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博士学位论文

关于二氧化碳排放与可再生能源转型的经济驱动的研究

Essays on the Economic Drivers of CO₂ Emissions and Renewable Energy Transition

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摘要

本论文包括六篇独立的文章，涉及两个不同的研究主题：二氧化碳排放和可再生能源消费，这两者都是在减缓气候变化的背景下进行研究的。除了第 1 章的介绍，论文的每一章都是一篇论文，独立解决一个具体的研究问题。前三篇文章研究了二氧化碳排放的影响因素，其余三篇论文集中探讨了可再生能源转型的驱动因素，以此作为解决二氧化碳排放和气候变化的解决方案。第一篇文章（第 2 章）研究了工业化对尼日利亚二氧化碳排放的影响。文章采用 Kaya 恒等式框架并使用时间序列分析技术。结果表明，工业化与尼日利亚的二氧化碳排放有负相关关系，这与传统上论文工业结构转型对环境有害的观念相悖。在第一篇文章的基础上，第二篇文章（第 3 章）通过研究经济发展与二氧化碳排放之间的非线性关系，验证了五个非洲国家中环境库兹涅茨曲线假说的有效性。文章进一步将经济发展分解为工业和农业经济发展。采用了 STIRPAT 经验模型和面板协整方法。结果表明，EKC 假说在非洲是无效的，不论经济发展是由农业还是工业化驱动。第三篇文章（第 4 章）进一步关注运输部门的二氧化碳排放。它研究了城市化对亚洲运输部门二氧化碳排放的影响以及私营部门投资在减少排放方面的作用。使用与第 3 章相同的方法，结果表明城市化对交通二氧化碳排放的影响取决于其他因素。还有证据表明，私营部门对运输部门的投资以及铁路运输基础设施的发展对运输部门二氧化碳排放有减少的作用。此外，分析表明，对于具有相同城市化水平的两个亚洲国家，如果该国私营部门在运输部门和铁路基础设施方面的投资较高，则其运输部门二氧化碳排放量将会降低。第四篇文章（第 5 章）研究了影响可再生能源份额，特别是中国可再生能源电力份额的因素。在向量误差校正模型的框架下使用时间序列分析方法，结果表明经济和金融发展促进了中国的可再生能源消费，而贸易开放，外商直接投资和化石燃料工业的“游说效应”削弱了该消费。第五篇文章（第 6 章）基于前一篇文章，研究了四十六个国家中可再生能源消费的决定因素，特别关注非水电可再生电力在总用电量中的份额。使用面板协整方法，结果表明，经济因素对非水电可再生能源消费的规模和份额有不同的影响，这些影响大多数是长期的。油价的上涨和金融发展在提高非水电可再生电力的规模和份额方面发挥了重要作用。贸易开放对非水电可再生能源发电的份额有显著的积极影响。经济发展对非水电可再生能源的规模扩张产生了积极影响，但对其在总用电量中的份额产生了负面影响。外商直接投资，对“京都议定书”的认可，固定资本形成总额和资源租金对非水电可再生能源消费没有影响。最后一篇文章（第 7 章）探讨了知识产权保护对可再生能源消费的影响。Ginarte-Park 指数用于衡量知识产权保护的强度，而可再生能源在最终能源消费总量中的份额用于衡量可再生能源消费。结果表明，知识产权的水平和改革对可再生能源消费没有显著影响。

