straw is out of

[415] Jingyi Han et.al (n 204).
[416] Jiamin Xie, 'Discussion on the Development of Biomass Power Generation in China (in Chinese)' (2012) china-nengyuancom <http://www.china-nengyuan.com/tech/china-nengyuan_tech_94301.pdf> accessed Feubrary 2017.
[417] Adding the fuel cost at 0.40 - 0.49 Yuan/kWh plus operation costs at 0.3 Yuan/kWh.
[418] Interview with manager from Shandong Gaotang 30MW Biomass Power Generation Project.

stock. Therefore, the purchase task is critical because it has to be done in a short period, which requires the recruitment of a large crew of temporary workers collecting straw from different locations at the same time. In addition, after the acquisition, straw must be immediately pre-treated for later storage properly, because if the water inside the straw has not been treated, the high moisture will lead to spontaneous combustion afterwards. More than that, the transportation for straw can be burdensome as well. Straw that is commonly available in the market is divided into two categories: grey straw and yellow straw. Grey straw (cotton straw) is easier to transport, for it requires simple loading to a lorry. Yellow straw (wheat straw) is harder to transport for it could be blown away during transportation. Therefore, a briquette machine is used during yellow straw collection, and some biomass power plants use it for material handling as well. The straw will be pressed into blocks by the briquette machine, making it easier to transport. Some plants argue that they are unable to afford this technology, as it will raise the cost of production. Sometimes, straw stocks fall short of market demands because they can also be sold to racecourses and horse farms to make fodder. In such a tight market, straw prices could rise to very high at 400 to 600 Yuan a ton. To power plants, straw is only fuel, but to the farms, it is fine grain. Briquettes are therefore used because they can afford the cost and also because it will be transported over long distances. However, for power plants, the extra cost of briquetting is too much of a burden. Also, the transportation distance is accounted for in the budget. If the location of collection is too far away from the power plant, then the cost of transport may be too high. As a result, according to the data of the year when interviews were conducted,[419] the straw

[419] Interviews in 2013 with manager from the Shandong Gaotang 30MW Biomass Power Generation Project and manager from the

purchase price once reached as high as 700-800 Yuan per ton.[420] Therefore, projects without government support (financial and political) often struggle to operate and to make profits. While the national subsidy is still available at present, biomass energy plants can expect only 15 years of support from the date the project is commissioned; after 15 years, the government will remove subsidies and the feed-in tariff will be the same as for fossil fuel powers. Since 2010, the Trial Measures for Management of Prices and Cost-Sharing for Renewable Energy Power Generation[421] further stipulates that the subsidy tariff for projects approved each year will be 2 per cent less than those approved in the previous year.[422] Such mechanisms have left the renewable energy companies with very little time to get the necessary returns.

A similar situation is seen in the wind power industry. None of the wind project studied in this research claim to have achieved satisfying profits at the moment.[423] The cost of wind power is much higher than fossil fuel generation, due to considerable construction costs, maintenance costs, loan interest, labour costs, and taxes.[424] The 0.7 Yuan/kWh feed-in tariff for wind projects comprises a national standardized feed-in tariff at 0.61 Yuan and a subsidiary 0.09 Yuan, available only in Shandong Province. However, the provincial subsidiary officially ceased from 2012, and interviewees[425] even claimed that some projects stopped receiving this 0.09 Yuan from as early as 2010. This is to say that they have hardly made any profits since then. Han et al. have provided detailed data on operation costs in wind projects.

Shandong Kenli Biomass Generation Project.
420 In the year of 2012.
421 Convention on Biological Diversity (n 413).
422 Ibid, (n 413).
423 Interviews with all three managers of the wind projects.
424 Debra Lew and Jeffrey Logan, ‘Energizing China’s Wind Power Sector’ (2001) National Renewable Energy Laboratory.
425 Manager interviewees from Shandong Weihai 69 MW Wind Power Project and Shandong Wulian Dongfeng Phase I Wind Power Project.

They pointed out that "to maintain equipment, a wind farm needs to pay about 0.15 Yuan for every kWh of electricity it generates. The average rate of interest on loans for wind farms is about 9 per cent of the total costs. The salaries of employees are estimated to be about 0.07 Yuan/kWh. Another 0.03 Yuan/kWh relates to other issues in wind farm management. Taxes imposed on wind farms include a value-added tax (VAT)[426] and income tax.[427] Import tariffs and VAT on imported goods are refunded.[428] On average, wind farms pay 0.17 Yuan merely on taxes for every kWh of electricity."[429] Such high generation costs make wind electricity far less competitive in comparison with fossil-fuelled electricity. In fact, the subtotal costs for wind power generation in Shandong can be up to 0.65 Yuan/ kWh while the cost of coal-fired electricity is only 0.30 Yuan/kWh.[430] With abundant fossil fuel resources available at a much lower cost, no power company is willing to take on economic losses to develop wind power.[431] And the current practitioners in other renewable energy sectors are likely to lose enthusiasm in wind renewable power development as well. Bonded by renewable energy quotas for power and grid companies, a number of our interviewees[432] indicated that these large SOEs have been inviting powerful lobbies to canvass the government to avoid high costs incurred by more renewable energy installation.

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426 "Wind farms enjoy a preferential VAT rate of 8.5%, half of the rate normal enterprises are experiencing." Jingyi Han, 'Renewable Energy Development in China: Policies, practices and performance' (PnD Thesis, Wageningen University, Wageningen, NL 2009).

427 "Refunded completely in the first 2 years, refunded for 50% in the next 3 years (which means a tax rate of 16.5%), and experiencing the full rate (33%) afterward." Ibid.

428 Source: Notice on Adjusting Import Tax Policies for High Capacity Wind Turbines, Key Components and Raw Materials, 14th April 2008, Customs Tariff Commission of the State Council [2008] 36''Policy on adjusting import taxof wind turbine components''.

429 Jingyi Han et.al (n 204).

430 Ibid.

431 This may be a short-sighted strategy as the UK this year saw the costs of renewals fall well below those of fossil fuels. China may be different because the abundance of coal in situ means that transportation costs are low. However, as globally the price of renewables reduces even in markets where there is an abundance of fossil fuels renewables become much more competitive and indeed within a relatively short time span much cheaper. See Adnan Z. Amin, 'The Falling Costs of Renewable Energy: No More Excuses' (*Huffpost The Blog*, Nov 30 2015) <http://www.huffingtonpost.com/adnan-z-amin/post_10557_b_8600240.html> accessed Feb 2017.

432 As governmental officer interviewees requested anonymity to the highest degree, I will not mention the cities from which they come.

With the intense competition among renewable power developers and the small profit margin offered by the power grid, renewable energy companies in China are desperate for international financial resources. Among them, CDM is a significant channel for accessing foreign funding.[433] For example, in smaller companies such as the Minhe Livestock Co. Ltd.,[434] carbon trading incomes make up 80%-90% of its annual revenue. For larger energy cooperation, such as wind energy companies, CDM used to provide 10 per cent of profits for a 5 MW wind farm. In 2008, the first CDM contract on wind project between Spain and Shandong was signed. According to this contract, the Spanish Endesa Generacion S.A. buys CERs from Huaneng Zhongdian Changdao Wind Power Co. Ltd. through the Shandong Changdao 27.2 MW Wind Power Project at a price of 8 Euro/t of CO_2 reduction (about 58 Yuan/t of CO_2 reduction). Within the contract period, 58,705 tons CO_2 equivalent emissions would be reduced annually, which provided Huaneng with 34 million Yuan of Spanish funding. However, according to the interviewee from that project,[435] they could profit four million Yuan after applying cost deductions. Another wind project funded by Spain and established in the same year concerned a larger wind farm[436] and was receiving 10–12 million Yuan annually from CDM buyers. Because Chinese wind farms hardly make any profit themselves, such extra income is a vital incentive for them to continue and survive. However, since the first implementation period of the Kyoto Protocol expired in 2012,[437] many CER buyers

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[433] Asmerom M. Gilau, Robert Van Buskirk and Mitchell J. Small, 'Enabling Optimal Energy Options under the Clean Development Mechanism' (2007) 35 Energy Policy 5526.
[434] Animal Manure Management System (AMMS) GHG Mitigation Project, Penglai, Shandong Province, P.R. of China
[435] which is also the manager interviewee from Shandong Weihai 69 MW Wind Power Project.
[436] Located in Weihai as well.
[437] First commitment period: 2008-2012; In Doha, Qatar, on 8 December 2012, the "Doha Amendment to the Kyoto Protocol" was adopted. The amendment includes: New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020; during the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990

ceased their contracts with Chinese companies. Since June 2011, the international carbon trading market has experienced a steep fall in prices from its highest at 14 Euro/t of CO_2 reduction to as low as 0.12 Euro/t of CO_2 reduction. The 2012-approved Shandong Wulian Dongfeng Phase I Wind Power Project was able to sell its CER at only 0.5 Euro/t. As this project is providing the equivalent of 88,464 tons of CO_2 per annum it can earn only about 0.3 million Yuan from the project, which almost fails to cover the expenses for CDM project application as well as applications for approval from government. From the second half of 2010, CER was sold even lower at 0.12 euro per ton. And the UNFCCC request of an issue fee for reduction verification at 1.5 dollar/ton (about 1.4 Euro/ton) is leaving applicants with no profit at all with which to develop CDM projects. Many Chinese enterprises have ceased work related to CDM applications and have hence lost interest in utilizing green technologies, as both are time- and money-consuming. Only a few demonstration projects still have the intention of running renewable energy plants because all financial support provided for such projects is guaranteed and sufficient.

From a national level, the utilization of renewable energy technology is a considerable burden to national revenue. On December 30th, 2015, the National DRC promulgated Notice on coal-fired electricity feed-in tariff reduction of and general commercial and industrial electricity price reduction, and decided to levy an increased renewable energy surcharge from 0.015 to 0.019 Yuan per kilowatt hour. This surcharge will raise a 19 billion Yuan fund annually for renewable energy development. However, data provided by the Ministry of Finance demonstrates that expenses needed for renewable energy tariff subsidiaries in 2014 are

levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

49.138 billion Yuan, within which 27.5 billion and 7.407 billion Yuan is used to subsidize wind power and biomass power projects. Therefore, after deducting the 19 billion revenues from the renewable energy surcharge there remains a 30 billion Yuan deficit unfulfilled from the previous year. The current surcharge is much lower than the expected 0.025–0.03 Yuan per kilowatt-hour enough to pay the arrears of subsidiaries promised to the renewable energy companies. Moreover, with the increased renewable energy proportion targeted by the 13th Five-Year Plan, the gap will be enlarged every year. In China's renewable energy industry, a serious delay of subsidies reaching the power companies is common, and the subtotal has exceeded 70 billion Yuan in arrears. A postponement of two to three years for the companies' accounts to be credited is typical. My interviewees[438] believe that despite a secured feed-in tariff, a timely payment of subsidies is equally important to the survival of a renewable energy company. Recently, there have been rumours that the Ministry of Finance is making an effort to fix the arrears but the specific operating schedule is not yet clear. China has formulated a goal to increase its use of non-fossil energy accounting for 15 per cent of the national energy consumption by 2020. Yet the path to achieve such a goal has to be assisted financially in accordance with the additional cost of renewable energy generation. Up until now, funds have not matched the growing size of the market; the domestic development of the renewable energy industry still has a long way to go.

