The grand green challenge: Assessing progress in eco-innovation through Y02 patents

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Abstract

This paper is framed by the role of eco-innovation trends on the progress made so far in the sustainability transition towards a more circular economy. Patents are identified as a means to acquire some new and fresh insights on this matter. A proposal is submitted to operationalize the concept of "eco-innovation" as comprising all the technological contributions subject to patent protection under the novel meta-class Y02, a category for climate change prevention and mitigation technologies proposed by the European Patent Office. Building on this proposal, an overview on the global technological market progress dynamics in these fields is presented.

KEYWORDS: Sustainability; Innovation, Eco-innovation; Patents, Circular economy

1 Introduction

The question of how to curb and accommodate climate change and environmental sustainability is bound to be a defining societal question in the 21st century. This is a deeply ramified behavioural, organisational and technological global task. Issues such as limited global natural resources, growing economic competition in world markets, the expansion of higher living standards and access to health to a rapidly increasing world population (estimated to reach 10 billion people by 2050) compound the difficulties posed by the evolving climate dynamics (OECD, 2012). There is a need to empirically understand how individuals and collective agents mobilise and succeed in meeting these "grand challenges". This notion refers to systemic policy puzzles and includes adverse climate shifts, devastating pandemics, demographic unbalances, exploding urbanization and other transnational phenomena provoking stress in existing social, economic and political structures (Foray et al., 2012). Technology may be an instrumental part of the response, in areas such as clean energy and emissions sequestration (Anadón, 2012). Assessing environmental innovation seems indispensable, not only to gauge its possibilities in addressing the environmental negative impact of economic activity, but also to appraise policies helpfulness, and identify new business and market opportunities (Haščič and Migotto, 2015).

This paper contributes to this agenda by placing the role of technological innovation centre stage. New technologies are determinant in the development, implementation and acceleration of novel solutions to environmental problems, at a global scale (Dechezleprêtre et al., 2011). This is especially true regarding the materials life cycle: how raw materials are extracted, products made, commercialized, used, reused, recycled or discarded. Energy sources, alternative non hazard/toxic materials, more efficient products - made to be durable, reused, and recycled - promoting concepts like "functional service economy"[1], waste reuse as an input source/energy, new ways to enable synergies and materials sharing between enterprises, all these circular inducing developments seem grounded on the materialization of suitable technologies that allow them (Park, 2014). New generation technology show potential for tackling environmental degradation, boosting more circular processes and products, mirroring the way the old industrial-polluting complex ultimately promoted the nowadays linear economy 'take-make-dispose'. Environmental innovation appears vital to positively steer the difficult balance between economic development, international competitiveness and managing natural capital, towards the implementation of a more sustainable, circular, economy (EMF, 2012; WEF, 2014)[2].

[1] Also known as "performance economy", selling services rather than products, benefiting both manufacturers (who retain control over the products, enhancing their maintenance and recovery), and consumers (only paying the service, and normally getting a better one) (EMF, 2012).

[2] Circular economy is a broad concept enclosing products designed to minimize negative environment and societal impacts, reducing the use of non-renewable resources (using instead renewable resources below their rates of regeneration), eliminating toxic and hazardous materials, and increasing the life,

However there is still insufficient information regarding environmental technology trends on a global scale (Dechezleprêtre et al., 2011). Our assumption is that the rate and direction of technological environmental innovation (eco-innovation) can cast some light into the processes of transition towards a next techno-economic paradigm. The hypothesis we wish to discuss is whether patents, a well-worn technological innovation indicator, can still provide some new and fresh information concerning this grand goal, its most recent evolution, dynamics and markets. In this exploratory study, the following approach is proposed: the operationalization of the concept of "eco-innovation" as comprising all the technological contributions subject to patent protection under the novel meta-class Y02, a category for climate change prevention and mitigation technologies proposed by the European Patent Office.

To the extent of our knowledge this is the first study that uses Y02 climate change prevention and mitigation technologies patent data, to describe the geographic market distribution at the global level.