关键词：二氧化碳排放；可再生能源；可持续发展；缓解气候变化

Abstract

This thesis comprises six self-contained essays and deals with two distinct research topics - CO₂ emissions and consumption of renewable energy - as they relate to climate change mitigation. In addition to Chapter 1 which is the introduction, each essay represents one chapter of the thesis and addresses a specific research question. The first three essays look at the influencing factors of CO₂ emissions while the remaining three essays focus on the drivers of renewable energy transition as a solution to rising CO₂ emissions and climate change. The first essay (Chapter 2) analyses the impact of industrialisation on CO₂ emissions in Nigeria. The essay employs the Kaya Identity empirical framework and uses time series analysis techniques. The results show that industrialisation has a negative relationship with CO₂ emissions in Nigeria, undermining the notion that industrial structural transformation is harmful to the environment. Building on the first essay, the second essay (Chapter 3) investigates the validity of the environmental Kuznets curve (EKC) hypothesis in five African countries by investigating the non-linear relationship between economic development and CO₂ emissions. This essay further disaggregates economic development into industrial and agricultural economic development. The STIRPAT empirical model and panel cointegration methods are adopted. The results show that the EKC hypothesis is not valid in Africa, regardless of whether economic development is driven by agriculture or industrialisation. The third essay (Chapter 4) further focuses on CO₂ emissions from the transport sector. It studies the impact of urbanisation on transport CO₂ emissions in Asia and the mitigating role of private sector investment in the transport sector. Using the same method as Chapter 3, the results show that the impact of urbanisation on transport CO₂ emissions depends on other factors. There is also evidence that private sector investment in the transport sector and the development of rail transport infrastructure have reduction effects on transport CO₂ emissions. In addition, the analysis shows that for two Asian countries with the same level of urbanisation, transport CO₂ emissions will be lower in the country with higher private sector investment in the transport sector and rail infrastructure. The fourth essay (Chapter 5) studies the factors influencing the share of renewable energy, particularly electricity in China. Using time series analysis and vector error correction model, the results show that financial and economic development promote renewable energy use in China while trade openness, foreign direct investment and the “lobby effect” of the fossil fuel industry undermine it. The fifth essay (Chapter 6) builds on the previous one and investigates the determinants of renewable energy use in forty-six countries, focusing specifically on the share of

non-hydro renewable electricity in total electricity consumption. Using panel cointegration methods, the results show that economic factors have different impacts on the size and share of non-hydro renewable electricity consumption, and these impacts are mostly in the long run. Increase in oil price and financial development play significant role in enhancing both the size and share of non-hydro renewable electricity. Trade openness has a significant positive impact on the share of non-hydro renewable electricity generation. Economic development has a positive effect on the size of non-hydro renewables but a negative impact on its share in total electricity consumption. Foreign direct investments, ratification of the Kyoto protocol, gross fixed capital formation and resource rent do not have impact on non-hydro renewable electricity consumption. The last essay (Chapter 7) examines the impact of the protection of intellectual property rights on renewable energy consumption. The Ginarte-Park index is used as an indicator of the strength of intellectual property right protection while the share of renewable energy in total final energy use is used to indicate renewable energy consumption. The results show that the level and reform of intellectual property rights do not have significant impact on renewable energy use. Overall, the study shows that the drivers of CO₂ emissions and renewable energy transition may differ from country to country. Hence, country-specific policies, rather than a generalised approach, should be adopted to achieve climate change mitigation.

Keywords: CO₂ emissions; Renewable energy; Sustainable development; Climate change mitigation

Contents

Claim of originality	ii
Copyright	iii
Abstract (Chinese version)	iv
Abstract (English version)	v
Contents	vii
List of Tables	viii
List of Figures	x
Chapter 1: Introduction	1
1.1 Background to the study.....	1
1.2 Problem statement.....	5
1.3 Research questions.....	7
1.4 Thesis outline and summary.....	7
1.5 Author's published work.....	15
Chapter 2: Impact of industrialisation on CO₂ emissions in Nigeria	16
Chapter 3: Is the environmental Kuznets curve hypothesis a sound basis for environmental policy in Africa	44
Chapter 4: Urbanisation, private sector investment in the transport sector and CO₂ emissions in Asia	71
Chapter 5: Factors influencing renewable electricity consumption in China	95
Chapter 6: Focusing on the right targets: What drives non-hydro renewable energy transition?	117
Chapter 7: Does intellectual property rights protection constitute a barrier to renewable energy? A preliminary econometric investigation	144
Chapter 8: Conclusion	161
References	165
Acknowledgement	197