6.7.3.2 Access to public facilities (power grid)

A suitable location for a power plant influences its productivity and technological performance directly. For example, an ideal site for a wind farm would be one with rich wind

[438] See in general interviews with all manager interviewees recruited in this research.

resources. Similarly, a biomass power plant would be ideally located at a place close to straw resources, such as cornfields, in order to have a sufficient fuel supply. A feasibility report is required from all approved projects by the DRC. Such reports include resource detection for power generation. As the construction of power plants falls into this “approval project” category, enterprises must provide a feasibility report before proceeding. For example, as with wind farm projects, experts will test the wind speed at the site, which also depends on air temperature, barometric pressure, and altitude.[439] At the same time, convenient transportation is important for reducing operational costs of a biomass power plant. Close proximity to railways or motorways helps in lowering transportation costs during the running of the plant. More importantly, a good location means good infrastructure conditions and a reasonable distance to the power grid.[440]

The fact that connection to the power grid becomes a bottleneck for growth of renewable energy in China is probably caused by two main reasons.[441] Fisrt, a big challenge like the instability of wind power for grid management is associated with renewable energy.[442] Of the three wind farms the author visited, none has had a convenient and barrier-free access to the power grid. Such difficulty in getting connected to the power grid is partly due to a constrained level of smart-grid technology available in China. This technology directly determines the grid’s capacity to withstand sudden changes in voltage loads. For example, a wind farm could generate fifty thousand volts in a flash, which requires that its corresponding converting station being designed to carry this much load, so that the stability of the power

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439 Jingyi Han et.al (n 204).
440 Ibid.
441 Ibid.
442 Mathews and Tan (n 379).

grid as a whole will not be affected. However, due to the low power-dispatching ability of the current grid, wind power is considered to be “trash power” because it is neither predictable nor controllable. Thus, in practice the proportion of wind energy connected to the grid is kept below 20 per cent. To upgrade power grid to accommodate power fluctuations and properly distribute in-taking capacity for intermittent energy sources, China has been making significant investment in the area. In the State Grid Corporation of China project, the Chinese government put 9.4 billion Yuan on this demonstrating project to integrate wind and solar photovoltaic generation and storage devices into the state power grid. Yet, at the same time, the grid needs to establish a number of thermal power units for energy emergencies in order to facilitate wind energy. While in low power-consumption periods, such as during the Spring Festival and other holidays, or when there is a failure of in-taking capacity of the grid, wind farms will be requested to "abandon wind." Nevertheless, the power grid will have to spend more to accept intermittent wind power than energy generated from more stable resources like hydropower or thermal power. Some have suggested the solution of using energy storage technology to offset the uncertain character of wind power. However, the cost is too high (5 Yuan/kWh) making this option unfeasible in practice.

Secondly, the high feed-in tariffs (in comparison with fossil fuel power) stipulated by the DRC led to reluctance in the national grid to purchase renewable energy. From the power grid side, the price difference between the feed-in tariff for electricity generated from desulphurized coal and the tariff for renewables is paid by the national government, levied from renewable energy tariff surcharges.[443] Renewable energy-power price surcharges are collected by

[443] Convention on Biological Diversity (n 413).

provincial power grid. Although they are used for payment of some province (autonomous region, municipality) subsidies for renewable energy power prices, and the remaining amount is designed to be used for quota trading and national balancing, they are favoured by the power grid companies because they are accounted for as company income and taxed accordingly.[444] On the other hand, the power gird companies[445] are obliged to purchase all electricity generated by the approved power plants, and to provide transmission and supply to end-users. However, when the approved purchasing price is higher than the price of fossil fuel power, the extra cost is apportioned within the whole power grid.[446] In addition, currently China's power grid must require fossil fuel power plants to limit their output at times to allow renewable energy in-taking because the renewables like wind power have fluctuating or unstable voltage characteristics.[447] Such ancillary services needed to promote renewables lead to a conflict between fossil fuel power plants and renewable energy plants. This is because the uniformed tariff mechanism determines a proportional relationship between the operation hours of generator and company profit. Therefore, none of the companies are willing to lower their generator utilization hours, which will also increase the cost for the power enterprises and cannot be compensated under the existing pricing mechanism. Most of the time, the grid and the local government would prefer not to reduce fossil fuel power plants' output rather than avoid wind abandon, as they benefit more from thermal power enterprises from a lower energy price and higher tax revenue. As a result,

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[444] To advance the development of the renewable energy industry and ensure the rational distribution of renewable energy power price surcharges, and, based on the Chinese Renewable Energy Law 2006 and the Convention on Biological Diversity, this Commission has formulated, upon research, the UNFCCC.

[445] The State Power Grid Corporation and the Southern Power Grid Corporation.

[446] Jingyi Han et.al (n 204).

[447] for example on a windy day, wind farms would provide more electricity than average. As the grid can nolt takes in fixed amount of electricity at once, it has to ask the thermal power plants to take downtimes in order to take in all electricity generated from wind recourses.

harsher requirement is put on renewable firms. For example, while the effective tax rate for conventional thermal power plants is about 6 per cent to 8 per cent, the government tax biomass power plant at 11 per cent.[448] Due to the low energy density, and the high cost of biomass fuel, pre-processing, transportation and energy storage, biomass power plants struggle to profit under such tax rate. At the end of the day, as traditional power plants are reluctant to provide such ancillary services, the local government has to force them to take turns cutting down on production. Therefore it becomes an administrational burden to the local authority as well.[449]

In addition, although the DRC stipulates that for concession/approval projects it is the power grid's responsibility to construct a transmission line to the power plants,[450] "there is no obligation regarding the time the construction should be finished or the standard of transmission line."[451] Many renewable power plants thus need to build an additional transmission line to the distant grid at extra cost to its construction expenses in order to secure early completion. However, grid expansion is too costly for power plants, with an average cost of 350 million Yuan to construct 100 km of transmission line.[452] Power plants such as wind farms and biomass power stations are normally built in remote areas due to

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448 Xie (n 416).

449 R.A.P. and CHANGCE, *Research on the Reform of China 's On-Grid Tariff Mechanism* (The Regulatory Assistance Project, Feburary 2016).

450 On August 13, 2013, the National Development and Reform Commission issued the "Interim Measures for distributed power generation management", requiring the grid companies take responsibility for access facilities and consequent alteration expenses for investment and construction related to distributed power generation projects, and to ensure that electricity from distributed power generation enjoys priority and full acquisition. Distributed power generation projects that meet the criteria required by the DRC are to be given construction subsidies or unit power generation subsidies. From October 2012 to February 2013, the State Grid has issued the "Opinions on implementation of providing on-grid services for distributed photovoltaic generation" and "Opinions on implementation of providing on-grid services for distributed power generation." On-grid service will be provided free of charge with priority for access of not only the distributed power generated from photovoltaic, but also to 10kv and below projects of solar energy, natural gas, biomass, wind, geothermal energy. The favourable policy has expanded to a comprehensive utilization of resources and many types of power generation.

451 Jingyi Han et.al (n 204).

452 Ibid.

their possible effect on the local environment. In such cases, power plants will have to pay for a considerable amount of construction to get access to the main power grid; not to mention a much more expensive grid upgrade, with better transformers suitable for the nature of renewable power or to improve the efficiency of electricity transportation.[453] In practice, application for grid connection has become a barrier to access for public grid facilities. In order to avoid instability and trivial issues, the power grid has no inclination towards in-taking renewable energy and smaller power generation enterprises. According to the interviewees,[454] most of the pre-project constructions and applicable procedures were conducted by the power plants. In getting approval for grid connection, one of the interviewed power plant representatives claimed that they acquired many costly documents, such as project feasibility reports and scientific research to finally get an approval. It required more than 100 stamps from different departments and took one and a half years to go through all the procedures including seeking approval from the provincial Power Construction Corporation as well as the provincial DRC's project approval.[455] Finally, while accepting applications from any qualified power plants, the power grid sets up difficulties during the processing of connection approval. Except for the pre-connection works including acquiring approvals from different government departments and institutions, the power grid will ask power plants to provide a feasibility survey for connection, grid connection designs, as well as most of the infrastructure needed for connection (partial power grid construction, transmission line construction, relay construction and converting station construction). If a

453 Ibid.
454 A general summary of interviews with government officer and plant manager interviewees.
455 CDM manager interviewee from Shandong Wulian Dongfeng Phase I Wind Power Project.

power plant refuses to develop these infrastructures, the grid will find excuses to postpone their application for connection, which means significant deficits each day because they have to pay off the interest and loan principals needed to build the projects in the first place. In fact, the national government clearly required the grid to complete such facilitating jobs[456] and provided special funds to support the grid for construction and maintenance of transmission facilities. Unfortunately these works that ought to be undertaken by the grid have virtually all been completed by power plants. As a result, many companies have renounced the use of renewable energy, and a large amount of electricity generated from already established wind farms is rejected by the grid and so wasted. This so-called "wind abandon," is due to the lack of ability to absorb fluctuant wind power by the local grid and causes operational downtime among wind farms. "Therefore, the current renewable energy landscape in China, especially in the case of wind power, features a backlog of completed projects which are not actually connected to the grid."[457] Behind the booming construction of renewable energy projects, the expense required to sustain long-term development of the industry remains high in China.

With high generation costs, renewables in China are sold at relatively low on-grid prices. This has brought a great economic burden onto the renewable energy investors and postpones

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[456] Chinese Renewable Energy Law 2006 article 14: "Power grid enterprises shall conclude grid connection agreements with enterprises which generate electricity by using renewable energy resources and which have gone through the administrative licensing or archive-filing formalities according to the plan for the development and utilization of renewable energy resources, purchasing in full amount the on-grid electricity of the grid-connected power generation projects which meet the grid connection technical standards in the coverage area of their power grids. Electricity generating enterprises are obliged to cooperate with power grid enterprises in protecting grid security.
Power grid enterprises shall strengthen the power grid construction, expand the scope of areas where electricity generated by using renewable energy resources is provided, develop and apply intelligent power grid and energy storage technologies, improve the operation and management of power grids, improve the ability for absorbing electricity generated by using renewable energy resources, and provide services for bringing electricity generated by using renewable energy resources on grid." English version available at http://english.mofcom.gov.cn/article/policyrelease/Businessregulations/201312/20131200432160.shtml

[457] Ramon, 'Wind Energy Takes Off in China' (*China Environmental News*, 17 June 2008) <http://china-environmental-news.blogspot.co.uk/2008/06/wind-energy-takes-off-in-china.html> accessed Feburary 2017, quoted by Caprotti (n 322).

many power companies from getting involved in renewables in China, as they wait for the market to reach maturity and become profitable. At the same time, the development of renewable energy is also a large expense for the Chinese government, as it requires hundreds of billions to subsidize the sector. To break through the vicious circle of “high costs/low price – insufficient investment – high costs,”[458] an improvement in renewable energy technology commercialization and reduction in price of such technologies are crucial.

6.7.4 Renewable energy project application cost

The cost of starting-up a green-energy project is high. As well as investment on plant construction itself, the cost includes the approval of application expenses, the price of established managerial experience, and building up and maintaining public relations. Moreover, the process usually takes a long time, absorbing lots of human resources, and adequate social network. During subsequent operation, power plants need to overcome the difficulties derived from overlapping government authorities while making small profits from the meagre feed-in tariffs.

Renewable power plant establishments are categorized as approval projects (some refer to them as “concession projects” [459]) that need approval from the DRC.[460] For example, power companies that intend to construct wind farm projects larger than 50 MW were required to get approval from the national DRC before 2013, and smaller projects had to be approved by the provincial and lower-level government.[461] Since May 15th, 2013, according to the Plan for

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458 Jingyi Han et.al (n 204).
459 Ibid.
460 The Catalogue of Investment Projects Subject to the Approval of Government (Issued by the State Council, effective 2013; Invalidated by：Notice of the State Council on Issuing the Catalogue of Investment Projects Subject to Government Confirmation 2014)
461 Jingyi Han et.al (n 204).