Lanjouw and Mody and (1996) and Dechezleprêtre et al.(2011) have already focused on the subject of patents for environmentally-responsive technology but focusing more on technological production and diffusion across countries, and they do not use the Y02 category.

Our foremost goal is to contribute and further the debate, with empiric evidence on the geographic market distribution and diffusion of climate-mitigation inventions, understanding the global trends of technological “eco-innovation”: how are they evolving in the global arena?; where are eco-innovations been used?; which countries can be distinguished as markets of eco innovation technologies?; within eco-innovation technologies, which sub categories are being further participated and in which countries?

This paper is organised as follows: Section 2 discusses the advantages and disadvantages of applying the patent indicator to environmental innovation; Section 3 presents and critically examines the data source; Section 4 explores some of the patents data, looking into eco-innovation trends and country participation; and Section 5 concludes, presenting the summary of findings, underlining some of the limitations and considering ideas for further research.

reuse, and recovery potential of materials in a closed-loop relation where one waste in another one material input (IAU, 2013).

2 Innovation toward sustainability – Patents

2.1 Patents as an "innovation" indicator

Innovation is defined as a process of novelty introduction to increase value (Balconi et al., 2010). The area of innovation indicators has seen intense activity since the mid-twentieth century. Since the early 1960s R & D statistics helped gauge the economical efforts committed to knowledge production. Indicators concerning R&D (R&D expenditures, intensity, capital stock or staff - number of scientific personnel in different sectors) gradually allowed the observation of technological activity in enterprises (mainly at the applied research level) and government (in terms of funding of basic science, particularly in universities, and technical support at the level of public goods provision) (OECD, 2008; Patel and Pavitt, 1995). Nevertheless they are solely available at an aggregate level, not enabling the analysis by technology group, and without complete data with respect to private R&D expenditures (Haščič and Migotto, 2015).

Other indicators as surveys (for example from OECD and the EU, that are usually very costly); bibliometric data (scientific publications used for examining knowledge diffusion, lacking however information on market output); brands (reveal potentially marketable technical advances, but say nothing about their market success); and patent analyse, are some examples of invention and technological progress indicators aiming to assess the outcome, the output, from the innovative activity (Haščič and Migotto, 2015; Kim and Lee, 2015; Mendonça and Fontana, 2011; Patel and Pavitt, 1995).

A patent is a public contract between an inventor and a government, which awards monopoly rights, for a specific period of time, regarding the use and licensing of an invention (Griliches, 1990). The invention must be novel, not trivial, and must demonstrate a significant breakthrough. In summary, it is an industrial property right to a knowledge asset on a new, non-obvious, idea (Guellec et al., 2011). To protect this right, a trade-off relation is established between the inventor, who reveals detailed information about the patent, and the state, which guarantees protection against its use by others, for a specific period (20 years), in a given geographical area. The patent system can be defined as a way to induce new knowledge, with economic interest (Smith, 2006).

In the last decades, the use of patent analyses and statistics to examine the processes of innovation and technical change, has become quite popular in the Academia, used in several areas of knowledge (Guellec et al., 2011). Pioneers authors as Schmookler (1972), led the way, using patents for the analysis of technological and inventive activity. Other studies streamlined the experience of patents as an economic indicator, to measure scientific and technological activities and their relation with R&D activity, like Scherer (1983, 1965), Mansfield (1984), or Griliches (1990). In the late 1980's, others focused on the use of patents to examine the competitiveness of countries and industries, creating revealed technology advantage indexes for various countries (Patel and Pavitt, 1995; Pavitt, 1988, 1985).

Since patents are considered an indicator of invention (Ghisetti and Quatraro, 2013; Miao and Popp, 2014), of available accumulated knowledge (Popp et al., 2011), as well as of technological change (Verdolini and Galeotti, 2011), they have been also identified as a proxy for innovation (Diaz Arias and van Beers, 2013; Nemet, 2012; Nesta et al., 2014; Verdolini and Galeotti, 2011) and likewise can be thought off as a proxy of technological eco-innovation[3].

The case for deploying patents for appraising "eco-innovation" and eco-innovation's impact on new economic systems centred in a more sustainable model seems to be a special case of a larger research opportunity.