List of Tables

- Table 2.1** Summary statistics of variables
- Table 2.2** Summary of augmented Dickey Fuller (ADF) unit root test results
- Table 2.3** Lag selection order criteria
- Table 2.4** Cointegration rank test
- Table 2.5** Results of cointegration equation
- Table 2.6** Summary results of short term dynamics (VECM)
- Table 3.1** Definition of the variables used in the study
- Table 3.2** Descriptive statistics for the variables used in the analysis
- Table 3.3** Results of panel unit root test
- Table 3.4** Pedroni panel cointegration test
- Table 3.5** Kao residual cointegration test
- Table 3.6** Johansen Fisher panel cointegration Test
- Table 3.7** Summary of the fully modified OLS regressions
- Table 4.1** Definition of the variables used in the study
- Table 4.2** Average of the variables for the selected case countries in Asia
- Table 4.3** Summary statistics of the variables for the selected case studies in Asia
- Table 4.4** Results of Fisher-ADF panel unit root test
- Table 4.5** Results of Im-Pesaran-Shin unit root test
- Table 4.6** Johansen-Fisher panel cointegration test
- Table 4.7** Summary of the fully modified OLS (FMOLS) regressions
- Table 5.1** Summary result of ADF unit root test
- Table 5.2** Lag selection order criteria
- Table 5.3** Johansen cointegration rank test
- Table 5.4** Summary result of the vector error correction model
- Table 5.5** Langrange-multiplier test for serial correlation
- Table 5.6** Jarque-Bera test for normality
- Table 5.7** Result of forecast-error variance decomposition (FEVD)
- Table 6.1** Definition of the variables used in the study
- Table 6.2** Panel unit root tests
- Table 6.3** Pedroni cointegration test

Table 6.4 Kao cointegration test

Table 6.5 Johansen Fisher panel cointegration test

Table 6.6 FMOLS and DOLS regressions

Table 6.7 Robustness checks of the FMOLS and DOLS estimates

Table 6.8 Short run dynamics

Table 6.9 List of countries in the study

Table 6.10 Summary of current literature on the determinants of renewable energy adoption

Table 7.1 Summary statistics of the variables

Table 7.2 Correlation matrix of the variables

Table 7.3 Summary results of the impact of IPR on renewable energy (all countries)

Table 7.4 Regression analysis of the impact of IPR on renewable energy (developing countries)

Table 7.5 Impact of changes in IPR on renewable energy

List of Figures

- Figure 1.1** Trend of global CO₂ emissions from energy consumption
- Figure 1.2** CO₂ emissions in developed (OECD) and developing (non-OECD) countries
- Figure 1.3** Proportion of fossil fuel and renewable energy in total final energy consumption
- Figure 1.4** Framework of the thesis and linkages among the case study papers
- Figure 2.1** GDP growth and GDP per capita growth rates in Nigeria, 1980-2012
- Figure 2.2** Sectoral composition of GDP in Nigeria, 1980-2011
- Figure 2.3** Industrial, agriculture and service value added (as % of GDP) in Nigeria
- Figure 2.4** Trend of CO₂ emission in Nigeria, 1980-2012
- Figure 2.5** Roots of characteristic polynomial
- Figure 3.1** Trend of CO₂ emissions per capita (mmt) in five selected Africa countries
- Figure 3.2** Trend of GDP per capita (US\$) in five selected Africa countries
- Figure 3.3** Energy intensity (Btu per US\$) in five selected Africa countries
- Figure 3.4** Energy structure (%) in five selected Africa countries
- Figure 3.5** Urbanisation rates (%) in five selected Africa countries
- Figure 3.6** Population growth (%) in five selected Africa countries
- Figure 5.1** Electricity consumption and CO₂ emission in China
- Figure 5.2** Share of renewables in total electricity consumption in China, 1980-2011
- Figure 5.3** Plot of actual and fitted values of renewable electricity consumption
- Figure 5.4** Graph of eigenvalue stability test
- Figure 5.5** Impulse response function (IRF)
- Figure 7.1** R & D investments in different regions in 2005 (%)
- Figure 7.2** Systematic impacts of intellectual property rights

Chapter 1: Introduction

1.1 Background to the study

The world has experienced significant and unprecedented global warming in the past few decades. The level of global temperature has shown consistent and significant increase from the beginning of the twenty-first century. According to NOAA National Centers for Environmental Information (2017), global average temperature levels have broken record five times since the start of the 21st century. In 2016, global average land and sea surface temperatures were 0.94°C and 0.75°C respectively above the 20th century average. The resultant global warming has been identified as a major cause of extreme weather events and environmental catastrophes in recent years (AAAS, 2014). It is also associated with economic losses and poses considerable threats to the progress already made in global development. For example, an IPCC report (Parry et al, 2007) noted that climate change is detrimental to economic development, health, poverty reduction, ecosystem and even human survival. Therefore, this has raised concerns among global governments and decision makers.