Institutional Reform and Functional Transformation of the State Council and the Decision of the State Council on Matters Concerning Administrative Approval Items to be Cancelled and Delegated to Lower Levels, the National Energy Board decentralized its authority to provincial governments in regard to wind power project approvals. So from 2013 approving renewable wind and biomass projects is at the discretion of each province. But the central government still has significant influence on business decisions of the power companies by holding the right of approval, mainly executed through the provincial DRCs. For example, the National DRC selects several locations for wind farm concession (project-bidding), according to the wind resource report provided by the China Meteorological Administration. "Power companies who are interested in generating electricity from wind energy, and provide investment facilities like the establishment of access roads and power grid" are only invited to bid for the development rights from the selected locations and a limited number of projects.[462] Moreover, since the renewable industry is virtually dependent on state subsidies, the national energy authorities remain responsible for quantity control, feed-in tariff setting, and subsidy budget management.

Application for approval of renewable energy generation projects requires renewable energy companies to hand in project proposals and relevant application documents. According to our interviewees,[463] the approval process usually starts with a decision from headquarters based on a review of the project distribution plan designated by the current national five-year plan.[464] Then the power company conglomerate will try to acquire government project

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[462] Ibid.
[463] manager interviewees from all three wind projects and the three Guoneng funded biomass projects.
[464] The currently effective five-year plan is The 13th Five-Year Plan for Environmental Protection.

approval, followed by plant construction. During construction, application for power grid connection and the establishment of peripheral infrastructure needed for the connection will be conducted at the same time. After the completion of construction, or sometimes during construction, operation staff will then become involved in the project. During the process of application for the approval, companies need to provide many documents required by the DRC. According to the Administrative Measures for the Investment Projects Subject to the Approval of Government (2014)[465] Article 12, project applicants need to submit the following documents in accordance with national laws and regulations: (a) the site suggestion issued by local-government planning administrative department (for projects required to use state-owned land); (b) preliminaries of land-allocation opinions issued by the land and resources administrative department; (c) the environmental impact assessment issued by the environmental protection department; (d) an energy conservation review; and (f) certification for urban planning, land use, resource utilization, public safety production, public interests, production licence, equipment imports, tax exception confirmation, and so on. Among them, project filing, the feasibility report, environmental impact assessment, the land-use report, proof of funds, preliminary government planning approvals, the safety assessment with safety evaluations before and after the construction, are the most important documents, each incurring a cost ranging from ten thousand to 200 thousand Yuan. Therefore, on average, expenses to get domestic approval are at least one million Yuan per project. For the projects that are applying for CDM-certified CO_2 reductions, power companies will have to pay for audit and administration fees required by the CDM, which are approximately 50-70 thousand

[465] The Catalogue (n 460).

Yuan. Also, project developers will need a consulting agency to prepare documents and manage the project application, which will cost about 30–40 thousand Yuan. Moreover, CDM will charge an issue fee based on the amount of CER issued. Thus, for a project issued with 100 thousand tons of CO_2 reduction, it will be charged 15 thousand dollars (about 100 thousand Yuan). This adds up to more than 200 thousand Yuan per CDM project to be spent on application.

Because renewable energy projects are “approval projects”, they have to go through the most demanding project approval procedures. Project developers need to get approvals and authorization from dozens of government departments including the DRC, the Environmental Protection Bureau, the Department Of Water Resources, the Department of Land Resources, Provincial and City Planning Bureau, the Provincial Bureau of Public Construction, and so on. In recent years, some projects with plants to be built in mining areas also needed to provide a report of the mineral richness and underground water of the located area. For off-shore wind farm projects, applicants need to get approval from departments like the State Oceanic Administration and the Fishery Bureau. Not only do these procedures cost money but they also require plenty of time to be spent on preparing documents and waiting for decisions. For example, a wind power project calls for 1–2 years to conduct anemometry, and then a qualified Electric Power Design Institute will be commissioned to finish a feasibility study report, which will normally take six months to a year. Afterwards, the pre-project feasibility study will be submitted to the DRC and they will review the supporting documents for two years. Some have to go through an even longer period because they have to start from a township-level DRC and proceed to the province level. When all application documents have been reviewed by the provincial DRC, the commission will put the project onto a waiting list before a national planning is completed and made known at the provincial level. Having received approval from the DRC, power companies then need to get in contact with the provincial power grid and wait for the grid connection approval application to be reported to the national grid; and this usually takes another year to receive a final decision. These procedures add up to at least a four to five-year period, which is a considerable cost in time and an increase in risk. Another commonly cited project category is that of "recorded projects," which are generally small-scale and domestic utility projects for which criteria are relatively low that only require reports for recordation. But projects that involve large-scale energy generation, especially those employing advanced renewable energy technologies, ought to go through more stringent procedures which require a minimum of 770 days for processing.[466] Thus, even before construction, large sums of money, time and expertise have been invested in the application process. In more complex cases where inter-province power grid constructions are needed, the grid establishment itself is subject to the approval of the investment administrative department of the State Council.[467]

6.8 Difficulties in decision-making and management

While provided with meagre profits due to the current feed-in tariff, large SOEs in China are obligated to develop renewable energy projects. In fact, they are the ones that have the finance and the capability to improve green technologies to adapt to local situations.

[466] interview with CDM manager from the Shandong Wulian Dongfeng Phase I Wind Power Project

[467] Notice of the State Council on Issuing the Catalogue of Investment Projects Subject to the Approval of Government (2014): Power grid project that is:
1) ± 500 kV and above DC project conducted cross-border, inter-provincial (district, city);
2) 500 kV, 750 kV, 1000 kV AC project conducted cross-border, inter-provincial (district, city), shall be approved by the State Council Investment Director Departmental. Among them, ± 800 kV and above DC projects and 1000 kV AC projects are to be reported to the State Council for record. The rest of the projects will be approved by local governments, of which ± 800 kV and above DC project and 1000 kV AC project should be approved in accordance with national planning.

However, these companies are not able to make investment decisions freely and entirely by themselves due to the interdependency of power and grid companies in meeting government planning rules and requirements.[468] Decision-making in the power companies is strongly influenced and constrained by local and national government. This is particularly true because the directors of these companies are under the supervision of the Communist Party secretary of the company, or serve in Party posts at the same time. Therefore, the system may result in power enterprises lacking the capacity to act fully autonomously in their own interests.

The underlying problem with the ruling party in China itself has a long history. With definite power over the minority of issues in China, the Party had it's ruling become more effective regulating the country than the enforcement of Laws. And it had been a frequently resorted aid to pursue social goals of the people.[469] Therefore, the decision-making of power companies does not depend on the company board and managing team solely, but "depends on the fluid and conflicting interests"[470] of different authorities under the country's leadership. For example, management teams of the state-invested/controlled companies are "are evaluated on the basis of their adherence to government objectives, with possible consequences for their future careers."[471] In terms of technology import and innovation, business behaviour has to act in accordance with political preference. According to the interviewees,[472] even though a developed country's transferor is willing to provide help by all means (equipment, blueprints, know-how, training, etc.), there is still a risk of technology

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468 Gosens and Lu (n 86).
469 Feldman (n 292).
470 Ibid.
471 Hongbin Li and others, 'Political Connections, Financing and Firm Performance: Evidence from Chinese Private Firms' (2008) 87 Journal of development economics 283; Chenggang Xu, 'The Fundamental Institutions of China's Reforms and Development' (2011) [American Economic Association] 49 Journal of economic literature 1076.
472 R&D staff from a world leading turbine manufacturer and the technical director of the provincial power gird.

failure. This might be due to a change of environment and material resources during production. And it requires bold investment without specific expectations in return by the receiver. But the leader election system in these large Chinese state-owned companies is a hindrance to technology import and innovation. A leadership team only last for 3–5 years and most decision-makers would want a good record of achievements during this period. This is why a lot of companies are focused on making quick money and only take a minimum level of risk when investing. As renewable energy projects are low in profits, they are not much liked by most executives. Thus, the slow improvement of China's independent technology is exacerbated by the persistence of such conservative attitudes.

Even among private-owned companies, those that have a close relationship with the Party will be clearly favoured during competition. "China's indigenous innovation policy included a mandate to consolidate industry so that one or a few Chinese companies would dominate key sectors."[473] "After decades of reforms, SOEs today produce an estimated half of China's total manufacturing and services output and they dominate such sectors as energy, telecommunications, and transportation."[474] Interviewees[475] indicate that at present renewable technologies are only affordable by large state-owned/state-invested companies as the cost of construction and operation is substantial, and government subsidies and preferential loan systems are easier for SOEs to get access to. These companies have better

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[473] The Commission on the Theft of American Intellectual Property.

[474] Andrew Szamosszegi and Cole Kyle, *An Analysis of State-Owned Enterprises and State Capitalism in China* (2011).

[475] interviews with managers from the Shandong Shanxian 1*25MW Biomass Power Plant Project, the Shandong Gaotang 30 MW Biomass Power Generation Project and the Shandong Haiyang Qiuershan Wind Power Project

guanxi[476] with the government and are thus well informed regarding government resources and planning which will allow them to start preparation earlier than private companies.

At the same time, the small profit margin is not attractive enough to involve massive private sources in the renewable energy industry,[477] while the increased cost of fundraising currently deters investors from entering the renewable energy industry. The interest rate available for SOEs is six per cent annually, and coupled with the financing expenses the interest rate will be raised to seven per cent to eight per cent. For private companies, the cost will be even higher. On the other hand, the feed-in tariff is coming down while operational expenses in renewable energy power plants are growing as discussed in previous sections. It is getting more and more unrealistic to comply with the return rate requirements of the State-owned Assets Supervision and Administration Commission of the State Council[478] (i.e. wind power projects shall have a 12 per cent rate of return). And "uncertainty over power prices (depends on government approval) further hinders the inflow of capital focused on renewable energy projects."[479] Such a market is considered unhealthy because "private investment has become the predominant force in wind farm construction in other more established markets. For example, around ninety-five per cent of investment in wind farms was contributed by the

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[476] It is based on personal networks and actually has great influence on social/political relationship in Chinese society.

[477] Power companies used to have plenty of capital available, but this too has changed in recent years. Coal prices have risen, while electricity prices remain fixed at low, government-determined levels. See Chi-Jen Yang, Xiaowei Xuan and Robert B. Jackson, 'China's Coal Price Disturbances: Observations, Explanations, and Implications for Global Energy Economies' (2012) 51 Energy Policy 720. The weaker financial performance of the utilities' core businesses may now hamper wind farm investment. See Liming Qiao and others, *China Wind Energy Development Update 2012* (2012)

[478] The SASAC is a crucial department of the Chinese government, which is entrusted with formal ownership and management of all non-financial state enterprise assets. It plays an investor in the SOEs for the government to have a better control of decision-making of these companies. See Chi Lo, *Understanding China's growth: forces that drive China's economic future* (Springer 2007).

[479] Caprotti (n 322).

private sector in India."[480] Moreover, the future of the Chinese renewable energy market is worrying.

Similarly, from the renewable energy IP protection aspect, the aforementioned localization policy has intervened in the market and created an unexpected need for domestically made renewable power generators. The intended promotion of the local manufacturing capacity of wind turbines and boilers is enticing companies to invest in acquiring manufacturing processes and technologies. Indeed, "The mandatory localization rate policy has shown its function in expanding domestic supply markets and reducing costs."[481] However, the gap between capability and production aims of the local manufacturers drives them to either provide low-quality[482] equipment or to steal technologies from the exporters. Therefore, although the average cost of renewable energy equipment has declined, the overall cost from a power plant's operation and maintenance has not been substantially reduced. The obsession with the percentage of localized production ultimately resulted in unsatisfactory IP development in China for infringement is seemed inevitable as it is rooted in any developing country's instinct and acquiesced to pursue the country's interest. "Just as the government is intimately involved in businesses of all types and government officials are privately involved in private businesses, the government is involved in infringement."[483]

Government control over the price of electricity and project approval has resulted in the uncertainty in the energy market, making investors hesitant to participate in the market. For example, establishing a wind farm requires a land lease permitted by the government.

