Who Owns the Future? Reflections on Patenting, Private Value Accrual and Societal Disbenefit in the Context of Biofuel Technology Transfer

Klapper, Rita; Upham, Paul; Allison, Gordon

Published in:
Technology Transfer and Entrepreneurship

DOI:
10.2174/2213809902666150910230947

Publication date:
2015

Citation for published version (APA):
Klapper, R., Upham, P., & Allison, G. (2015). Who Owns the Future? Reflections on Patenting, Private Value Accrual and Societal Disbenefit in the Context of Biofuel Technology Transfer. *Technology Transfer and Entrepreneurship*, *2*(2), 70-80. https://doi.org/10.2174/2213809902666150910230947

Technology Transfer and Entrepreneurship, 2015, *2*, 000-000

Who Owns the Future? Reflections on Patenting, Private Value Accrual and Societal Disbenefit in the Context of Biofuel Technology Transfer

Paul Upham*

Centre for Integrated Energy Research and Sustainability Research Institute, University of Leeds, UK

Abstract: Investment in new energy technologies is inadequate relative to the timescale on which greenhouse emissions need to be reduced. This raises questions concerning the policy instruments intended to facilitate the spread of lower carbon energy supply technologies. This paper theorises the role of patent practices and relationships between firms of different size and power, drawing on what little evidence is available in relation to biofuels. We bring firm-level theory of value creation together with a critical perspective of selected innovation theory, to discuss the ways in which patents may be used such that the consequences are contrary to the public good. Considering the implications for clean energy technology transfer, particularly the case of biofuel technology, we conclude that while there is relatively little information on the ways in which patents may hinder clean energy technology transfer, there are certainly sufficient grounds for concern.

Keywords: Biofuels, intellectual property, patent strategy, innovation, value creation.

1. INTRODUCTION

This paper discusses the role of patenting in innovation, technology change and our associated ability as a species to avoid environmental collapse [1]. It sets the context for subsequent empirical work and relates to on-going trends in the roles of knowledge and value in market economies [2]. Specifically, we relate a theory of firm-level value creation to alternative patent strategies and policy debates relating to the need for technological change for climate change mitigation, particularly renewable energy. Our underlying premise is that global financial, economic and environmental crises require different ways of thinking, different ways of acting and different ways of doing capitalism. In particular, in terms of the environmental impact of contemporary economic systems, the prospect of a number of discontinuous, large scale, interconnected environmental and climatic changes this century demands a rapid shift towards more sustainable practices [3]. Deploying new, low carbon energy technologies internationally is one of the more important of these shifts [4].

Patenting is already playing a role in clean technology development; at issue is the nature of that role, the implications for the rate at which new technologies are adopted and hence the implications for the future state of the planet. While technology is only one factor that will shape this future, it is nonetheless an important one. The number of international patent applications filed in the EU relating to climate change mitigation technology, relative to GDP, more than doubled between 2000 and 2007 [5]. While this is viewed positively at policy levels, policy influence over incumbent energy firms and supply cartels, particularly in terms of encouraging new entrants and renewable energy technology innovation, is far from straightforward. Indeed one of the main challenges is the need to co-ordinate the phase-in of low carbon sources with the phase out of so-called 'brown' sources [6]. The scale of the required deployment of low carbon energy technology is huge, but the level of contemporary investment in particularly renewable energy technology by the incumbents is modest: contrast, for example, BP's $8bn investment in low carbon energy technology[1] over 2005-15 with its single year operating revenue in 2010 of $267bn, or its $20bn compensation fund for the Deepwater Horizon oil leak [7, 8].

It is known that patents are used strategically to block competitors [9-11]; that some of this activity can be regarded as aggressive - including by so-called patent 'trolls' [12] - and that the social cost of not using a patent increases in proportion to its scope [11]. Somewhat conversely, it is also known that there is a strong temporal aspect to the societal value of patents: a need to balance the benefits to first and subsequent generations of developers [13]. Acquiring knowledge that is not used at one point in time may have the function of blocking others' actions, but it also enables a firm to be ready for its future use, when an opportunity presents itself or, a specific likelihood in the clean energy sector, the policy environment becomes more consistently and vigorously supportive.

Overall, perceptions of the value to society of different levels of stringency for patent law have fluctuated over the years [14]. A common narrative, though, is one in which the small firm or inventor battles against a large company in defence of his or her intellectual contribution [15]. While the reality is more complex, the role of patents is mediated by a range of contextual factors including the interactions of small and large firms, the latter often multinationals, as we discuss below. A key aspect of this interaction is what we term as 'value hoarding', challenging the assumption that

*Address correspondence to this author at the Centre for Integrated Energy Research and Sustainability Research Institute, University of Leeds, Leeds, UK; Tel 0044(0)1133432796; E-mail: paul.upham@leeds.ac.uk

2213-8099/15 $58.00+.00

there is necessarily a positive association between innovation, patent filing and societal benefit in terms of a benign shaping of the future. Drawing on Schumpeter's principles of Creative Accumulation and Creative Destruction in conjunction with Bruyat's [16, 17] and Bruyat and Julien's [18] theory of new value creation through entrepreneurship, we describe a theoretical basis for corporate strategies of value accrual based through patenting. We then consider the implications of this for clean energy technology transfer, including the particular case of biofuel technology. We are very well aware of the (often rightly) contested nature of biofuel technology and of the advantages and disadvantages of different feedstock and conversion technology types, combinations, conditions and scales of production. We take biofuels as a case principally because it is one of the very few cases where previous work exists in relation to the connections between patenting, national and international IPR policy and corporate strategy. Although others [16, 19] have examined firm size in relation to patent litigation, and although there have been major surveys of corporate use and non-use of patents [11], defensive and offensive patent practices seem to be untheorised in terms of value creation and related studies in the clean energy sector are scant.

There are also further reasons for focusing on the relationship of smaller and larger firms when considering the role of patents in both facilitating and hindering technological change. Firstly smaller firms have been repeatedly shown to be in many ways more successful sources of innovation, highly personalised in their values provision and more often pioneers of radical innovations than their larger counterparts [20, 21]. Small firms have also been credited with making a fundamental contribution to local, regional and national economies due to their net contribution to employment and job creation [22], taking over a social role as recipients for labour released due to rationalisation, scaling down and decentralisation amongst larger businesses, management buy-outs, and the introduction of new technologies [23]. Thus while we could have restricted our discussion to IPRs held by firms of unspecified size, organisational size does seem to be an important variable (albeit but one among many) in both innovation and in realising societal benefit in addition to private benefit from technological innovation.

Secondly, in so far as IPRs play a critical role as a mediator of societal value, so they often also figure highly in the relationships between smaller and larger firms. Fundamentally, IPRs mediate the realisation of value through the allocation of ownership. Yet the relationship of small and large firms, particularly multinationals in innovation generally, and in relation to IPRs specifically, is ambiguous [22]. McDonald [24] expresses it thus in relation to one particular sector: "the patent system is not equally suited to all; it suits the pharmaceutical industry very well indeed, and most small firms (SMEs) very badly". Similarly, critical voices [24, 25] have suggested that MNC purchasing power, dominant market positions and socio-economic, political and technological dominance exert a variety of pressures on stakeholders, particularly SMEs operating in globalized commodity markets.