There are very strong proof that climate change is as a result of human activities (AAAS, 2014; Walsh et al., 2014). Human activities and socio-economic phenomena such as production and consumption, population growth, industrialisation, urbanisation, transportation and combustion of fossil fuel energy are among the chief factors causing climate change as well as other environmental problems. Research has shown that CO₂ emissions from the combustion of fossil fuel energy sources are largely responsible for climate change (Boden et al., 2012). According to climate scientists, CO₂ emissions blanket the earth and block heat from escaping into the atmosphere, thereby causing increase in temperature (Walsh et al., 2014). Figure 1.1 shows the trend of global CO₂ emissions from energy combustion in the past three decades. From the available statistics, there is an upward trend of energy-related CO₂ emissions. Specifically, CO₂ emissions from energy consumption increased from 18.4 billion metric tonnes in 1980 to 32.7 billion metric tonnes in 2010, indicating a 77.5% increase over this period; and have stabilised around 33 billion tonnes afterward.

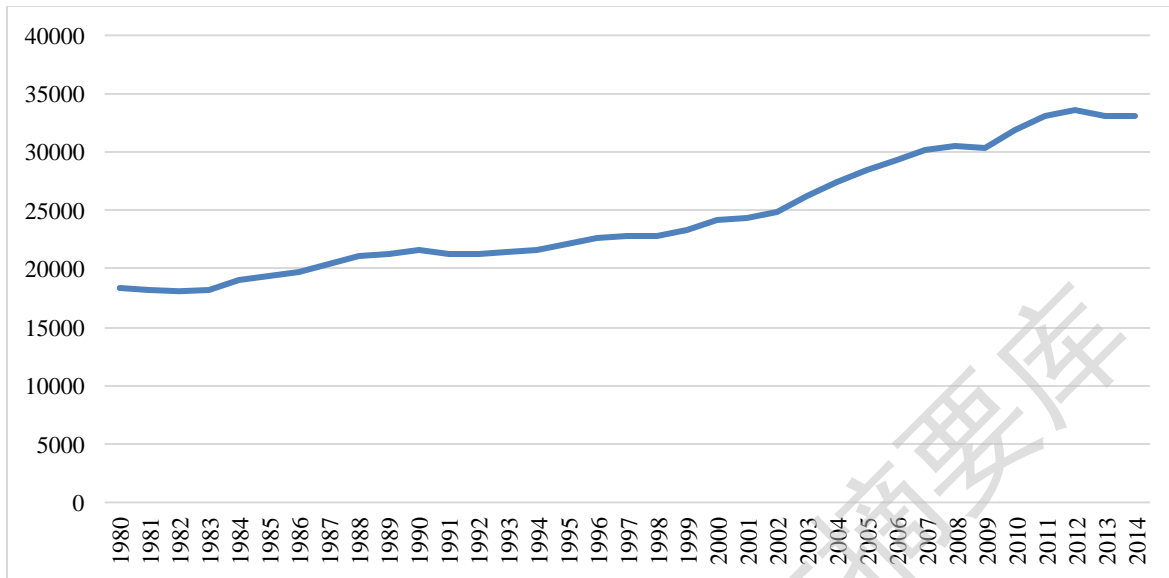


Figure 1.1: Trend of global CO₂ emissions from energy consumption

Source: Data from United States Energy Information Administration (EIA) online database

Developed countries like the OECD countries and emerging countries like Brazil, China, South Africa and India are responsible for the high level of global CO₂ emissions. Thus, the main challenge for developed countries is how to meet the growing needs for energy and sustain economic growth and development while reducing CO₂ emissions and environmental impacts. On the other hand, developing countries have contributed on a lesser scale to global CO₂ emissions. From figure 1.2, it can be seen that the developed and industrialised OECD countries are the main contributors to global CO₂ emission growth up to 2003. However, the emissions of non-OECD countries have surpassed that of OECD countries since 2005, and have kept an upward trend. IEA (2010) also notes that the aggregate energy-related CO₂ emissions of non-Annex I developing countries exceeded those of Annex I industrialised and transition countries (that have ratified the Kyoto Protocol) in 2008. This trend supports the notion that current and future pro-development policies in developing countries will account for future growth in energy consumption and CO₂ emissions (Gertler et al. 2013; Jakob et al., 2011).