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480 Ibid.
481 Jingyi Han et.al (n 204).
482 Quality criteria can relate to individual turbine scales, annual full load hours, lifetime of turbines, etc.
483 Feldman (n 292).

> Leases for industrial purposes last for 50 years, but development permits typically require the developer to construct a farm within two years or lose the development rights. To safeguard long-term renewable energy strategies, power companies are competing to secure sufficient land with prime wind resources.[484]

With the growth of wind resource exploration, the best locations that have access to good quality wind resources have become fewer and fewer. The costs of acquiring approvals and the costs of constructing wind farms are increasing accordingly, especially with regard to the development of off-shore wind powers. For instance, between 2000 and 2005 when development of wind power was strongly encouraged in some places, land usage was easy to get approved and assigned with zero rental costs. Lately land costs have become increasingly high and it is rather difficult and expensive to apply for plots.[485] As a result, although the price of wind turbines has decreased, with increasing project development costs there has been no substantial decrease in construction costs per kWh. Consequently, the development of wind power in China is restrained. Such recession would not be discovered from a macro perspective at the national level, but is evident in local-government behaviour. Our interviewees implied that a lot of projects that were approved have now been required to withdraw.[486] A few plants were shut down and become non-performing assets to the conglomerate.[487]

The recent slowdown was seen in the biomass sector as well. Permit authority for biomass power plants is in the hands of provincial governments. The stricter control over permits of

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[484] Gosens and Lu (n 86).
[485] Interviews with government officers recruited from Weihai, Yantai and Rizhao.
[486] Ibid.
[487] Turbine suppliers such as Tianjin Vestas are being acquired because the business prospects are gloomy.

the government is actualized through site-selection limitation determined by the provincial Power Design Institute, which is virtually a government agency. A site-selection decision by the Power Design Institute is one of the first documents needed for the approval of an application. Therefore, the Institute has absolute power over the assignment of lands for the development of renewable energy power plants. It provides a fuel resource survey, according to which a site is considered suitable for biomass power plant construction. The institute will delimit a radius, and within it only one biomass plant will be approved for construction. As far back as 2005, the radius was 30 km, which was changed to 50 km later, and to 80 km subsequently and is now delimited to 100 km.[488] As the radius becomes wider, fewer biomass power plant projects are approved. Malicious speculation in the biomass energy industry has led to this restriction as well. Interviewees[489] claim that an enclosure of project resources by some investment companies has been saturating of the market. Opportunistic project applicants were grabbing land leases not to develop renewable power plants themselves but in order to wait for good-faith developers who intend to, or are forced to, invest in power plants and may have to buy out/take over the development permission. Indeed, such speculative activity is able to bring faster and greater profits than developing and operating a renewable energy power plant. Even for a real developer, "the financial benefits of being able to exploit these resources for the next 50 years"[490] outweigh the less productive power plant, which requires ten to twenty years to get investment returns. Therefore, from 2010, the national DRC has partially withdrawn the install capacity approval authority in order

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488 Interviews with manager interviewees from Shandong Kenli Biomass Generation Project and Shandong Gaotang 30MW Biomass Power Generation Project and government officer interviewees from Gaotang and Shanxian.
489 Ibid.
490 Gosens and Lu (n 86).

to control such irresponsible project enclosures. As a result, no biomass power project was approved between 2010 and 2012.

The economic concern of the local government is another factor that could result in hardship in developing renewable energy projects. Especially from the recession in 2008 onwards, the government has been desperate to stimulate domestic demand to keep up economic growth that can be reflected in GDP, which is the key criterion for the evaluation of government performance. Yet renewable energy projects enjoy a three-year tax exception and a three-year 50 per cent tax deduction to follow.[491] Such a preferential tax policy can act as an opportunity for the power companies to hide other business activities under the approved projects so that they can profit more than they should have by enjoy low tax rates.[492] Even if the businesses were carefully monitored to avoid such tax-evading behaviour, none of the renewable energy power plants are profiting sufficiently to be counted as major taxpayers. Thus, the more renewable projects are constructed in the province, the more likely is the government's revenue to decline. Accordingly, local government is encouraging renewable energy industry with a flagging interest. Unless there is a fundamental political change in China with more business-friendly channels opening up, a new pattern of business behaviour will not be seen.[493] Likewise, only when and if the availability and access of the most advanced renewable energy technologies become economical will all doubts and hesitation about the wide appliance of such technologies be dismissed and lead to the growth of more commercial and affordable equipment.

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491 Interview with officer interviewees recruited from all visited regions where projects are located.
492 Jingyi Han et.al (n 204).
493 Wen-Qiang Liu, Lin Gan and Xi-Liang Zhang, 'Cost-Competitive Incentives for Wind Energy Development in China: Institutional Dynamics and Policy Changes' (2002) 30 Energy Policy 753 p.761.

6.9 Summary

This chapter has clearly identified the current energy needs and environmental problems derive from such growing needs in China. Therefore attempts have been made by the Chinese government to pursue a balance in between. Measures in terms of IP law reform and encouraging policy are made available to renewable energy developers to improve legal environment and technology absorptive capacity in the country in order to facilitate and attract TT in developing. Among these efforts, a variety of favourable policy created by the Chinese government has played a critical role in promoting TT much more effectively than the IP law amendments required by TRIPS and forced under pressure from developed countries. However, there still exist the considerable costs regarding almost every aspect of introducing ESTs. And plenty of difficulties in terms of the political status are challenging the future of China's sustainable development. Thus, wise reforms to change the situation should be made with respect to the culture and interest of people in the country.

Chapter VII: Conclusion

7.1 IP Solutions at international and national level

Based on the observations and analysis set out in the previous chapters, some sensible and potentially workable reforms are to be pursued in order to provide solutions to current barriers and difficulties.

7.1.1 Preparatory stage

Given the fact that there are significant differences in circumstances between each country, nations need the freedom, to the maximum extent, to experiment and decide upon commitments to international obligations.[1] Thus, at a primary stage of intended reforms to the current international IP law system, before any substantial amendments are made to TRIPS provisions, proper mechanisms should be made available to member states under the Agreement, which should make it easier for adaptations and will have a positive effect on climate change TT on an international level. For example, "multilateral monitoring and information exchange mechanisms can play a useful role in helping [countries] to learn what constitutes effective [TT]"[2] and when adjusting standards for green technology IP protection enforcement. In practice, it is a problem for developing countries that have little knowledge about the availability of the most advanced technologies and the detailed methods of international TTs. To reduce the problems of such asymmetric information, TRIPS could serve transitionally "as an intermediary conduit for knowledge about successful technology

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[1] Gerald K. Helleiner, 'Markets, Politics and Globalization: Can the Global Economy be Civilized?' (2001) 2 Journal of Human Development 27; J. Michael Finger, *The Doha Agenda and Development: A View from the Uruguay Round* (ERD Working Paper Series 21, 2002); Charles Sabel and Sanjay Reddy, 'Learning to Learn: Undoing the Gordian Knot of Development Today' (2007) 50 Challenge 73.

[2] Bernard Hoekman, Keith E. Maskus and Kamal Saggi, 'Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options' Research Program on Political and Economic Change Working Paper PEC2004-0003 <http://www.colorado.edu/IBS/pubs/pec/pec2004-0003.pdf> accessed Feburary 2017

acquisition programs that have been undertaken by national and sub-national governments in the past."[3] It could also provide information such as a list of suggested royalty rates, conditions and contract clauses that will make it a high possibility for both parties in the TT to reach an agreement. Of course, such services would require extra efforts in multilateral monitoring and private/public cooperation from both developed and developing countries.[4] But it would be beneficial as a mild reform of the current system, moving towards the goals of the Agreement.

7.1.2 Introductory stage

A second stage of the transition period could allow a soft landing for all member states before any fundamental amendments made to the Agreement. Fostering the TT of climate mitigation technologies, which is "logically viewed as an essential element of the global solution to the climate change problem"[5] could be achieved with a more specified approach but in a less binding manner at this stage. For example, private collaboration between companies from developed and developing countries on "sector-specific training programs, technological cooperation projects, pilot plants involving technology leaders and laggards"[6] are confirmed to be very effective ways for technology dissemination. These can be actively promoted within the TRIPS Council and indicated in the reports of the Panel and Appellate Body, which have great influence over the interpretation of current articles. Ambiguity in the relevant provisions

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[3] "Thus, it is well documented that the Japanese Ministry of Industry and Trade (MITI) played an active role in encouraging ITT. However, practical details about the policies adopted are not readily available." Bernard M. Hoekman, Keith E. Maskus and Kamal Saggi, 'Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options' (2005) 33 World Development 1587 (n 2).
[4] Sabel and Reddy.
[5] Matthieu Glachant and Jean Philippe Nicolai, 'The Incentives to North-South Transfer of Climate-Mitigation Technologies with Trade in Polluting Goods' (2016) Center of Economic Research at ETH Zurich, Working Paper 16/242.
[6] Ibid.

could be utilized through favourable guidance towards more active measures that are needed for increasing ITT.

7.1.3 Sound stage

"Another hotly debated solution is to differentiate IPRs for specific green technologies."[7] This could be done at a later stage than practical mechanisms established at the international level. By introducing amended patent terms, compulsory licensing, fast-track patent application programmes[8] or voluntary patent pools[9] only in the green technology field, the IP system could be altered for the specific needs of climate change mitigation without affecting the entire structure of the TRIPS agreement.[10] Some have furthered this approach of expanding the global commons for knowledge that will eventually lead to negotiations over agreements on access to technologies (in the climate change context, green technologies in particular).[11] These agreements are supposed to be applied by all WTO member states parallel to or under TRIPS. Such an approach would have the result of placing inventions and innovations of publicly funded research into the public domain. "The idea is to preserve and enhance the global commons in science and technology without unduly restricting private rights in commercial technologies."[12] Countries, according to their technology development

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[7] Matthew Littleton, 'The TRIPS Agreement and Transfer of Climate-Change-Related Technologies to Developing Countries' (2009) 33 Natural Resources Forum 233.

[8] Eric L. Lane, 'Building the Global Green Patent Highway: A Proposal for International Harmonization of Green Technology Fast Track Programs' (2012) 37 Berkeley Technology Law Journal.

[9] see Hoekman, Maskus and Saggi (n 2); David G. Ockwell and others, 'Key Policy Considerations for Facilitating Low Carbon Technology Transfer to Developing Countries' (2008) 36 Energy Policy 4104; Keith Maskus, 'Differentiated Intellectual Property Regimes for Environmental and Climate Technologies' (2010) OECD Environment Working Papers No 17; Glachant and Nicolai (n 5).

[10] Lane (n 8). It has been noticed that China, Japan, the U.K. and the U.S. have launched the accelerated patent examination for green-energy technologies.