2. MATERIALS AND METHOD

We take developing country technology transfer for greenhouse gas emissions mitigation as a strong case of societal value creation. IPR in the pharmaceutical sector, specifically generic drug production, might be a similar case. While related arguments would apply to patent strategy in, for example, the consumer electronics sector, the societal benefits potentially foregone might be more debateable. With this rationale in mind, the paper is structured as follows: first we review selected aspects of the small-large firm relationship and discuss the Schumpeterian concepts of Creative Destruction (CD) and Creative Accumulation (CA) and their relevance to innovation, Schumpeter being perhaps most classically and reverently associated with the field of technology innovation. We then critically investigate conceptions of value creation, proposing a model based on conceptualisations of entrepreneurship as value creation [17, 18]. The latter follows a four variable model of the entrepreneur, the organisation, the process of firm creation and his/her interactions with the environment, enabling a complete picture of the firm's development. Thereafter, we review ways in which patents may be used strategically to secure value within the firm in ways that limit wider societal benefit, particularly in relation to international technology transfer. Through this process, we identify themes arising from the discussion, which we then consider in relation to the transfer of biofuel technology to developing countries. Given the paucity of data available, the paper inevitably reflects the authors' views as much as an empirical base.

3. DISCUSSION

3.1. Innovation and Small-Large Firm Relationships

As Schumpeter observed [26, 27], clustered MNCs share certain elements of collective capitalism. They invest heavily in global R&D and marketing, but they also represent power in markets and politics. These resources are concentrated geographically: by the 1980s, over 80% of all R&D expenditure occurred in five countries: the US, Japan, France, the UK and Germany [28, 29]. This is, however, a highly dynamic and competitive context: on the current trends, China is set to overtake the EU by 2014 in terms of absolute R&D expenditure [5]. While EU total research investment rose by 50% between 1995 and 2008, in China it rose by 855% [5].

Despite on-going shifts in the global economic power balance, the firms involved collectively influence (if not determine) the rules of the game in the global economy [25]. In economic terms, it is only growth firms and successful start-ups that pose countervailing power [25]. Whether or not such firms are in general more innovative than larger incumbents is unclear. One estimate from the mid-1980s suggests that small firms produce some four times as many innovations per R&D dollar as middle-sized firms and 24 times as many large firms [30]. However a more recent estimate [31], integrating empirical studies of the associations of firm size and market competition with product and process innovations, did not find evidence of substantial differences in the strength of the influence of either firm size or competition on the two innovation types.

Indeed the relationship between entrepreneurial small firms and multinationals is full of such contradictions: relationships between the two are often perceived as marriages of convenience, often (but of course not always) with smaller firms owning technology of interest to larger firms [2]. Nonetheless, in general, larger companies need new products to keep their marketing portfolio full and acquisition of small firms or rights to their innovations offers one way of meeting this need. Aware of this, small firms tend to pursue their own agendas in their dealings with their larger counterparts, aiming to give as little as possible and to build their own in-house skills whilst working with large firms [32]. The small firm strategy is often to sell marketing rights and entertain different contracts with large firms, thus ensuring independence and flexibility [32]. Large companies can be useful partners for entrepreneurs, as the former have access to world-class technologies [33, 34], as well as relatively efficient marketing channels and logistics with a global reach.

Given the above ambiguities in the relationship between innovation and firms of radically different size, a return to theory is merited when thinking about the relationship between value creation, firm size and societal benefit. Below we revisit classical Schumpeterian concepts and later theoretical developments, setting the scene for what we see as a more contemporary and perhaps less stylized account of the dynamics involved.

3.2. Creative Destruction and Creative Accumulation Revisited

Schumpeter advocated two approaches to the innovative process: *Creative Destruction* (CD) and *Creative Accumulation (CA)*. The first focuses on the role of new entrepreneurs entering market niches, introducing new ideas and challenging existing firms through a process of *Creative Destruction* (Prozess der kreativen Zerstörung), considered the engine of economic progress [35]. CD can ex post be observed as economic discontinuity, which then becomes the entrepreneurial momentum ex ante to introduce innovations and to earn monopoly profits, on condition that an entrepreneur is early enough in identifying market opportunities [25].

Nelson and Winter [36] further developed Schumpeterian ideas into Schumpeter Mark I and Schumpeter Mark II technological regimes. Mark I focuses on the key role of new firms in innovative activities, i.e. CD; Mark II focuses on the role played by large and established firms, i.e. CA. CD is understood as a micro-economic process in nature, with important macro-economic implications [37]. In particular, small, new, innovative firms, highly personalised in their values provision, are classically viewed as a key source of innovations [20].

In terms of Schumpeter's theoretical developments [38], CA came later (1942) and related to the role of large firms as engines for economic growth *via* the accumulation of non-transferable knowledge in specific technological areas and markets [39]. The idea is that in large firms there is a strong positive feedback loop from successful innovation to increased R&D capability and activity, setting up a feedback loop that in turn reinforces market concentration [40].

CA is thus associated with a number of processes of institutionalised innovation by large firms [41]. When entrepreneurs engaged in processes of CD expose their innovations to the market, large firms may legally appropriate a major part of that intellectual property and add to their own proprietary knowledge stock. This is assisted by the use of near-monopoly power, substantial in-house R&D departments and networks of partners such as research universities and private and public research institutes [41]. Internal and financial resources allow the larger firms to recruit the competencies required to embed externally developed generic knowledge into the development of new products and services internally [41]. Moreover, utilising scale economies and monopoly power, large firms are able to create high barriers to entry of new entrants [42], impact upon industry life cycles and market structure [43].

Both concepts - CD and CA are thus the opposite ends of a continuum [41]. Fig. (**1**) provides a stylised, Schumpeterian approach to value creation as being a function of CD and CA, in relation to innovation and IPR, specifically patenting. Both the processes of CA and CD are thus conceived of as being socially beneficial.

3.3. Schumpeterian Logic and Bruyat's Theory of Value Creation

This brief rehearsal of one aspect of Schumpeterian thought provides a context for considering the process of value creation, for which purpose we use a perspective provided by Bruyat & Julien [16, 18], defining entrepreneurship as concerning the relationship between the individual and value creation ("l'objet scientifique étudié dans le champ de l'entrepreneruship est la dialogique individu/creation de valeur") [16]. Bruyat's concept is in turn based on Gartner's four-variable model for entrepreneurship [42], comprising the individual, the process, the environment and the enterprise. This approach suggests that new value is created in terms of more or less intense change in the environment directly related to the entrepreneurial process [44]. In other words, at the heart of the entrepreneurial process we find the act of value creation, as a result of the interaction between the individual and his/her environment. At the beginning of the process we have:

The Individual (I) => New value creation (NVC) [18] where the individual defines himself or herself in relation to the structure, i.e. the organisation that is being created. Hence the individual is both constrained and created by the object that (s)he constructs. From this it can be concluded that:

The Individual (I) ⇔ New value creation (NVC) [18] indicating the dialogic between the two entities who form a system. Following general systems theory [44], the entrepreneurial system can be considered a *type 9* system, meaning that it is capable of learning and creating and that it has intention [18]. The system as such is also open and interacts with its own environment, as shown in Fig. (**2**). Similar to Gartner's conception [42], this model is comprised of four key aspects: the individual, the object created (i.e. the organisation and/or an innovation), the environment and the process (Fig. **2**).