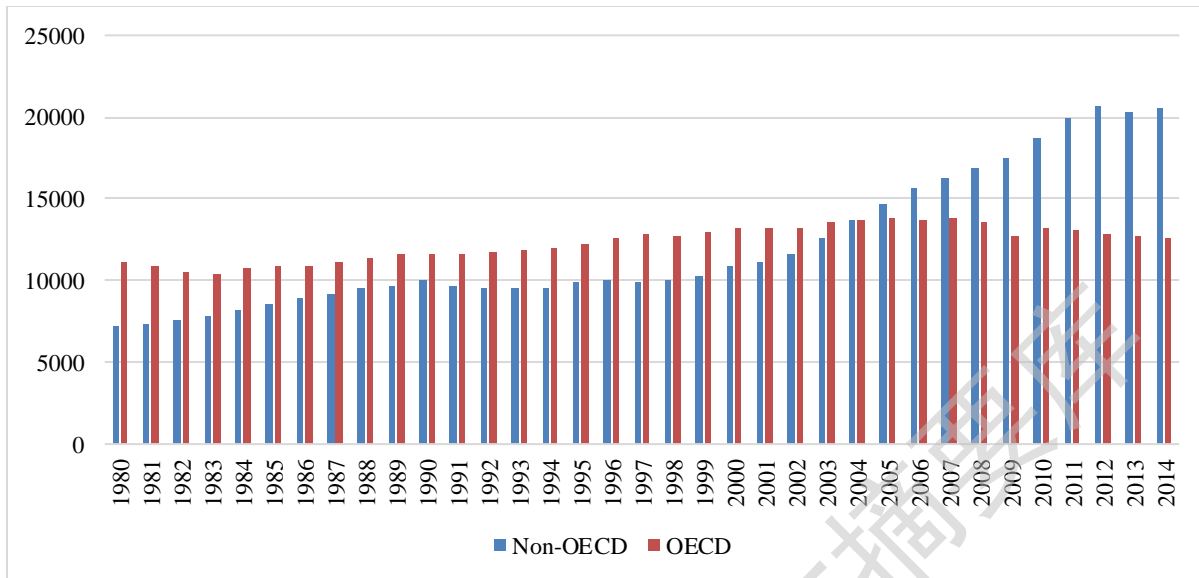


Figure 1.2: CO₂ emissions in developed (OECD) and developing (non-OECD) countries

Source: Data from United States Energy Information Administration (EIA) online database

The growing CO₂ emissions in developing countries particularly poses a challenge for them as they are keen to promote energy access, infrastructure construction, structural transformation, economic development and poverty reduction. Therefore, a number of important questions emerges - What are the causes of CO₂ emissions? Can developing countries promote economic development while also achieving environmental sustainability via CO₂ emissions reduction? Does economic development aid or hurt the environment? And how can developing countries reduce CO₂ emissions associated with economic activities? Answering these important questions require a proper understanding of the driving forces of CO₂ emissions with the aim of mitigating its growth.