[11] John H. Barton and Keith E. Maskus, 'Economic Perspectives on A Multilateral Agreement on Open Access to Basic Science and Technology' in Simon J. Evenett and Bernard M. Hoekman (eds), *Economic Development and Multilateral Trade Cooperation* (The World Bank 2006)

[12] "The agreement could cover either 'input liberalization' under which researchers from other countries could participate in, or compete with, local research teams for grants and subsidies, possibly combined with increased opportunities for temporary migration of scientific personnel and additional student visas; 'output Liberalization' under which researchers in other countries would have access to nationally generated science and data, including scientific databases, thus ensuring that IPRs not limit access

capacity and needs should be allocated with different obligations. Obviously, bold proposals like these will have to provide "safeguards for security-related regulation,"[13] and allow member states "to reserve sensitive areas of technology and to designate different levels of commitment to open access," in order to encourage ratification.[14]

At the same stage, modifications made to the TRIPS provisions could be introduced. For example, as discussed earlier, a more practical provision requiring patent applications to disclose know-how used in inventions could be added to the Agreement. Moreover, favourable terms could be offered to member states when dealing with IP in order to make a national political effort on climate change and renewables, including setting up a meaningful carbon price and encouraging renewable energy literacy among different types of companies. This could be actualized through developed country members' duties where they are required to provide "technical and financial cooperation" for TRIPS implementation to all developing countries.[15] Alternatively, by expending the scope of article 66.2[16] from the LDCs to all developing countries on the basis of the common interest of the planet (for example, climate change mitigation goals), governments (especially those of developed nations) will endeavour to find means of increasing international TT to meet their legal obligations. "One option would be for governments in developed countries to increase technical and financial assistance for

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to basic scientific knowledge; or, 'full liberalization'. The latter would combine the first two, both expanding international flows of research contracts and personnel and increasing global access to outcomes." Hoekman, Maskus and Saggi (n 2).

[13] Ibid.

[14] Ibid.

[15] The TRIPS Agreement.

[16] Article 66.2: "Developed country Members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base." See Suerie Moon, 'Does TRIPS Art. 66.2 Encourage Technology Transfer to LDCs?: An Analysis of Country Submissions to the TRIPS Council (1999-2007)' UNCTAD - ICTSD Project on IPRs and Sustainable Development, policy brief No 2 December 2008 <https://iprsonline.org/unctadictsd/docs/New%202009/Policy%20Briefs/policy-brief-2.pdf>

improving the ability of poor countries to absorb technology and engage in trade."[17] As a result, financial mechanisms under TRIPS would target "capacity building in IPRs and technical regulations and standards, establishing public and public-private research facilities, and facilitating trade in technology-related services."[18] Given the different interests, environmental needs and technology capability of developing countries, efforts towards the harmonization of criteria regarding factors such as patentability, term of patent, compulsory licensing, and national emergency within TRIPS should be tested at first in a limited way at the regional level through, for example regional IP offices that apply regional standards.[19] In this way, it would avoid upheaval in all member states simultaneously and therefore cushion the blow. These could be possible options towards a balanced approach that takes into account the interests of both producers and users of technological knowledge included by TRIPS in its objectives. With a common understanding about the issues of climate change and a minimized impact upon innovation and patent application rates, such a differentiation would have a better chance of being agreed by most member states of TRIPS.

7.2 IP protection, policy-making and business strategy for the future Chinese renewable energy market

Despite the difficulties discussed in the previous chapter VI and the high cost of receiving renewable energy technologies for developing countries like China so far, importing and absorbing such technologies could be crucial to the objective of protecting the global environment. Recognizing this, the Chinese government has played a critical role in promoting

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[17] Hoekman, Maskus and Saggi (n 2).
[18] Ibid.
[19] Ibid.

TT much more effectively than the IP law amendments required by TRIPS and forced under pressure from developed countries. This is actualized through preferential policies granted to clean-energy industries, subsidies, technology localization requirements, and mandatory renewable energy quotas among big power enterprises. Worryingly, due to some subsidies already ceasing, the use of green tech is in decline. As a result, reforms to facilitate climate change TT should be made as early as possible in the current transition stage because they could ease the burden of climate change technology use and innovation in the future. In this global climate change crisis, society must be awakened to the peril before it is too late. Any investment that is meaningful for the mitigation of climate change must be seen as a source of environmental security in the long term, not seen exclusively as something to protect the financial interests of companies. The need for collaborative regulation and global policy incentives to foster the creation of markets for environmental TT should be highlighted in future international negotiations.

Governments in the developed and developing world should put effort into establishing a financially practical framework to facilitate TT beyond expediency.[20] To some extent, such an establishment should enable developing countries like China to address their need for environmental technologies and start to play an active role in TT as transferors. Failure to facilitate IP law reforms tailored to cope with environmental problems and the efficient enforcement of such reforms have the potential to limit China's ability to maintain its current position in the global renewable energy industry, and may hamper international efforts on climate change mitigation. However, we should keep seeking a healthier pattern of growth

[20] Including significant donation from all government and encouraging national policies to facilitate TT.

that must be established in China with only necessary and sufficient respect to IPRs because it will affect the country's economy when it has gone through the current transition period and reaches higher levels of technological advancement.[21]

Constant attention to IP protection and IP law enforcement is unquestionably needed. Although there is hesitation about transferring the most advanced technologies to China, a considerable proportion of China's economic growth still depends on TT from abroad.[22] Incentivized by the size and policy of the domestic market, it seems that IP protection has not hindered TT to China. However, with the growing need for climate change technologies in China, it was and will be even harder to get cutting-edge technologies from foreign enterprises or multinational corporations if they are wary of the poor IP environment.[23] Therefore, from the pull-side of TT, China has to shift focus away from growth that "leads to a continued focus on a carbon-fueled economy,"[24] and promote "areas in which China's renewables market is exhibiting clear signs of innovation and leadership, as opposed to reaction to market conditions."[25] China is now developing a remarkable number "of its own energy technology that it has a home-grown incentive to increase the protection of energy technology IPR in its market."[26] Thus, consolidating IP protection and education is a benefit for China's long-term development as well.

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21 See Louis S. Sorell, 'A Comparative Analysis of Selected Aspects of Patent Law in China and the United States' (2002) 11 Pac Rim L & Pol'y J 319.

22 Vikram Nehru, Aart Kraay and Xiaoqing Yu, *China 2020: Development Challenges in the New Century* (World Bank: PREM Sector Department (EASPR), 1997) p.11.

23 See Edwin Mansfield and Banco Mundial, *Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer* (1994)

24 Federico Caprotti, 'China's Cleantech Landscape: The Renewable Energy Technology Paradox' (2008) 9 Sustainable Dev L & Pol'y 6.

25 Ibid.

26 Kiel Downey, 'Intellectual Property Rights and Renewable Energy Technology Transfer in China' (2012) 9 SCJ Int'l L & Bus 89, supra note 50

Traditionally, China was described as "a net importer of renewable energy technology, technical know-how, and project development capabilities. This is especially the case where established technologies—developed mostly outside China—are concerned."[27] However, as we have discussed in this research, from 2005 onwards, after a generation of absorbing foreign capital and technology, China is now beginning to export them and becoming a manufacturer of other renewable energy generation equipment. In the case of wind power, many foreign manufacturers are facing increasing pressure to market themselves in China now, in contrast to the time when the supply of the vast majority of turbines and components depended on imported technology.[28] In the biomass energy sector, the acquisition of the Danish biomass technology company Bioener during the financial crisis in 2009 brought Chinese biomass energy generator-manufacturing to a better position. Before this, each biomass power plant established by Guoneng (National Bio Energy Co. Ltd.) had to pay huge royalties to Bioener while at risk of the unpredictable cancellation of technology supply by the foreign licensor. However, by taking the opportunity created by the global finance crisis in 2008, Guoneng (National Bio Energy Co. Ltd.) acquired its former licensor Bioener and the BWE (Burmeister and Wain Energy A/S), and actualized technology localization with all of its biomass energy projects. In recent years, Guoneng (National Bio Energy Co. Ltd.) has begun to export its equipment, know-how, and experiences to other countries as well. According to my interviewees,[29] foreign clients such as the Philippines have been in contact with the Guoneng (National Bio Energy Co. Ltd.) head office about biomass power generation. The delegations

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27 Caprotti (n 24).

28 See Wen-Qiang Liu, Lin Gan and Xi-Liang Zhang, 'Cost-Competitive Incentives for Wind Energy Development in China: Institutional Dynamics and Policy Changes' (2002) 30 Energy Policy 753.

29 manager interviewees from Shandong Gaotang 30MW Biomass Power Generation Project and Shandong Shanxian 1*25MW Biomass Power Plant Project.

are forwarded to Guoneng (National Bio Energy Co. Ltd.) funded plants in Shandong to conduct on-site tours, investigations, and to discussion cooperation. In the foreseeable future, as the need to develop and diffuse its own indigenous technology among other countries grows, weak IP protection could become a handicap to Chinese renewable technology development. Indeed, moderately strong IP protection is helpful for securing returns for foreign investors as well as for up- and-coming domestic technology benefiters of TTs, and more importantly, it is absolutely vital for encouraging investment in R & D that is meaningful for the long-term growth of the renewables industry.[30] From this perspective, China needs to take enforcing IPRs more seriously in order to build a solid foundation for healthy development in the future.[31]

At the same time, a more effective IP system, particularly with respect to the climate change crisis, is needed. Chapter VI shows that in promoting renewable energy TT and encouraging technology innovation, the role that IP protection plays is minor and perhaps dispensable. Rather, IP protection enhancement is dependent on several conditions such as "increasing human capital, particularly in technical skills, expanding technical infrastructure, developing efficient managerial techniques, encouraging international trade and investment from abroad,"[32] and sufficient and timely support from government for the financial and political aspects. All of the listed factors demand huge investment and sacrifice from public and private sources. Meanwhile, in China the beneficial effects of enforcing climate change or renewable energy IPRs is subtle, because renewable energy technology utilization and innovation takes a

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[30] Robert M Sherwood, 'The TRIPS Agreement: Implications for Developing Countries' 37 IEDA 491 p.504.
[31] Mikhaelle Schiappacasse, 'Intellectual Property Rights in China: Technology Transfers and Economic Development' (2003) 2 Buff Intell Pro LJ 164.
[32] Keith E. Maskus, 'Intellectual Property Challenges for Developing Countries: An Economic Perspective' (2001) U Ill L Rev 457.

relatively small share of the energy market. Moreover, the earnings of the renewable energy industry currently depend on government planning and subsidies, which means relying on more factors such as “the country's gross domestic product (GDP), the share of the GDP that government is willing to spend on research and development (R & D).”[33] Therefore, in order to allow market forces to work freely, helping the renewable energy industry to find its position and future, a trend of decentralization of approval is needed. Government policies should increase the weight of market factors and encourage more private companies to participate in the renewable energy industry.

Nonetheless, it is imprudent to advise developing countries, especially the large mid-income ones like China, to become servile to Western standards, because, “it may actually be in the best interest of the developing countries not to encourage strong IPRs because piracy, or learning by copying, are more economically feasible”[34] at this stage of development and of the maximizing of the effectiveness of currently available climate change technologies. On one hand, renewable energy technologies are too complex to fully absorb and commercialize simply by reverse-engineering or piracy without the relevant know-how and other assistance from the technology holder.[35] On the other hand, it needs considerable investment from private and public sources of the TT receiving country to deliver wide application. This has been discussed in detail in the sections on climate change technology development status and the cost of such technologies. Thus, carefully loosened IP protection or moderately amended IP laws would have secured reasonable returns for technology inventors as well. Instead of

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[33] Keith E Maskus, ‘Intellectual Property Rights and Economic Development’ (2000) 32 Case W Res J Int'l L 471 p.277

[34] See Keith E. Maskus, ‘Lessons from Studying the International Economics of Intellectual Property Rights’ (2000) 53 Vand L Rev 2219 p.2222; Sherwood (n 30) p.503 (arguing that extremely poor countries have less to lose in pursuing strong IP protection).