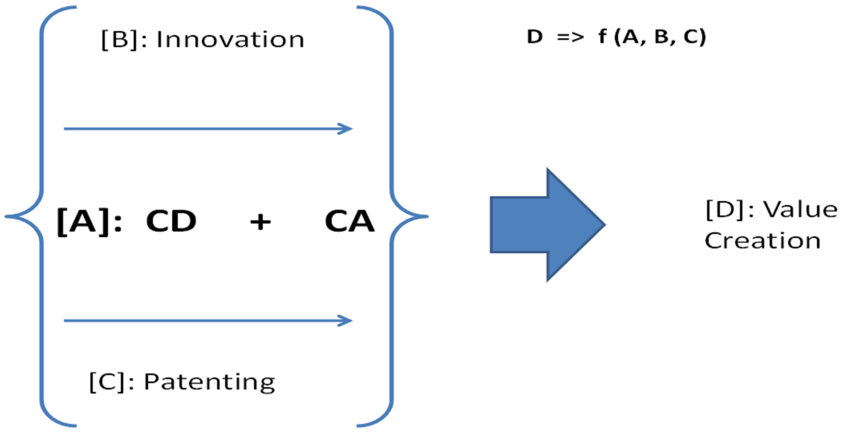

Fig. (1). A stylised, Schumpeterian approach to value creation as being a function of Creative Destruction (CD) and Creative Accumulation (CA).

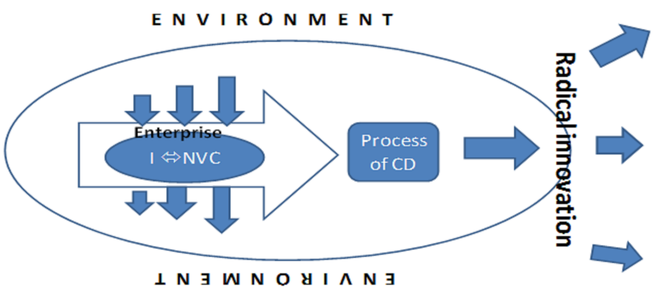

Fig. (2). The entrepreneurial process located within its environment and time (after Bruyat & Julien, 2001).

Taking this initial model further, we propose a theoretical understanding for the relationship between the entrepreneurial individual (I) involved in new value creation (NVC) which leads through a process of CD to (radical) innovation. However, this process, which is potentially favourable for society, can be impeded by the process of CA, as the act of value creation takes place not in a vacuum but in a particular context or environment involving, in practice, agents such as MNCs, government subsidies, university and other research laboratories and a wide range of stakeholders who seek to influence the system in their interests, as shown in Fig. (**3**). In this respect our conception of value creation through innovation corresponds with those who argue that CD and CA are not exclusive, but rather interrelated processes [41].

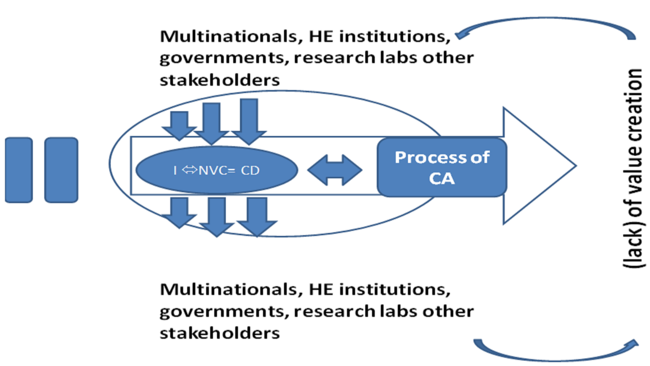

Fig. (3). The relationship between value creation, CD and DA in the context of stakeholder influences.

3.4. Critical Views of Patenting

Thus far, we have extended the classical account of innovation by bringing this together with an account of value creation processes that emphasises the complexity of the relationships of firms and their environments. In this section we add to this account of complexity by introducing what might be termed the 'critical' literature on patent strategy. By 'critical' is here meant work that questions the relationship between patenting, innovation, societal welfare and social change, be this conceptually or empirically.

As with technological innovation generally, there remains a widespread assumption that patenting is a socially positive activity. Yet patenting primarily has private value. Moreover, use of patenting as a competitive, strategic tool, rather than simply a defensive one, has a long history. For example, a cyclical salience to technological innovation in US anti-trust law over the period 1890-2000 has been observed [45], as well as Woodrow Wilson's critique in 1912 of the practice of purchasing patents that then remain unused. More recently is the question of whether IPR mechanisms have any positive relationship at all to innovation - and perhaps a negative relationship - suggesting that factors such as the technological paradigm and firm characteristics and capabilities have more of a bearing on innovation rates [46].

While the patent is nominally supposed to be a means to the end of protecting IPR, it has become much more than this, arguably since the 1982 inauguration of the Court of Appeals for the Federal Circuit (CAFC) in the United States, a specialist patent court, in authority just below the Supreme Court [47]. From this perspective the patent has become an end in itself, with strategic value independent of innovation, supported by a technology-push myth of a linear innovation process in which R&D is at a chronologically early point in the chain, rather than the more complex, contemporary actuality. Moreover small firms and developing countries have had little power in the development of the global patent system [47].

Examining patent behaviour in more detail, we can distinguish two strategic approaches to the use of patents by

German companies, namely offensive and defensive patenting. Offensive patenting pertains when a firm is already earning a return from an innovation, which it later patents in order to hinder or block another firm planning to patent a similar but not identical innovation [48, 49]. In comparison, defensive patenting pertains when a firm patents its innovation to prevent another firm patenting that same innovation, even though it has not needed the patent, up to that point, in order to earn a return [48, 49].

Offensive patenting may involve building a web of patents that are not used directly for IPR purposes, but which serve to protect another patent [48, 49]. Such blocking of others' attempts to patent and/or sell their own, closely related products [50], by patenting around a product, is also referred to as creating a patent thicket, cluster or bracket [51]. Associated activities have been termed *blitzkrieging*, consolidation, blanketing and flooding, fencing and surrounding, by patent harvesting and ramping up [52, 24]. A qualitatively different strategy is patent stacking [53]. Patent stacking in combination with reach-through license agreements (RTLAs) may extend the influence of a patent holder onwards through time, in relation to subsequent innovations in which they are not directly involved. An RTLA gives a patent holder rights (e.g. to a royalty) in subsequent downstream discoveries, often in lieu of an upfront payment to use the patented innovation. Through multiple patenting around an innovation, rather than of the specific innovation only, there is a higher chance of retaining rights to a return.

3.5. Value Creation and SME-MNC Inter-Relationships

In the light of the above, in this section we consider the relationship between larger and smaller firms, specifically processes of value creation and the role of patenting therein. Arguably, CA is associated with institutionalised innovation by large firms which appropriate the intellectual property of individual entrepreneurs and protect it as a major part of their own intellectual property. However, the ways in which innovation processes are perceived by industrialised societies has changed over time [40]. Innovation has come to be less understood as the capability to innovate and more as the ability to discover new technological principles in terms of the systematic exploitation of "the effects produced by new combinations and use of pieces in the existing stock of knowledge" [40]. This new understanding requires systematic access to the state-of-the-art and new procedures for disseminating information about the stock of technologies available, so that knowledge and information exchange between innovators is made possible [40].