Several countries have committed to reducing CO₂ emissions under the framework of the recently approved Paris Climate Agreements. This is also in addition to global commitments to the Sustainable Development Goals (SDGs), which significantly incorporated environmental sustainability into global development agenda. In the framework of these global agenda and responses to climate change, several measures have been recommended and are even currently implemented in order to reduce CO₂ emissions from energy combustion. Some of these policies include levying carbon prices and taxes, facilitating investment in research and development, expansion of renewable and clean energy and improvement in energy efficiency. Of these measures, renewable energy has attracted significant attention and priority. Energy transition from

CO₂ emission-intensive fossil fuel to renewable energy seems necessary to keep the increase in global temperature well below the 2° Celsius above pre-industrial levels and achieve zero net carbon emissions in the first half of this century, which are the main goals of the climate agreement. Figure 1.3 shows the proportion of fossil fuel and renewable energy in total final energy consumption. From the figure, fossil fuel dominates the energy consumption structure. Even though the share of renewable has grown between 1980 and 2012, the growth is very minimal and fossil fuel still accounts for about 81% of total final energy consumption in 2012.

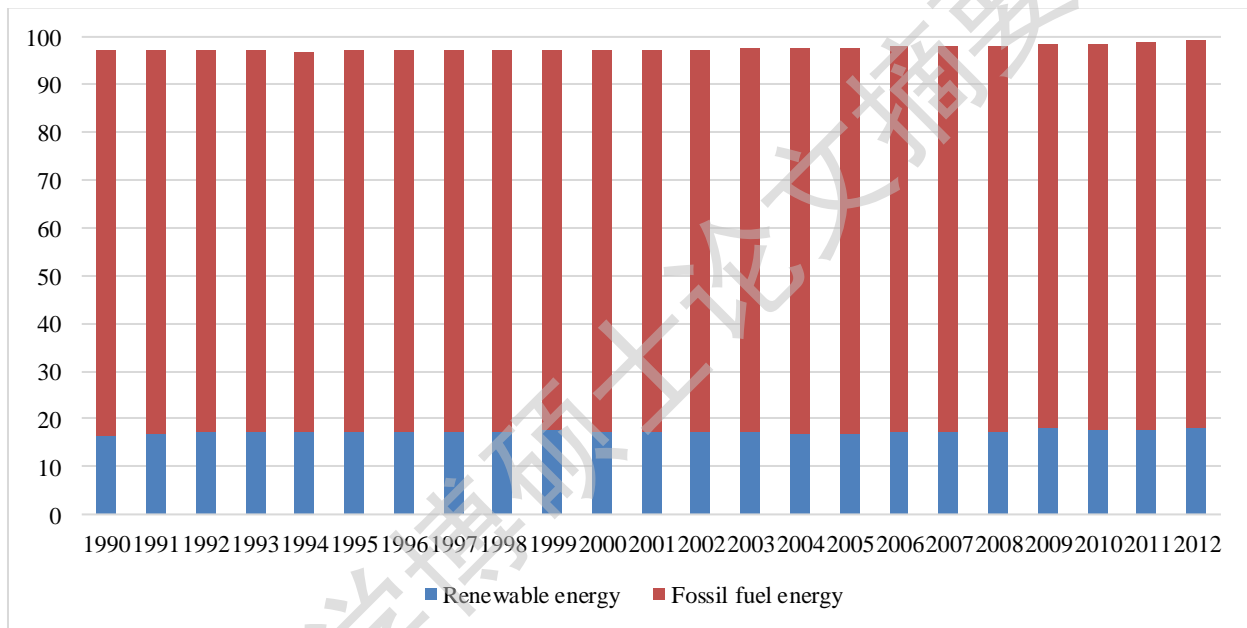


Figure 1.3: Proportion of fossil fuel and renewable energy in total final energy consumption

Source: Data from World Bank online database

With this background, promoting the development, deployment and use of renewable and clean energy sources such as solar, hydro, geothermal, wind and nuclear energy has been identified as a major means of reducing CO₂ emissions by substituting emission-intensive fossil fuel energy sources which dominate the current global energy consumption structure (Obama, 2017). The global climate agreements emphasise both national and globally coordinated climate policy efforts. This requires countries to take specific actions tailored to their circumstances, which is known as intended nationally determined contribution (INDC), and also coordinate their actions and policies with the rest of the world. It is therefore necessary to analyse the drivers of renewable energy use in order to understand the factors that can facilitate or impede its rapid development and use.