[35] Sherwood (n 30) p.503.

being panicked about IP theft (which usually thieves are unable to learn from efficiently) and to boost economic development, countries could be looking for a more functional IP system that can play an active role in accelerating a technological innovation cycle and expanding climate change TT. To reduce the cost of climate change technologies by narrowing the range of IP protection,[36] the curtailment should push technology holders and developers to a position where they are spurred on to innovate for financial reasons. Actions such as: tacitly consenting to a shorter green-patent protection period articulated by national IP laws of a TRIPS member state; an easier way to acquire compulsory licensing on renewable energy technologies; or a lower compensation level of climate change IP infringement for environmental protection purpose; would have had a better effect on stimulating technology innovation, for they might have facilitated the maturing of a new technology to realize a commercialized and widely affordable price.[37] The fast tracks for green patents, which exist in the US and the EU,[38] can be used as a reference for such reforms and to distinguish climate change technology from irrelevant technology. As the filling process is shortened for green-patent applications, the protection period could be reduced accordingly. Generally speaking, a developing country which focuses on strictly protecting and enforcing IPRs that are actually trimmed according to the need of climate change mitigation, as well as

[36] for example, some ESTs that cost less in R & D or so crucially important to climate change mitigation can be excluded from patentability. This should be based on a case-by-case bisis.

[37] Jorrit Gosens and Yonglong Lu, 'Prospects for Global Market Expansion of China's Wind Turbine Manufacturing Industry' (2014) 67 Energy Policy 301.

[38] Antoine Dechezleprêtre, 'Fast-tracking "Green" Patent Applications: An Empirical Analysis' Centre for Climate Change Economics and Policy Working Paper No 127, Grantham Research Institute on Climate Change and the Environment Working Paper No 107 (2013) <http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/02/WP107-fast-tracking-green-patent-applications.pdf> accessed Feburary 2017; "The EPO has an online searchable global database of green patents, and the US Patent Office online database covers US patents only." Ros Davidson, 'Wind Manufacturers Act to Defend Intellectual Property Rights' (*Wind Power Monthly*, 26 January 2012) <http://www.windpowermonthly.com/article/1114292/wind-manufacturers-act-defend-intellectual-property-rights> accessed Feburary 2017.

incentivizing technology development, should be able to consolidate the legitimate interests of IP holders while enhancing sustainable economic growth in developing countries.

If IP is made more accessible for an exchange of better trade conditions and more efficient climate change mitigation in a developing country, correspondingly, the fairness, openness and transparency of China's domestic market, or of any other TT- receiving countries, will become equally important. Successful TTs cannot be disconnected from national treatment provided for foreign companies. An open economy are more likely to attract the FDI that involves TT while benefitting domestic businesses as well by absorbing and profiting from the technology received.[39] Removal or revision of protectionism articles in the Chinese contract law, patent law, and anti-monopoly law is more applicable across current renewable energy markets as the need for a transparent, consistent, predictable, precisely monitored and evaluated renewable energy sector grows.[40] The adoption of a more market-oriented, decentralized and less erratic government intervening over project planning and electricity pricing is needed to facilitate the industry.[41] Through an effective monitoring and evaluation system, the government can still have macroscopic control over the industry while avoiding the issue of lacking connections from renewable projects to the grid. In practice, "monitoring and evaluating programs can be constructed around a set of key indicators— such as the number of projects connected to the grid, or a series of connections over a specific time span—which clearly track progress."[42] Regarding policy-making, government should ensure fair competition in the renewable energy market, as "pressure to innovate will only exist if

[39] Maskus, 'Intellectual Property Challenges for Developing Countries: An Economic Perspective' (n 32) p.471.
[40] Wendy Annecke, 'Monitoring and Evaluation of Energy for Development: The Good, The bad and The Questionable in M&E Practice' (2008) 36 Energy Policy 2839.
[41] Liu, Gan and Zhang (n 28).
[42] See details in Caprotti (n 24).

manufacturers compete on equal terms in tenders."[43] It is, therefore, important to provide a fair and accessible platform for fund raising, to revise the localization percentage requirement,[44] and to push domestic developers to upgrade their technology to a good quality standard regardless of the cost. This will help rectifying warped growth among Chinese domestic manufacturers and release decision-making from non-market interference.

Any policy adjustment pursuing the above objectives will take a considerable amount of time and capital[45] before it noticeably affects society. Therefore, experimental reforms to IP laws and bold attempts at environmental policies need to be put into practice right now. At the current cost, to develop and apply renewable energy is still high and burdensome to most Chinese power companies. Renewable energy equipment manufacturers, on the other hand, do not yet appear to have the "strength to compete with global leaders in the most established export markets in the near future."[46] Therefore, Chinese power companies are more accepting of lower cost, lower-quality, domestically manufactured equipment. This could become a potential issue when the economic downturn passes and high-quality facilities are needed, as it will cost even more to dismantle and replace these cheaper ones. Therefore, while awaiting for changes in IP protection and improved environmental policy to take effect, developing countries like China should continue trying to take advantage of financial aids from international sources (such as the CDM), and use them as a springboard to establish a high starting point within its domestic market and to be equipped to reach out to the global market.

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43 Gosens and Lu (n 28).
44 Accomplished by introducing percentage quotas for installations with equipment from domestic suppliers. GWEC, *2012 Global Wind Report* (Annual Market Update 2012, Global Wind Energy Council (GWEC), Belgium, 2013).
45 Gosens and Lu (n 28)
46 Ibid.

Appendix I: Semi-structured interviewing questions

In this research four different categories of people will be interviewed from the Chinese firms' technology department, managerial department (including plant manager, in-house lawyers and manager in charge of CDM project) and local government department in relation to the energy industry. Each person will be invited to participate in interviews. Employees from technology department will be expert in assessing, implementing and replicating in particular, and well-knowledge with information that is directly based on technical abilities. Plant managers, lawyers and CDM managers will have an understanding of the difficulties in getting agreement and the legal/administrative procedures necessary for TT. And their opinions are also crucial for starting a project, selecting appropriate technology and replication of the technology absorbed afterwards. Regional government officers have a broader view of the development of the local energy industry and changes in policies. Analysis of the views of different type of practitioners will create a comprehensive understanding of the TT process and what role has IP law plays at the firm level. As according to the down-top operating model of CDM and GEF, most projects are initiated by private sector, thus any factors that would influence individual firms' in their TT action will ultimately result in TT failure.

What is their understanding of IP law? What difficulties have they experienced with IP issues? What expectation do they have on the current IP protection? And how efficient has the national law system and CDM been in facilitating TT in China? These questions are designed to find out enterprises' willingness and actual motivation to participate in TT,[1] the impression they have of IP law, their view of the current approaches available for them to get access to

[1] Is it because they share environmental protection zealousness or is it because that the projects provide profitable opportunities?

technology that is needed, and difficulties they have faced in receiving and innovating green technology.

Common questions as warm-up:

1. Name; position in the firm; what project have you been involved.
2. What is your understanding of climate change TT (technology pool, import equipment, licences, know-hows, future innovation)? Do you think it is worth importing climate change technologies and for what reason you think that way?
3. Do you consider climate change/or environmental protection an urgent issue to be dealt with? Give a number out of 10 to describe the urgency, and give an example to both "1" and "10".
4. What do you know about the Chinese IP system? (laws, policies, institutions, government departments, courts…) Did you have any experience working with them? How's your feeling about it?
5. What preparation do you have to make for the last TT project and how long did it take?
6. From what platform do you always be informed of new technologies that are useful for your project/company? Do you feel that there is enough information about climate-related technology accessible from commercial pathway?
7. What do you think are the most important means of financing environmentally sound technology transfer projects? Are you getting enough funding and facilitates to foster efficient technology transfer in your project and afterwards? If not, what is the

reason for the lacking and in what sectors do you think should be given more focal support?

8. Could you please name the key organizations in your country which you consider the most important in policy-making for adoption of climate-relevant technologies and/or for the selection and implementation of climate-relevant technologies?

9. Could you please provide a list of legal and technical assistance bodies in your region that you would turn to if you have any relevant difficulty during technology transfer? What kind of assistance and consultant do you think is necessary during and after a cooperative project? (for example inventory of technology agency or suppliers, inventory of specialized law firms, comparative assessment of technology platform…) Except for the known assistance, what other aids would you like to see the government provide for you in attracting and complementing TT?

10. If the green-techs are no longer patentable will you be more willing to employ them in your company activities? At the same time, will you develop on top on current available techs to improve the area?

Questions for legal department:

1. Did you ever come across with any difficulty that is due to patentability/strong or weak IP Rights protection? Any example in the last project you have attended? Did you benefit from exception to IP rights according to national policies and objectives (and techs that is acquired through compulsory licence or waiver by the owner)? Do

you have faith in compulsory licensing and why? Do you think that IP protection level will influence price of technology?

2. What disadvantages as a Chinese company in negotiating cooperation contracts? In what aspects do you feel that is not as good/proficient as foreign contractor? Dose any of these relevant to IP issues?
3. What procedures do your company have to go through during the last international TT? Is the national IP system friendly enough for international TT practice? How long did it take to finish legal procedures last time and what was the cost? Which steps do you think are unnecessary/repetitive/excess and why?
4. Please include as many key decision makers as you consider relevant, and list the contacts by various sectors, including energy, agriculture, transportation, forestry, industry, waste management, health, infrastructure and fishery sectors. Has your country set priorities for climate-relevant technology transfer in the various sectors? : If so, could you summarize your experience of the priority on mitigation and adaptation technologies by sector? In case your region has set priorities for one or more sectors, could you summarize key features of the planning and priority-setting processes that led to these priorities?

Questions for technology/technician department:

1. Could you please provide a list of institutes (with addresses) in your region that collect and disseminate technology-related information on sectors such as energy and

transportation? What information sources does your organization consult in the preparation of climate-relevant technology transfer initiatives?

2. In what form did the last imported technology transferred to your company (equipment, staff training)? Do you consider the technology you have received included core/basic IPs? Are those foreign technologies provided in a high/affordable price? Are there any domestic companies providing like products/service? Why did you choose to get techs from foreign sources? Is there any cost difference between domestic TT and international TT?

3. What do you consider as a reasonable time period for R&D, innovation and commercialisation of a new technology in the climate change technology industry?

4. What benefit did your department get from the project? Do you think you have further innovation capability now to develop new techs on your own or with other domestic firms after the TT? Will you do it and why? What will cost you in doing this (money, time, admin works)?

Questions managerial department:

1. What stimulus interested you to initiate the projects? What aid, grants and subsidies have been provided to you for implementing the project? What are the most feasible sources for financing climate-relevant technology transfer in your region?

2. Did you ever come across with any difficulty that is due to patentability/strong or weak IP Rights protection during the projects and after(any owner refuses to transfer or reveal information)? Why did those difficulties happen (are the transferor fear of

low protection in China or China's competence?)? How did you dealt with them and what did you compromise? Did you benefit from exception to IP rights according to national policies and objectives? Have you ever managed to make applications to gain any technology by compulsory licensing permission granted by the government?

3. Do you think the national IP system friendly enough for international TT practice? What is the percentage of fund is taken to operate IP related issues in the project that you have experienced? In what forms do you prefer to import technology (equipment, licence, know-hows) and what difficulties do they bring? Is current level of IPR protection deters you from making decision of further technology imports? In general how much did it cost to complete a TT? Are there any other cost does it take if you plan to develop the technology imported?

4. Are you looking forward to join another project like this again or import new techs from abroad in the future and why? Which sector in particular deters/encourage you from doing so?