Technological knowledge is generally embedded in some form of specific blueprint form such as a patent, artefact, a design, a software programme, a manuscript or composition [39]. By design, this knowledge is often not fully shared and the concentration of patents in the ownership of a few countries and a few MNCs in particular locations is potentially antithetical to the process of sharing that knowledge with the many. Knowledge and innovative activity are geographically clustered [54] and the tendency toward spatial concentration has become more marked over time [55]. Yet the capacity of an economy to benefit from technical change and innovation is finally "dependent on the dynamic efficiency with which firms and institutions can diffuse, adapt, and apply information and knowledge" [40]. The diffusion of such knowledge is key to growth [40]. Once the contribution of an innovation is manifest as leading-edge technology, other firms are able to deploy that technology through purchase of related but different design and incumbent firms whose technology is no longer on the leading edge experience competition, i.e. the process of CD is in place.

Whereas knowledge can - theoretically - be shared freely, there are costs associated when acquiring knowledge [56]. The cost for filing a patent in two countries amounts to $16,971, 7 countries $59,397 and 15 countries $119, 381; these figures include official feeds, maintenance, legal and translation costs [57]. The costs highlight the importance of economies of scale when patenting, but also the need for adequate financial resources when engaging on this path. It can be assumed that MNCs, with larger resources than small firms, will have less trouble funding patenting than young, struggling ventures. Hence processes of CA and IPR accrual may accentuate the imbalance of access to financial resources of small and large firms, creating significant barriers to entry for small businesses, so impacting new value creation potentially beneficial for society.

Through the process of CA, the production of knowledge becomes the privileged domain of the "comfortable world" of standard models [58], with stakeholders such as R&D laboratories and universities specialising in knowledge production and in particular generic knowledge with potential for large-scale commercialisation processes [41]. This contrasts with CD which supports the key role of small business in providing impetus for change, innovation, personalised value propositions and specific knowledge [59].

Knowledge is the core of the global economy [25] and as such "knowledge represents the capabilities of individuals or social groups associated with meaning and understanding, as well as the abilities to organise, interpret and assess information while information is knowledge reduced to messages that can be transmitted to decision agents" [60]. Knowledge is concentrated in the hands of a few multinationals in a limited number of locations and is associated with established power dynamics. Hence US policy-maker concern regarding the relationship of economic strength to maintain national security and military might [24, 47]. In particular in the 1980s, high technology and associated patents were considered as key to keeping American technology American. The pharmaceutical industry was quick to use this opportunity to establish a monopoly, rather than the diffusion of information that may have benefited foreign companies and thus jeopardised US innovation, competitiveness and security [47, 61]. As Macdonald observes: "some companies now have no activity beyond collecting patents in the hope of obstructing the innovation of other companies" [47].

MNCs collaborate with the most successful universities and research laboratories to access the latest technology and knowledge [62]. Yet the increased propensity of universities to patent inventions has reduced spill-overs from research, as universities now benefit more directly from in-house innovation [63]. Increasingly, universities forge formal and informal ties with companies, yet to date the focus has been on large firm relationships. US universities are particularly successful in filing patents (see for instance California University with 364 patent filings in 2007, followed by MIT with 175 filings, Columbia with 114 and Texas System with 95 filings [57]. In 5th position we find Osaka University with 91 filings and Tokyo University with 67 filings in 10th position (ibid). The same data as of 2007 reveals the complete absence of European universities.

The European Commission has found that many service sector innovations do not necessarily meet the requirements for protection through patenting, that twice as many industrial as service firms applied for a patent and that more industrial than service firms apply for a trademark [58]. One reason for this may be the mismatch between the type of knowledge generated by universities and research institutes and the knowledge needed by the services sector. Such knowledge can only exceptionally be synthesized and transferred in a codified manner, something that is easier for technological knowledge [58]. As a result, the EC called for a complete rethink of European innovation policy in line with the changing socio-economic, political, technological and environmental circumstances, with particular focus on innovation in services, seen as a main enabler for the creation of the knowledge-based economy and hence a priority for Europe [58]. Disruptive innovation helps firms and economies grow through the creation of new business and the development of new product markets, i.e. in Schumpeterian terms ‘new economic space’ [59]. Arguably, small firms’ innovative capacity, also for disruptive innovation, enables them to create ‘uncontested market space’ [59].

In the remainder of the paper we discuss issues arising from the above in relation to a specific example of the use of IPR for societal benefit, namely technology transfer in the clean energy sector, using biofuels as a specific case. We note how little study there has been on the role of the acquisition of patents for blocking purposes in the clean energy sector.

3.6. Technology Transfer and IPR

Enhancing technology transfer to developing countries has been an integral part of the global climate change regime since the inception of the United Nations Framework Convention on Climate Change (UNFCCC), yet the role of IPRs has emerged as a particularly contentious issue in this context [64]. Many developing countries and some nongovernmental organisations (NGOs) have advocated the use and expansion of the flexibilities on IP available within the WTO TRIPS Agreement, such as compulsory licensing, while many developed countries and business associations claim that only strengthened IP regimes will encourage the necessary innovation, transfer and diffusion of such technologies [65].

In 2010, with the purpose of mapping the clean technology patent landscape, the European Patent Office (EPO) reviewed 60 million patent documents and identified 400,000 that matched one or more of 50 clean energy technology categories. The EPO also elicited 160 responses organisations regarding their IP licensing behaviour (constituted of 47% MNCs; 7% large firms; SMEs with fewer than ten employees constituted 24% of the private company respondents; others 34%). Respondents with headquarters in Germany, the US, Japan, France and the UK amounted to 74 per cent of the total respondents and 63% of respondents focused on biomass/biofuels [65]. The study found that the leading six countries with actors innovating and patenting CETs are Japan, the United States, Germany, the Republic of Korea, the United Kingdom and France. Aside from geothermal, national (geographic) concentration in all CETs is relatively high: the top six countries account for almost 80% of all patent applications in the CETs reviewed.

Views on IPR posing barriers to technology transfer are mixed and it is clear that IPRs are only one factor in a complex situation [66]; with the capacity to assimilate, implement and develop a technology also being important. Hence an examination of companies developing solar photovoltaic (solar PV), biofuel and wind technologies in Brazil, India and China concluded that IPRs are unlikely to be a significant barrier to access in the immediate future [65]. Similarly most patents for CETs are not filed in least developed countries (LDCs) in any case, given their small market potential [67]. This would leave companies in those countries free to use others’ inventions. On the other hand, while the overall effect of strong patent protection on the transfer of technology is not clear, as demand for new energy technologies strengthens in response to climate change policy, corporate action may frustrate technology transfer through the refusal to license and the use of other kinds of restrictive business practices [68]. In this regard, based on company case studies in India involved in CETs, gaining ownership of or access to IP may be a necessary but not sufficient requirement for successful low-carbon technology transfer [69]. Moreover IPRs seem to be slowing down the rate at which Indian firms are able to develop commercial hybrid vehicle technologies without infringing existing international patents owned by industry leaders such as Toyota and General Motors [70].