1.2 Problem statement

This thesis analyses the driving forces of CO₂ emissions and renewable energy consumption focusing on economic factors. For the analysis of the drivers of CO₂ emissions, there are three papers focusing on Nigeria, panel of five African countries and panel of eight Asian countries from different contexts and perspectives. For the study on Nigeria (Chapter 2), the impact of industrialisation on CO₂ emission is investigated. The Nigerian economy has grown impressively in the past decade, but the economic growth has not translated to considerable and sustained poverty reduction and human development. Thus, policy makers and international development organisations have advocated for industrial structural transformation as a means for achieving inclusive growth and development. However, there is no empirical study that analyses the impacts of industrialisation on CO₂ emission in Nigeria. This study thus fills the gap by investigating the impact of industrialisation on CO₂ emissions in Nigeria using the Kaya Identity empirical framework. In Chapter 3, the non-linear impact of economic development (GDP) on CO₂ emissions in Africa is examined within the environmental Kuznets curve hypothesis. Pro-development policies in Africa and the region's quest for poverty reduction could have impact on environmental sustainability. In line with the environmental Kuznets curve hypothesis, economic development causes environmental problems in the early stages up to a certain point before leading to improvement in environmental conditions. But studies on the validity of the EKC in Africa are rare. Therefore, the contribution of this paper to the literature is that it focuses on Africa countries and also disaggregate economic development into agriculture and industrial-based economic development. The third paper (Chapter 4) on CO₂ emissions centers specifically on the role of urbanisation and private sector investment in infrastructure on transport CO₂ emissions in Asia. Asia's economic development has caused new challenges such as high urbanisation rates and the associated environmental issues, including CO₂ emissions from the transport sector. The paper analyses the impacts of private sector investment in the transport sector on transport CO₂ emissions and whether the former can "crowd-out" or mitigate the impact of urbanisation on CO₂ emissions. The second part of the thesis examines the drivers of renewable energy transition and is based on papers focused on China and panel of developed and developing countries. Transitioning from traditional fossil fuel sources to clean and renewable energy is crucial for the reduction of CO₂ emissions from energy combustion. Chapter 5 investigates the driving forces of renewable electricity use in China. The country is currently the largest emitter of CO₂ globally and efforts to

stem climate change require significant actions from China. Hence, the focus of this study on China. However, unlike previous studies on China and other countries, this study emphasises the share of renewable electricity in total electricity use rather than the size. This is a major value addition of this study to the empirical literature. Following up on the previous study, Chapter 6 investigates the driving forces of renewable electricity use in forty-six developed and developing countries. In addition to focusing on the share of renewables rather than the size, this paper specifically centers on non-hydro renewable electricity consumption. This is based on the idea that there are technical and economic differences in hydro and non-hydro renewable energy sources, hydro energy is currently largely exploited, and climate change could undermine the potentials of hydro energy sources in the future. Thus, exploring non-hydro renewable energy is vital to ultimately achieving decarbonisation and sustainable development. Lastly, Chapter 7 examines the impact of the protection of intellectual property rights on the adoption of renewable energy using panel data analysis of one hundred and two countries. Given the differences in resource endowment, economic development level and technological advancement among countries, there is need for technology and know-how transfer from technologically-advanced countries to technologically backward countries. But the issue of intellectual property rights is a major point of discussion in innovation and technology transfer, including clean energy technology innovation and transfer. The available evidence are mixed and based on case studies, theoretical and legal analysis. But there is no known study that has used econometric analysis to examine the subject. This study takes advantage of the Ginarte-Park index on the strength of intellectual property right to analyse the impact of IPR on renewable energy adoption.

In summary, the main contributions of the thesis to the literature are highlighted below. Very few studies have explored how the structure (rather than level) of economic development affects the environment in developing countries. In Chapter 2, the thesis focuses on the impact of industrial structural transformation on CO₂ emissions in Nigeria, taking cognisance of the level of development. There are rare (if any) studies that empirically investigates the impact of industrial structural transformation on the environment in Africa. Similarly, Chapter 3 re-investigated the EKC hypothesis. This paper contributes to the literature because it not only examine the validity of the EKC as most studies do, it also goes further to determine if the validity of the EKC is dependent on whether an economy is driven by agriculture or industrialisation. This is the first study that extends the EKC literature in this direction. In Chapter 4, the paper investigates the

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