5. Please include as many key decision makers as you consider relevant, and list the contacts by various sectors, including energy, agriculture, transportation, forestry, industry, waste management, health, infrastructure and fishery sectors. Has your country set priorities for climate-relevant technology transfer in the various sectors? If so, could you summarize your experience of the priority on mitigation and adaptation technologies by sector? In case your region has set priorities for one or more sectors, could you summarize key features of the planning and priority-setting processes that led to these priorities? What has your government done to facilitate the transfer and implementation of climate relevant technologies in different sectors in your country?

Questions for government officers in relation to the local energy industry

1. What are the favourable policies available for renewable energy project from the national level? What aid, grants and subsidies have been provided to the companies for implementing the project?

2. What are the favourable policies available for renewable energy project from the national level, including tax-deduction and land lease discount?

3. What have the local government done for financing and assisting climate-relevant technology transfer to your region?

4. What procedures are required to get a renewable energy project approved? Under what grounds will the government decline a proposed renewable energy project?

These questions are designed to find out enterprises' willingness and actual motivation to climate change mitigation,[2] difficulties they have faced in receiving and innovating technology and their impression about the current approaches available for them to get access to technology that is needed. And the interviewer will ask pilot questions prior to the formal interviews to test the effectiveness of semi-structured interviews adopted. Some people at certain positions,[3] especially state-owned enterprises, may not provide neutral opinions. The questions can be categorised with different themes for coding in Nvivo:

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[2] Is it because they share environmental protection zealousness or is it because that the projects provide profitable opportunities?
[3] E.g. Party Secretary

Themes:

▸ Access to and choice of technologies: Strong IP protection increase technology price, therefore cripple the companies from buying, keeping and innovate these green-techs; and also strong IP protection enables technology owner with primary control over TT and receivers could do very less about it. This theme relates to questions about opinion towards current IP system: e.g. Did you ever come across with any difficulty that is due to patentability/strong or weak IP Rights protection? Did you benefit from exception to IP rights according to national policies and objectives? Dose the national IP system friendly enough for international TT practice? Have you ever managed to make applications to gain any technology by compulsory licensing permission granted by the government?

▸ Difficulties caused by national and/or local government. This theme relates to questions about opinion towards Chinese government: Could you please name the key organizations in your country, which you consider the most important in policy-making for adoption of climate-relevant technologies and/or for the selection and implementation of climate-relevant technologies? Please include as many key decision makers as you consider relevant, and list the contacts by various sectors, including energy, agriculture, transportation, forestry, industry, waste management, health, infrastructure and fishery sectors. Has your country set priorities for climate-relevant technology transfer in the various sectors? If so, could you summarize your experience of the priority on mitigation and adaptation technologies by sector? In case your region has set priorities for one or more sectors, could you summarize key features of the planning and priority-setting processes that led to these priorities? Could you please provide a list of institutes (with addresses) in your region that collect and disseminate technology-related information on sectors such as energy and transportation? What has your government done to facilitate the transfer and implementation of climate relevant technologies in different sectors in your country?

- Assess need and possibility/feasibility to give exceptions to green-tech IP protections under TRIPS as it is urgent to deal with climate change. This theme relates to past experience of environmental international mechanisms: What aid, grants and subsidies has been provided to you for implementing the project? What do you think are the most important means of financing environmentally sound technology transfer projects? Do you feel that there is enough information about climate-related technology accessible from commercial pathway? Are you getting enough funding and facilitates to foster efficient technology transfer in your project and afterwards? If not, what is the reason for the lacking and in what sectors do you think should be given more focal support? What are the most feasible sources for financing climate-relevant technology transfer in your region?

- In applying TRIPS, has Chinese national IP law and governmental administration put heavy burden on enterprisers and deters them from importing and innovating upon foreign technology? This theme relates to questions about opinion towards launching and implementation of a project: What information sources does your organization consult in the preparation of climate-relevant technology transfer initiatives? Could you please provide a list of legal and technical assistance bodies in your region that you would turn to if you have any relevant difficulty during technology transfer? What kind of assistance and consultant do you think is necessary during and after a cooperative project? (for example inventory of technology agency or suppliers, inventory of specialized law firms, comparative assessment of technology platform…) What is the percentage of fund is taken to operate IP related issues in the project that you have experienced?

Codes such as:

- State-owned company;
- price/cost/time;
- assistant/funding/information/know-hows;
- procedure/administration;
- remedies;
- subsidies;
- future profits,
- understanding of IP law provisions,
- perception over IP related procedures,
- opinions on the particularity of climate change TT and its urgency
- motivations to benefit from innovation up on adopted technologies

will be put into analysis is to make sense of the massive amounts of data, reduce the volume of information, identify significant patterns and construct a framework for communicating the essence of what the data reveal. The research will try to find out enterprises' willingness and actual motivation to climate change mitigation,[4] identify what factors significantly

[4] Is it because they share environmental protection zealousness or is it because that the projects provide profitable opportunities?

affects TT decision-making and what difficulties are considered to be excessive and unbearable.

Appendix II: TT definition across disciplines

From an economist's perspective, technology is an important factor of economic development. They have long recognized that TT is "at the heart of the process of economic growth, and that the progress of different regions, in both developed and developing countries depends on the extent and efficiency of such transfer."[1] This is indicating that the economic goals weigh much when using economic discipline to define TT.[2] The limitation of an economist's lens is that it does not give much weight to the external factors, such as political factors, which have great impact on TT efficiency. In fact, political factors could be more influential in the context of climate change technology application. In contrast, sociology scholars often use innovation and technology as synonyms.[3] Sociologists consider the social effect of TT more than the economic input. TT is seen as a critical vehicle to help develop "the capacity for individuals and societies to cope with modernization and the constant change that accompanies it."[4] Such a perspective is highly valuable in the context of climate change mitigation, but it is limited when TT take place in-between countries in which one has less interest in capacity growth or living-standards improvement than the other.[5] This requires an international perspective that respects the benefits of all participating countries to increase ratification and cooperation.

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1 Edwin Mansfield and others, 'New Findings in Technology Transfer, Productivity and Economic Policy' (1983) 26 Research Management 11.

2 Giovanni Dosi, 'The Nature of the Innovation Process' in Giovanni Dosi and others (eds), *Technical Change and Economic Theory*, vol 988 (Pinter London 1988).

3 Everett M. Rogers, *Diffusion of Innovations* (4 edn, The Free Press, New York 2010).

4 Pranab Chatterjee and Henry Ireyes, 'Technology transfer: Implications for social work practice and social work education' (1981) 24 International Social Work pp. 14-22.

5 Surely some improvement in living standards in developing nations is wanted by the developed world (e.g. so that they can sell manufactured products etc. there). But such interest plays a minor role in motivating them taking actions to assist developing countries.

Anthropologists' work focuses on cultural evolution.[6] They do not study technology completely detached from the social environment; they study specific, individual technologies through particular cases. And they are "generally less concerned with the economic cost of technology but view technologies as existing and available."[7] Technology is considered as closely tied to other social phenomena, such as the economic development level of a country.[8] TT under this lens is seen as a tool to actualize the spreading of knowledge needed by the society.

From a management scholarship, TT is viewed as "a vehicle to either gain or sustain a firm's competitive advantages, or to bring financial and other benefits to collaborating firms."[9] Management theorists conceive of technology as "firm-specific information concerning the characteristics and performance properties of the production process and of product design."[10]

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6 George M. Foster, *Traditional Cultures: and the Impact of Technological Change* (New York & Evanston: Harper & Row. 1962); Elman R. Service, *Cultural Evolutionism: Theory in Practice* (Holt,Rinehart & Winston of Canada Ltd; First Printing edition 1971): "Technology is inert and passive. By itself it does nothing. Only when people use a technology in some way does it have an impact on human life. Therefore, they argue that we cannot say anything about the actual effects connected with a particular technology until we understand why and what people do with it."

7 L. Zhao and A. Reisman, 'Toward Meta Research on Technology Transfer' (1992) 39 IEEE Transactions on Engineering Management 13

8 Philippe Geslin, 'Anthropology, Ergonomics, and Technology Transfers: Some Methodological Perspectives in Light of a Guinean Project' (2001) 23 Practicing anthropology 23.

9 J. Ketteringham and J. White, 'Making Technology Work for Business' in Robert Lamb (ed), Competitive Strategic Management (Prentice-Hall 1984); J. M. Harris, R. M. Shaw and W. P. Sommers, 'The Strategic Management of Technology' in Robert Lamb (ed), Competitive Strategic Management (Prentice-Hall 1984); Chris Pappas, 'Strategic Management of Technology' (1984) 1 Journal of Product Innovation Management 30; Michael E. Porter, 'Technology and Competitive Advantage' in Competitive Advantage: Creating and Sustaining Superior Performance (The Free Press 2008).

10 Richard E. Caves, *Multinational Enterprise and Economic Analysis* (Cambridge university press 1996); John H. Dunning, International Production and the Multinational Enterprise (RLE International Business) (Routledge 2012); K. Pavitt, 'Technology Transfer Among the Industrially Advanced Countries: An Overview' in Nathan Rosenberg and Claudio Frischtak (eds), *International Technology Transfer: Concepts, Measures, and Comparisons* (New York (USA) Praeger 1985).

Appendix III: Absorptive capability in China

In many industries, like the wind sector, cooperation with foreign companies results in a form of equipment transfer through imports and assembly/factory setup in China rather than in transferring core technologies to local enterprises.[1] This might be due to a need to meet localization requirements[2] in the short term, while it is the transfer of knowledge and core technology that plays a crucial role in the establishment of a successful domestic renewable energy industry in the long term.[3] Despite a growth in capital strength to acquire foreign firms, the improvement of China's domestic absorptive capacity is another important factor facilitating TT.[4] In the renewable energy sector, sufficient support to fully absorb the most advanced technologies has not been developed. "Capability" includes the ability to absorb technology that was lawfully acquired as well as any given form of pirated IP, either from theft or from reverse-engineering of foreign renewable energy IP; and capability is considered to be low. This is due to the complex and interdependent nature of most core renewable-energy technologies, and "many Chinese firms do not have the complementary technology necessary to turn individual renewable energy IP into marketable products and services."[5] On the bright side, the risk of infringement due to unsatisfactory IP enforcement can be offset by the low absorptive capacity of the receiving market, therefore dismissing all the doubts on this score of the technology owners of TT to China.

[1] Interviews with technical group from all three wind projects.
[2] The 70% localization requirement by the DRC.
[3] Jingyi Han et.al, 'Onshore Wind Power Development in China: Challenges Behind a Successful Story' (2009) 37 Energy Policy 2941.
[4] Ivan Haščič and Nick Johnstone, 'CDM and International Technology Transfer: Empirical Evidence on Wind Power' (2011) 11 Climate Policy 1303.
[5] Kiel Downey, 'Intellectual Property Rights and Renewable Energy Technology Transfer in China' (2012) 9 SCJ Int'l L & Bus 89.

Absorptive capacity is "the ability of a firm to recognize the value of new information, assimilate it, and apply it to commercial ends."[6] It seems that China held significant shares of patents, globally, in renewable energy technologies, as discussed earlier in the chapter. In particular, in 2009, China owned over 10 per cent of patents in wind power, biomass, and concentrating solar power all over the world.[7] Moreover, approximately half of these patents originated in China.[8] However, when considering the number together with the scale of China's economy, which is larger than most developed countries,[9] the innovation density of the market is low.[10] This is particularly so in the renewable energy market, where supporting technology accumulation is still low and a facilitating grid has not been established. From this perspective, the most important reason that convinces foreign firms to transfer renewable energy technology to China is not the law reform but the low absorptive capacity and potential returns from the scale effect of the market. In the wind turbine generator industry more than 30 per cent of the leading manufacturers providing core components are foreign.[11] None of the domestic companies occupy unshakeable positions in the upstream market. Moreover, countries that already have a large amount of climate change technologies are expanding their IP possessions constantly. For example, according to the Clean Energy Patent Growth Index, new US green patents increased more than threefold since January 2010. "Trends include patents for power factor control and VAR support; sensor-system accuracy

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6 Wesley M. Cohen and Daniel A. Levinthal, 'Absorptive capacity: A new perspective on learning and innovation' (1990) Administrative science quarterly 128.