3.7. Studies of Blocking Patents

The PatVal-EU survey [11, 71] assessed the prevalence of non-use of patents, licensing and use of patents to block potential competitors. The results of the survey, conducted between 2003 and 2004, and which collected information on 9,216 patents filed between 1993 and 1997 in six European countries, are closely relevant to the thesis of value hoarding. Overall, 18.7% of patents were filed primarily to block other companies. 17.4% of patents were unused but were considered to be ‘sleeping’ rather than blocking [11, 71]. In large firms, 21.7% of patents were reported as being filed to actively block rival R&D and 19.1% were considered sleeping (not having the effect of blocking). Medium size firms developed a relatively high percentage of patents for internal use (65.6%) and had less than half the percentage of strategically held or sleeping patents as large firms. Smaller firms reported a very low incidence of unused patents (9.6% were blocking patents and 8.8 % were sleeping) [72].

This indicates the arguably more socially positive character of SME use of IPR, in terms of value hoarding, reflecting not altruism, but the way in which SMEs are under financial pressure to use the knowledge acquired inside the firm for new value adding activities. It also indicates a need for European policy makers to provide more support (including advice and finance) to small to medium-sized enterprises, to help them develop and acquire IPR for new value adding activities. This is particularly so in Europe: an American SME is twice as likely as a European SME to have a high share of its patent portfolio licensed [72].

There are studies using international databases and surveys that capture some aspects of inventor and patent mobility: e.g. Japan and the US [73]; the Australian Inventor Survey [74]; the European PatVal survey [11, 72]. However details such as the use of patents to block other firms were beyond the remits of these studies and it is debatable whether such data could be accurately elicited through survey or interview methods. It is this blocking activity that needs closer examination and for this purpose it is the movement of patents that must be observed. It is our intention that the theoretical basis that we have laid here will assist in empirical investigation of value creation chains, particularly the movement of intellectual value between firms, including internationally.

3.8. The Case of Biofuel Patenting

While studies of biofuel patenting specifically are very limited in number [75], the number of biofuel-related patents has increased substantially in recent years. Using the US as an example, between 2002-2007, 2,796 biofuel-related patents were published, with an increase of 610 per cent from 2002 to 2007 [75]. In 2007, the number of biofuel patents exceeded the combined total of solar power and wind power patents published [75]. Categorized by ownership entity, the patents published in selected technologies in 2006-2007 were 57 per cent owned by corporate entities, 11 per cent owned by universities or other academic institutions and 32 per cent undesignated [75, 76].

A substantial number of start-up biofuel companies (by definition small businesses) are offering novel biofuel technologies [77]. If any of these technologies become a definitive choice for a particular process, the company controlling that technology may secure greater control of the market and extend that control to other links in the commodity chain [78]. There are precedents for this in the related sector of agribusiness: a small group of multinational US agribusinesses has achieved oligopolistic control of commodity value chains through the strategies of horizontal and vertical integration [78, 79]. More generally, as Table **1** illustrates, biofuel technology is an area exhibiting a relatively high incidence of patent disputes relative to other clean energy options [80].

In the agribusiness sector, value is particularly accrued by obliging annual purchase by farmers of seed and/or agro-chemicals, to maintain yields. Two companies, DuPont-Pioneer and Monsanto, account for 56% of the U.S. seed corn market and four companies account for 29% of the world market in commercial seeds [81, 82]. Comparing the biofuel and agribusiness sectors, the biofuels industry has the potential to follow the trajectory of the agricultural biotechnology industry, with its divestitures, mergers and acquisitions leading to consolidation globally [75]. Indeed a restrictive IPR regime for advanced biofuel technology has been judged by some as likely to prevail, to the detriment of developing countries due to the technology being costly to obtain and difficult (inter alia) to adapt to local needs [75].

More generally, key issues of concern in this context include control of access to resources and imbalances in intellectual property right regimes across countries [75]. This

Table 1. Illustrative cases of recent biofuel patent infringement disputes.

Case	Company Descriptions	Year	Focus of Dispute
Gevo *vs* Butamax: on-going as of early 2013	Both are small to medium sized US employers with major financial backing: Gevo by e.g. Total and Richard Branson; Butamax by BP & DuPont	2011 to 2013+	At least 17 patents relating to the use of genetically modified yeast and enzymes to produce isobutanol, which has a higher energy content than ethanol, which can be blended to higher percentage than ethanol without vehicle conversion and which can be used as a feedstock for jet fuel and a range of chemicals.
Novozymes *vs* CTE Global: resolved in favour of Novozymes	Novozymes is a Danish biopharmaceutical firm; CTE Global is an Illinois-based enzyme distributor	2011-2012	A glucoamylase enzyme with higher thermal stability than prior glucoamylases. The patents also claim starch conversion processes using the enzyme. Glucoamylases are used to convert hydrolyzed corn starch to glucose, particularly in production of ethanol.
Novozymes *vs* Danisco: resolved in favour of Novozymes	Danisco was acquired by DuPont in 2011. It is a Danish speciality food ingredients company, with Genencor as a division specialising in industrial biotechnology and enzymes	2010-2011	Variants of alpha amylases that exhibit altered stability under high temperatures, low pH and other conditions. The patented variants can be used for starch conversion in ethanol production.
Neste Oil, *vs* Dynamic Fuels, Syntroleum & Tyson Foods: on-going as of early 2013	Neste Oil is a vehicle fuel producer, 50.1% owned by the Finnish state. Dynamic Fuels is a joint-venture of Tyson Foods, Inc., and Syntroleum Corporation, producing fuels from animal fats, greases and vegetable oils. Tyson Foods is one of the world's largest processors and marketers of chicken, beef, pork and prepared foods. Syntroleum is a small (but substantially capitalised) specialist in 2nd and 3rd generation biofuel technologies.	2012-2013+	A process by which diesel fuels are made from animal, plant, or fish fatty acids.

Sources: Lane (2013) and Fischer (2012).

potential for the concentration of knowledge and hence market power also applies in developed nations: in the US biofuel sector, while patent ownership in the emerging biofuel sector is not yet as concentrated as in the agricultural biotechnology sector, such concentration is taking place nonetheless [78].

Juma and Bell [75] posit three IPR scenarios in relation to wider (particularly developing country) access to biofuel technology and a number of mechanisms by which control over knowledge may be exerted. First is use of company and patent acquisition. For example, although small start-up companies in the agrobiotech sector still figure prominently as acquisition targets or as licensors to the large corporations, by 2002, 95% of patents originally held by seed or small agrobiotech firms had been acquired by large chemical or multinational corporations [75, 81]. When a few multinational companies are backed by a broad portfolio of patents, including proprietary entitlements on key enabling technologies, this may impede access to technologies if they refuse to license [75, 81].

Secondly, highly restricted access could occur if many different patented technologies (for agricultural and industrial processes) are required for producing second generation biofuels. Generically this has been referred to as the "tragedy of the anti-commons", which as a concept pertains to when multiple owners each have a right to exclude others from a scarce resource and no one actor has an effective privilege of use [53].

A third mechanism for control of knowledge and hence market power may be the use of "blocking" or "hold-up", in which patent holders are unwilling to license their technologies for strategic reasons: broad patents may be filed or purchased not for the purposes of product development, but to enable strategic use of the patents to prevent competitors from developing products. Patent lock-up may already be taking place, for example, with regard to critical enzymes in the biofuels production process [65]. Patenting of genetic material and reproduction methods is another possible route to controlling access to the best yields. For example, most of the 21 patent applications with the species 'Jatropha Curcas' in the title, listed in the European Patent Office register at the time of writing, relate to genetic aspects of the plant. While several applications were made by Indian companies, most of these are listed as having been withdrawn, something that merits further investigation.

3.9. Implications for Future Research, Theory and Practice

We began this study with the controversial hypothesis that IPR law may be hindering - and may come to hinder - progress lower carbon energy systems. We further hypothesized that this may be mediated by the differing market power of smaller and larger firms. We sought to explore these ideas in the context of bioenergy and related biotechnology, reflecting our own research interests in these fields and also entrepreneurship and sustainability.

We found that we could neither refute nor substantiate our hypotheses: we found no systematic studies of relevance that might function as secondary data sources and also that collection of relevant primary data is inherently challenging. Publicly available patent databases do not readily reveal the relationship of patent ownership, use and non-use over time, something that also became evident through discussion with specialist patent analysts. This is why the PatVal-EU study [11] relied on a company questionnaire survey as its investigative instrument. It may be that qualitative case-studies that build on information from such surveys are all that are possible. This option would entail following up IPR/patent cases inferred from the combination of similar survey data and knowledge of a particular firm's sector and particular activity. The obvious problem with such a research strategy is that it relies heavily on the open co-operation of firms, something that may be compromised in a context in which information is typically of substantial commercial significance.

Practically, we would suggest that there are sufficient grounds to warrant at least a light monitoring of the situation by informed observers, preferably supported by research as described above. In terms of theoretical development, we would emphasise the need to acknowledge that an increase in private value through IPR development or acquisition need not lead to an increase in the public good. The concept of *shared value* generation [83], in which companies seek to prosper through meeting social needs, needs to be seen in a qualified light (e.g. who gets to define those needs and how best to meet them?). Given the instance of at least one public body taking pre-emptive action to protect the public good from private patent acquisition in the bio-medical sector [84], it is clear that realizing shared value in practice will require more than gentle exhortation.

CONCLUSION

IPR, centring on patenting, shapes the world by controlling access to technology. We know from previous, empirical survey work that a substantial percentage of patents are deliberately withheld from use for a variety of reasons. We have shown how this generates private but not social value. Current and future challenges in the global economy require a better understanding of the roles and inter-relationships of both SMEs and MNCs in this value creation process. We have viewed the relationship between larger and smaller firms in relation to patenting in terms of Schumpeter's concepts of creative destruction and creative accumulation, concepts that are both multidimensional and non-exclusive [41]. To date, however, aside from [41] there has been little work on conceptualising the link between MNCs and SMEs, innovation and the foregoing Schumpeterian logic and also little empirical work on the role of patent strategy in clean energy technology transfer. Issues of commercial confidentiality are likely to be unhelpful in this regard. This paper is intended as a small contribution to addressing the gap in the extant literature. In describing the way in which MNCs may frustrate or thwart the process of creative destruction by entrepreneurial market entrants, we affirm Schumpeter's awareness of the capacity for market power to stymie innovation, while also acknowledging that there are advantages to the large-firm routinization of innovation [85]. The biofuel sector serves as an example of a new energy sector in which patenting activity is relatively high [65] but in which the potential for societal benefits are uncertain for many reasons, IPR being one of these.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

DISCLSURE

Part of this article has been reproduced from Proceedings of the 2013 EU-SPRI Forum Conference.

REFERENCES

[1] Randers, J. Global collapse—Fact or fiction? Futures 2008; 40(10): 853-864, doi:http://dx.doi.org/10.1016/j.futures.2008.07.042

[2] Kenney, M. The role of information, knowledge and value in the late 20th century, Futures 1996; 28(8): 695-707, doi:http://dx.doi.org/10.1016/0016-3287(96)00029-8

[3] Lenton, TM, Held, H, Kriegler, E *et al*. Tipping elements in the Earth's climate system, Proceedings of the National Academy of Sciences 2008; 105: 1786-1793.

[4] Edenhofer, O, Pichs-Madruga, R, Sokona, Y *et al.* (Eds). IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, USA: Cambridge University Press 2011.

[5] EC. Innovation Union Competitiveness report 2011 Executive Summary. Brussels: European Commission, Research and Innovation 2011. Available from http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011/executive_summary.pdf#view=fit&pagemode=none

[6] Verbruggen, A, Volkmar L. Basic concepts for designing renewable electricity support aiming at a full-scale transition by 2050, Energy Policy 2009; 37(12): 5732-5743, http://dx.doi.org/10.1016/j.enpol.2009.08.044

[7] BP. Business Overview, BP Alternative Energy website 2011a. London: BP. Available from: http://www.bp.com/liveassets/bp_internet/alternative_energy/alternative_energy_english_new/STAGING/local_assets/downloads_pdfs/AE_business_overview.pdf [accessed 14/07/2011].

[8] BP. Annual Report and Form 20-F 2010, 2011b. London: BP. Available from: http://www.bp.com/assets/bp_internet/globalbp/globalbp_uk_english/set_branch/STAGING/common_assets/downloads/pdf/BP_Annual_Report_and_Form_20F.pdf [accessed 14/07/2011].

[9] Hall, BH, Ziedonis, RH. The patent paradox revisited: an empirical study of patenting in the US semiconductor industry, 1979-1995, RAND Journal of Economics 2001; 32(1): 101-128.

[10] Ziedonis, R. Don't fence me in: fragmented markets for technology and the patent acquisition strategies of firms, Management Science 2004; 50: 804-820.

[11] Giuri, P, Mariani, M, Brusoni, S *et al*. Inventors and invention processes in Europe: Results from the PatVal-EU survey, Research Policy 2007; 36(8): 1107-1127. http://dx.doi.org/10.1016/j.respol.2007.07.008

[12] Sandburg, B. Inventor's lawyer makes a pile from patents, The Recorder 2001, July 30.

[13] Scotchmer, S. Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, The Journal of Economic Perspectives 1991; 5(1): 29-41.

[14] Mazzoleni, R, Nelson, RR. The benefits and costs of strong patent protection. A contribution to the current debate, Research Policy 1998; 27: 273-284.

[15] Chien, CV. Of Trolls, Davids, Goliaths, and Kings: Narratives and Evidence in the Litigation of High-Tech Patents, North Carolina Law Review 2009; 87, Santa Clara Univ. Legal Studies Research Paper No. 09-13. Available at SSRN: http://ssrn.com/abstract=1396319

[16] Bruyat, C. Création d'Entreprise: contributions épistémologiques et modélisation. Thèse pour le Doctorat de Sciences de Gestion, ESA. PhD dissertation. Grenoble: Université Grenoble II 1993.