7 Bernice Lee et. al, *Who Owns Our Low Carbon Future?* (Intellectual Property and Energy Technologies: A Chatham House Report, 2009) p.15 figure 2.7.

8 Ibid.

9 Ibid.

10 Resident patent applications per 100 billion USD GDP is in fact growing in China since 2014. This is indicating that although Chinese companies were lack of capability of turning acquired IP into marketable products and services, they are becoming more and more capable of doing so.

11 Energy and Security Group, *Clean Energy: An Exporter's Guide to China* (US Department of Commerce, International Trade Administration, 2008) p.45.

and availability; and reliability, including of towers."[12] This is saying that China is not as technologically advanced as industrialized countries, and the gap could be widened if no effective measures are taken immediately. "But IP will be increasingly crucial as more patents are filed, technology is transferred to developing nations and the financial stakes grow in a larger industry."[13]

The absorptive capacity can be assessed by looking at a country's level of dependence on foreign technology. Use of licences from abroad largely reflects a weak capability and less technological competence among domestic entities.[14] From this perspective, low absorptive ability is very evident in the wind energy sector in China. For example, although the Chinese government began to make efforts in attracting international TT soon after it installed the first utility-scale wind turbines in 1997,[15] and in the following year, especially between 2003 and 2009[16], it continued to encourage the development of indigenous wind technology through protectionist policies. Until now, many Chinese wind turbine manufacturers rely heavily on foreign licences, with most of these firms assembling rather than manufacting turbines. The interviewees mentioned[17] that although many turbine suppliers now claim to have independent designs, as buyers they understand this to mean being "more mature in

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[12] Ros Davidson, 'Wind Manufacturers Act to Defend Intellectual Property Rights' (*Wind Power Monthly*, 26 January 2012) <http://www.windpowermonthly.com/article/1114292/wind-manufacturers-act-defend-intellectual-property-rights> accessed Feburary 2017.

[13] Ibid.

[14] See Joanna I. Lewis, 'Technology Acquisition and Innovation in the Developing World: Wind Turbine Development in China and India' (2007) 42 Studies in comparative international development 208; Rasmus Lema and Adrian Lema, 'Technology Transfer? The Rise of China and India in Green Technology Sectors' (2012) 2 Innovation and Development 23; Joanna Lewis and Ryan Wiser, 'Fostering a Renewable Energy Technology Industry: An International Comparison of Wind Industry Policy Support Mechanisms' (2005) Lawrence Berkeley National Laboratory 1844

[15] "China's earliest manufacturers were two joint ventures between foreign and domestic manufacturers, created as part of a government program (the 'Ride the Wind' program of 1997) (State Planning Commission (SPC), 1997)" Jorrit Gosens and Yonglong Lu, 'Prospects for Global Market Expansion of China's Wind Turbine Manufacturing Industry' (2014) 67 Energy Policy 301.

[16] "Making wind farm development permits conditional on a minimum percentage of locally manufactured content (stated by the NDRC in 2003 and 2009)" ibid.

[17] A common perception of all three manager and technical group interviewees from wind projects.

assembling components sourced from suppliers."[18] The situation is a lot better in lower-capacity turbine manufacturing since 2010 because a number of manufacturers have been inspired to cooperate with foreign partners to design turbines, incentivized by internal and external assistance from both financial and technological angles.[19] The reputable Chinese independent innovation institution – the Wind Energy Technology Institute of Shenyang University of Technology – is able to license to well-known domestic companies such as Sany, New United, Sharpower, and many other smaller suppliers in China to develop 750 KW and lower capacity turbines.[20] However, no Chinese entities have yet managed to license wind energy technology to a foreign partner. And the smaller firms are not able to file any patents related to turbine manufacturing.[21]

As a result, although China's cumulative wind power installed capacity continues to rank first in the world, most wind turbines installed in 2014 are mainly 2 MW and less, accounting for 87 per cent of newly installed capacity, while 3 MW and above turbines account for only 4 per cent of total installations.[22] This is due to the aforementioned better localization rate in lower-capacity turbine manufacturing in the Chinese market. Moreover, these indigenous turbines tend to be licence-free, use fewer core component imports, and are thus a lot cheaper than equipment purchased from overseas. According to interviewees from Gosens and Lu's study, such a large proportion of lower-capacity turbine installation resulted from a

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[18] Interview with technical director from the Shandong Weihai 69 MW Wind Power Project.

[19] "As recently as the period between 2006 and 2011, a number of manufacturers received financial assistance from the Global Environment Fund and the NDRC to develop multi-MW wind turbines, in cooperation with foreign technology partners (under the China 'Renewable Energy Scale-up Program'; CRESP, 2012)." Gosens and Lu (n 15).

[20] China Wind Energy Association (CWEA), *The 2012 China Wind Power Installed Capacity Statistics* (http://wwwcweaorgcn, 2013) (In Chinese).

[21] Gosens and Lu (n 15).

[22] For analysis of annual installation capacity increase and a study of Chinese wind turbine cooperations, see Beijixing Power, 'Analysis of Installation Capacity in 2010-2014 (in Chinese)' (*http://fd.bjx.com.cn/*, 2014) <http://fd.bjx.com.cn/zhuanti/2014zjrl/> accessed Feburary 2017.

preference for a more economical way of coupling lower-capacity, lower-cost turbines, e.g. two 1.5 MW turbines cost less than one 3 MW turbine.[23] Such statistics reflect a lack of ability and motivation to fulfil market demand for large-capacity turbines in the short term.

A vicious circle can be found in the turbine manufacturing industry. At present most Chinese turbine makers still depend on core component imports with only the supporting systems being produced domestically. As a result, a larger proportion of the total profit of the sales is enjoyed by the foreign suppliers. Consequently, fewer funds are available for domestic R & D activities because the Chinese companies are not making enough profit to invest in innovation. With manufacturers being unable to upgrade indigenous turbines, short-sighted wind farms seeking cheap equipment suffer by paying more money and spending more time to maintain domestic turbines than imported ones. According to my interviewees, turbines produced by Goldwind and Sinovel, although known as sales champions in China (even in Asia) are reported to have the highest failure rate during operation. Interestingly, wind farms use an intuitive criterion to assess the performance of a turbine brand: the number of customer service personnel sent from the manufacturer. Companies like Vestas or XEMG, send only 5 or 6 people to look after the wind farm installed with their equipment. A small crew is able to take care of the whole farm. In contrast, maintenance staff that Sinovel hired to look after a wind farm usually added up to dozens of people. This is indicative of a higher failure rate. Some turbines produced by even smaller enterprises are more problematic because these private investors are in pursuit of profit alone. Therefore they tend to employ the cheapest components, regardless of quality and suitability. Maintenance costs of these turbines are

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[23] Gosens and Lu (n 15).

significantly higher and they need to be overhauled on a monthly basis. In order to avoid shutdown times, some irresponsible wind farms even abandon regular overhauls, leading to an increase in safety risks. In comparison, imported turbines have low failure rates and high full-load hour capability. According to Han and Lu, the average full-load hours of wind turbines in China (1,787h) is “much lower than that in Western countries such as United Kingdom (2,628h), Australia (2,500h) and United States (2,300h).”[24] They also investigated cases where “a wind turbine with 2000 designed full load hours can actually be in operation for only 300h a year.”[25]

The notorious IP problems in China’s market are known to many developed countries,[26] but such an impression is based on many products with most of them being very different to renewable energy technology.[27] Infringements of IP mostly appear in the entertainment and apparel industries[28] where pirate activities can be carried out with simpler technology at a low cost. Simple consumer products refer to, end-use consumer products that can be sold directly to customers without any intermediate steps, such as books, software, movies, music, and video games.[29] In contrast, to utilize stolen information about renewable energy technology, such as the chemical composition of a biofuel requires “a very specialized set of complementary skills, know-how, and equipment.”[30] The generation, connection, transmission and sale of electricity from biofuel also require “a vast, complex network of

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[24] Jingyi Han et.al (n 3)
[25] As was the case for three Huarui wind turbines installed in Boligenshan Wind Farm in 2003, quoted by ibid (n 3).
[26] See Office of the US Trade Representatives, *2016 Out-of-Cycle Review of Notorious Markets* (Executive Office of the President, at wwwustrgov, December 2016).
[27] Ibid.
[28] Kristina Sepetys and Alan Cox, ‘Intellectual Property Rights Protection in China: Trends in Litigation and Economic Damages’ NERA EcoNoMIc CONSULTING (2009) <http://www.nera.com/extimage /PUB IPR ProtectionChina_0109_final.pdf.> p.9.
[29] As of September 6, 2012, the black markets for these goods in China equalled $52 million (books), $565 million (movies), $466.3 million (music), $8.9 billion (software), and $589.9 million (video games). Havoscope, ‘Black Market Crime in China’ (*Global Black Market Information*, 2012) <http://www.havocscope.com/tag/china/> accessed Feburary, 2017.
[30] Downey (n 5).

products, processes, trade secrets, and know-how."[31] Without assistance from the experienced and specialized technology owner, lacking a strong base in its own ancillary technology, "a Chinese renewable energy firm that gains access to one piece of foreign technology cannot necessarily integrate that piece of technology into its operations."[32] As a result, successfully pirated renewable energy IP is actually hardly ever found in the Chinese market, reflecting the fact that Chinese firms are unable to integrate foreign IP into their operations fluidly.[33]

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31 Ibid.
32 Ibid.
33 See Office of the US Trade Representatives (n 26), See also Chpater V for detals.

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FORM UPR16

Research Ethics Review Checklist

University of Portsmouth

<u>Please include this completed form as an appendix to your thesis (see the Postgraduate Research Student Handbook for more information</u>

Postgraduate Research Student (PGRS) Information			**Student ID:**	639934
PGRS Name:	Xi Zhang			
Department:	Law	**First Supervisor:**	Professor Munir Maniruzzaman	
Start Date: (or progression date for Prof Doc students)		**1st October 2011**		

Study Mode and Route:						
	Part-time ☐	Full-time ☒	MPhil ☐	PhD ☒	MD ☐	Professional Doctorate ☐

Title of Thesis:	Climate-Change-Related Technology Transfer to China in the TRIPs Age and the Prospective Strategy in the Real World
Thesis Word Count: (excluding ancillary data)	87620

If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

UKRIO Finished Research Checklist:
(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: http://www.ukrio.org/what-we-do/code-of-practice-for-research/)

a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES ☒	NO ☐
b) Have all contributions to knowledge been acknowledged?	YES ☒	NO ☐
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES ☒	NO ☐
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES ☒	NO ☐
e) Does your research comply with all legal, ethical, and contractual requirements?	YES ☒	NO ☐

Candidate Statement:

I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)

Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):	E250

If you have *not* submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:

Signed *(PGRS)*:		**Date:** 30/09/2017

UNIVERSITY OF PORTSMOUTH

Xi Zhang <xi.zhang@port.ac.uk>

Ethics Review application ref E250

Sharman Rogers <sharman.rogers@port.ac.uk> 16 July 2013 at 14:07
To: Xi Zhang <xi.zhang@port.ac.uk>
Cc: Damian Carney <damian.carney@port.ac.uk>

Dear Xi Zhang

Ethics application ref E250 has now been approved.

Best wishes

Sharman Rogers

E
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