[17] Bruyat, C. Créer ou ne pas crééer? Une modélisation du processus d'engagement dans un projet de création d'entreprise. Revue de l'Entrepreneuriat 2001; 1(1): 25-37, http://asso.nordnet.fr/r-e/RE0101cb.pdf

[18] Bruyat, C, Julien, PA. Defining the Field of Entrepreneurship, Journal of Business Venturing 2001; 16 (2): 165-180. DOI: 10.1016/S0883-9026(99)00043-9

[19] Ball, GG, Kesan, JP. Transaction Costs and Trolls: Strategic Behavior by Individual Inventors, Small Firms and Entrepreneurs in Patent Litigation. February 1, 2009. U Illinois Law & Economics Research Paper No. LE09-005; Illinois Public Law Research Paper No. 08-21. Available at SSRN: http://ssrn.com/abstract=1337166 or http://dx.doi.org/10.2139/ssrn.1337166

[20] Alsos, GA, Isaksen, EJ, Ljunggren, E. New Venture Financing and Subsequent Business Growth in Men- and Women-Led Businesses. Entrepreneurship Theory and Practice 2006; 30(5): 667-686, doi:10.1111/j.1540-6520.2006.00141.x

[21] Kirchhoff, BA, Newbert, SL, Hasan, I *et al*. The Influence of University R&D Expenditures on New Business Formations and Employment Growth. Entrepreneurship Theory and Practice 2007; 31 (4): 543-559. Available at SSRN: http://ssrn.com/abstract=999461 or http://dx.doi.org/10.1111/j.1540-6520.2007.00187.x

[22] Michael, SC, Pearce, II, JA. The need for innovation as a rationale for government involvement in entrepreneurship, Entrepreneurship & Regional Development 2009; 21(3): 285-302.

[23] Curran, J, Storey, D. The Location of Small and Medium Enterprises: Are there Urban-rural Differences. In Curran, J and Storey D, Eds. Small Firms in Urban and Rural Locations. London: Routledge 1994; pp. 1-16.

[24] Macdonald, S. When means become ends: considering the impact of patent strategy on innovation, Information Economics and Policy 2004; 16: 135-158.

[25] Lahti, A. Globalisation, International Trade, Entrepreneurship and Dynamic Theory of Economics: The Nordic Resource Based View: Part Two, Global Challenge and the New Economics 2007. Helsinki: Helsinki School of Economics Working Papers W-437, Aalto University.

[26] Schumpeter, J. The Theory of Economic Development, Cambridge: Transaction Publishers, 1934.

[27] Schumpeter, J. Business Cycles: A theoretical, historical and statistical analysis of the capitalist process. New York: McGraw-Hill, 1939.

[28] Dunning, J. Multinational Enterprises and the Global Political Economy 1993. Reading, MA, Addison-Wesley.

[29] Eden, L, Levitas, E, Martinez, RJ. The Production, Transfer and Spillover of Technology: Comparing Large and Small Multinationals as Technology Producers, Small Business Economics 1997; 9: 53-66.

[30] Adams, W, Brock, J. The Bigness Complex, Industry, Labour and Government in the American Economy. New York: Stanford Economics and Finance, 1986.

[31] Damanpour, F. An Integration of Research Findings of Effects of Firm Size and Market Competition on Product and Process Innovations. British Journal of Management 2010; 21: 996-1010. DOI: 10.1111/j.1467-8551.2009.00628.x

[32] Kenney, M. Biotechnology and the Creation of a New Economic Space. California: UC Davis, 2007. Available from: http://hcd.ucdavis.edu/faculty/webpages/kenney/articles_files/Biotechnology%20and%20the%20Creation%20of%20a%20New%20Economic%20Space.pdf

[33] Markusen, J, Venables, A. Foreign Direct Investment as a Catalyst for Industrial Development. NBER Working Papers 6241. Cambridge MA: National Bureau of Economic Research, 1997.

[34] Lööf, H. Multinational Enterprises and Innovation Firm Level Evidence on Spillover *via* R&D Collaboration, International Journal of Production Economics 2009; 76(1): 61-85.

[35] Schumpeter, J. The Theory of Economic Development. Cambridge, Transaction Publishers, 1934.

[36] Nelson, RR and Winter, SG. An Evolutionary Theory of Economic Change. Cambridge, Mass: Harvard University Press, 1982.

[37] Aghion, P, Howitt, P. On the Macroeconomic Effects of Major Technological Change, Nordic Journal of Political Economy 1999; 25: 15-32. http://www.nopecjournal.org/NOPEC_1999_a02.pdf

[38] Schumpeter, J. Capitalism, Socialism and Democracy. New York: George Allen and Unwin Ltd, 1942.

[39] Patel, K, Zavodov, K. Schumpeter on Queen Elizabeth's Stockings and the Co-evolutionary Nature of Innovation, Homo Oeconomicus 2010; 27(1-2): 69-88.

[40] Soete, L, ter Weel, B. Innovation, knowledge creation and technology policy: The case of the Netherlands, De Economist 1999; 147 (3): 293-310.

[41] Filippetti, A, Frenz, M, Archibugi, D. The Effects of the Economic Downturn on Innovation: Creative Destruction versus Creative Accumulation, paper submitted to the 4th Annual Conference of the GARNET Network, Rome, 11-13.11.2009.

[42] Gartner, WB. A Conceptual Framework for Describing the Phenomenon of New Venture Creation, Academy of Management Review 1985; (10) 4: 696-706.

[43] Klepper, S. Entry, exit, growth and innovation over product life cycle, American Economic Review 1996; 86(3): 562-583.

[44]T. Verstraete, A. Fayolle, Paradigmes et Entrepreneuriat, Revue de l'Entrepreneuriat 2005; 4(1). Available from http://asso.nordnet.fr/adreg/RE0401tv_af.pdf

[45] Boulding, K. General Systems Theory, Management Science 1956; 2, 3: 197-208. Available from http://www.panarchy.org/boulding/systems.1956.html

[46] Dosi, G, Marengo, L, Pasquali, C. How much should society fuel the greed of innovators? On the relations between appropriability, opportunities and rates of innovation, Research Policy 2006 ; 35(8) : 1110-1121.

[47] Macdonald, S. Technology and the Tyranny of Export Controls. Whisper Who dares. London : Macmillan, 1990.

[48] Arundel, A, Patel, P. Strategic patenting. Background report for the Trend Chart Policy Benchmarking Workshop "New Trends in IPR Policy", Luxembourg, 3-4 June 2003.

[49] Blind, K, Cremers, K, Mueller, E. The influence of strategic patenting on companies' patent portfolios, Research Policy 2009 ; 38(2) : 428-436. Available from http://econstor.eu/bitstream/10419/24565/1/dp07013.pdf

[50] Cohen, WM, Nelson, RR, Walsh, JP. Protecting their intellectual assets: appropriability conditions and why U.S. Manufacturing firms patent (or not). Working Paper 7552. Cambridge MA National Bureau of Economic Research. Available from http://www.nber.org/papers/w7552

[51] Rivette, K, Kline, D. Discovering new value in intellectual property, Harvard Business Review, January/February 2000: 54-66.

[52] Hall, B, Ham, R. The Patent Paradox Revisited: Determinants of Patenting in the US Semiconductor Industry, National Bureau of Economic Research Working Paper 7062. Cambridge, M.A.: NBER, 1999.

[53] Heller, M, Eisenberg, R. Can patents deter innovation? The anticommons in biomedical research. Science 1998; 280: 698-701.

[54] Malecki, EJ. Everywhere? The Geography of Knowledge, paper prepared for the Journal of Regional Science 50th anniversary symposium, April 2009. Available from: http://www.blackwell-synergy.com/doi/abs/10.1111/j.1467-9787.2009.00640.x

[55] Asheim, BT, Gertler, MS. Knowledge Bases and Regional Innovation System. In Fagerberg, J, Mowery, DC and Nelson, RR, Eds. The Oxford Handbook of Innovation, Oxford: Oxford University Press, 2005; pp. 291-317.

[56] Patel, K, Zavodov, K. Schumpeter on Queen Elizabeth's Stockings and the Co-evolutionary Nature of Innovation, Homo Oeconomicus 2010; 27(1-2): 69-88.

[57] WIPO, World Patent Report: A Statistical Review, Geneva, World Intellectual Property Organisation Resources, 2008.

[58] European Commission, Towards a European Strategy in Support of Innovation in Services Challenges and Key Issues for Future Actions, Commission staff working document SEC, 1059 Europe INNOVA paper No.4. EC: Brussels, 2007.

[59] Gibb, A. Corporate Restructuring and Entrepreneurship: What can Large Organizations learn from Small? Enterprise & Innovation Management Studies 2000; 1(1): 19-35.

[60] Dasgupta, P, David, P. Towards a New Economy of Science. Research Policy 1994; (23)5: 487-521. http://dx.doi.org/10.1016/0048-7333(94)01002-1

[61] Merges, R. Commercial success and patent standards: economic perspectives on innovation. California Law Review 1988; 76: 805-876.

[62] Dicken, P. Global Shift: Reshaping the Global Economic Map of the 21st Century. London: Guilford Publications, 2003.

[63] Cooke, P. To Construct Regional Advantage from Innovation Systems First Build Policy Platforms, European Planning Studies 2007; 15(2): 179-194. doi:10.1080/09654310601078671

[64] Foray, D. Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies, Intellectual Property and Sustainable Development Series, Issue Paper No. 23. Geneva: International Centre for Trade and Sustainable Development, 2009.

[65] UNEP, EPO, ICTSD. Patents and clean energy: bridging the gap between evidence and policy. Final report, United Nations Environment Programme, European Patent Office and International Centre for Trade and Sustainable Development. Munich: European Patent Office, 2010, http://www.epo.org/news-issues/issues/clean-energy/study.html

[66] Roffe, P. Technology transfer on the international agenda (Comment). In Maskus, K, Reichman, J, Eds. International Public Goods and Transfer of Technology Under a Globalized Intellectual Property Regime. Cambridge: Cambridge University Press, 2005; pp. 257-264.

[67] Harvey, I. Intellectual Property Rights: The Catalyst to Deliver Low Carbon Technologies. London: The Climate Group, 2008. Available from www.theclimategroup.org/_assets/.../Intellectual-Property-Rights.pdf

[68] Hutchinson, C. Does TRIPS Facilitate or Impede Climate Change Technology Transfer into Developing Countries? U. Ottawa L. & Tech j. 2006; 3: 517-537.

[69] Ockwell, D, Watson, J, MacKerron, G, *et al*. UK-India Collaborative Study on the Transfer of Low Carbon Technology, University of Sussex (SPRU - Science and Technology Policy Research), Sussex and Institute of Development Studies and the Energy Resources Institute, New Delhi, 2007.

[70] Mallet, A, Ockwell, D, Pal, P. UK-India Collaborative Study on the Transfer of Low Carbon Technology. Phase II Final Report, University of Sussex (SPRU - Science and Technology Policy Research), Institute of Development Studies, Sussex and The Energy Resources Institute, New Delhi, 2009.

[71] Hughes, A, Mina, A. The Impact Of The Patent System On SMEs, Centre for Business Research, University of Cambridge Working Paper No.411, 2010, http://www.ukirc.ac.uk/object/wpaper/5602/doc/WP411.pdf

[72] Rassenfosse, G. How SMEs exploit their intellectual property assets: evidence from survey data, Small Business Economics 2012; 39(2): 437-452, doi:10.1007/s11187-010-9313-4

[73] Nagaoka, S, Igami, M, Walsh, JP, Ijichi, T. Knowledge Creation Process in Science: Key Comparative Findings from the Hitotsubashi-NISTEP Georgia Tech Scientists' Survey in Japan and the US, Hitotsubashi University, 2011, http://hdl.handle.net/10086/19402

[74] Jensen, PH, Thomson, R, Yong, J. Estimating the patent premium: Evidence from the Australian Inventor Survey, Strategic Management Journal, 2011; 32(10): 1128-1138, doi:10.1002/smj.925

[75] Juma, C, Bell, R, Advanced Biofuels and Developing Countries: Intellectual Property Scenarios and Policy Implications, in: UNCTAD The Biofuels Market: Current Situation and Alternative Scenarios, 2009. New York: United Nations Conference on Trade and Development, pp. 63-89, http://belfercenter.ksg.harvard.edu/publication/19798/biofuels_market.html?breadcrumb=%2Fpublication%2F19727%2Fbiofuels

[76] Kamis, R, Joshi, M. Biofuel patents are booming, Baker & Daniels LLP: Washington DC 2008; http://www.bakerdstreamingvid.com/publications/Biofuel%20Report.pdf

[77] Mannan, R. Intellectual property landscape and patenting opportunity in biofuels, Journal of Commercial Biotechnology 2009; 16(1): 33-46.

[78] Glenna, LL, Cahoy, DR. Agribusiness Concentration, Intellectual Property, and the Prospects for Rural Economic Benefits from the Emerging Biofuel Economy, Southern Rural Sociology 2009; 24 (2): 111-129.

[79] Heffernan, WD. Concentration of Ownership and Control in Agriculture. In Magdoff, F, Foster, JB, Buttel, FH, Eds. Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment. New York: Monthly Review Press, 2000; pp.61-76.

[80] Lane, EL. Green Patent Blog, Archive for the 'Biofuels & Biomaterials' category, San Diego, 2013. Available from http://www.greenpatentblog.com/category/biofuels-biomaterials/

[81] Fernandez-Conejo, J. The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets, Regulation, Industry Structure, and Research and Development, *Agricultural Information Bulletin* # 786, 2004. Washington, DC: USDA Economic Research Service.

[82] UNCTAD. Tracking the Trend Towards Market Concentration: The Case of the Agricultural Input Industry 2006. New York: United Nations Conference on Trade and Development.

[83] Porter, ME, Kramer, MR. Creating Shared Value, Harvard Business Review, Jan-Feb 11, https://hbr.org/2011/01/the-big-idea-creating-shared-value

[84] Editorial. Gene patents and the public good. Nature 2003, 423(6937): 207. http://dx.doi.org/10.1038/423207b

[85] Falck, O. Routinization of innovation in German manufacturing: the David-Goliath symbiosis revisited, Industrial and Corporate Change 2008; 18 (3): 497-506.

Received: July 30, 2015 Revised: September 3, 2015 Accepted: September 9, 2015