2.2 Patents analysis in environmental issues: limitations and advantages

Further knowledge on innovation and, especially, regarding environmental innovation, seems essential in order to understand its different dimensions on the road to sustainable development (Rennings, 2000).

Some studies already illustrate the extension of the indicator patents to the environmental innovation arena, especially concerning the theory of induced innovation. This concept, first introduced by John Hicks (1932), showed how changes in prices trigger innovation (as a way to cut back on more expensive factor), and the effect that government regulation can have in its stimulation(John Hicks, 1932 in Park, 2014; Popp, 2005). A hypothesis also drawn by Porter and van der Linde (1995), regarding the role of regulation in boosting environmental innovation (Porter and Linde, 1995). In an analysis of "environmentally responsive technology" in Japan, Europe, the USA and fourteen developing countries, Lanjouw and Mody (1996) found a correlation between pollution mitigation expenses and environmental innovation (using patent information), linking environmental policies and technological change. Reichman et al. (2008) also used patents, but instead focused on how intellectual property rights might operate in "green innovation". As for Johnstone et al. (2010), they examined the effect of environmental policies on technological innovation, in the "renewable energy" case. Focusing in climate change mitigation, Dechezleprêtre et al. (2011) similarly used patents to examine the dynamics and diffusion of innovation in the international arena and Hal and Helmers (2010) discussed the role of patents for "climate change-related technologies" and international technology transfer in general.

The attractiveness of using patents to 'narrow' fields of technology, namely on environmental issues, derives from some of their intrinsic features - they are "*widely available, quantitative, commensurable, output-oriented and capable of being disaggregated – an important advantage when analysing environmental technologies*" (Haščič and Migotto, 2015).

[3] Eco-innovation can be defined as innovation that avoids or mitigates negative environmental effects (Arundel and Kemp, 2009; Carrillo-Hermosilla et al., 2010, 2009; Rennings, 2000). For practical reasons, in spite of some recognizable differences regarding definitions like "environmental innovations", "sustainable innovations", or "eco-innovation", these definitions will be used analogously.

Patent databases enable the easily assess to data, for the most part already available electronically, in public registers, containing detailed, desegregated and updated information. They are based on objective standards (not self-evident, novelty, usefulness) and acquiescent to statistical analysis, as they are quantitative data. Each patent have information regarding the actual invention description, references of previous inventions (citations), inventor, inventor country, who is applying for the patent (companies, universities, individuals) and its nationality, country of patenting, among other interesting data. Moreover, patent information is also organised through standardized classifications schemes, which enable to circumscribe specific technological areas. Finally, only very few economically significant inventions have not been patented (Diaz Arias and van Beers, 2013; Griliches, 1990; Lovely and Popp, 2011; Nemet, 2012; Popp, 2005; Popp et al., 2011).

Nevertheless, patent statistics also have some limitations that should be taken into account. Patents are only an approximation, taken more safely as an indicator of invention (not finished, yet to be developed) than innovation (already introduced in operational context) or eco-innovation (Ghisetti and Quatraro, 2013). Likewise, patents point to inventive activity, but not to technology adoption (Ghisetti and Quatraro, 2013). The existence of a patent does not mean straightforwardly that the technology was adopted, and diffused. Patents grant protection to inventions of substantially heterogeneous economic value and several patents end up having little commercial value (Griliches, 1990; Lovely and Popp, 2011; Nemet, 2012; Nesta et al., 2014; Popp et al., 2011). It must also be considered that the propensity to patent varies across countries, sectors, firms, industries and areas of activity, due to several factors. The firm size or its ability to pay and maintain the cost of a patent is determinant. Some types of actors, sectors and fields are more prone to patenting than others, like plastics, rubber, drugs and computers. Not all inventions are patentable; there are several nonpatented technologies that cannot be identified in patent analyses. A process innovation can be protected through other means like trade secrets or know-how. Even differences between countries technological capabilities, and their enforcement of patent laws (ease of patenting; patent infringement litigation) hampers the comparability of the indicator patents (Diaz Arias and van Beers, 2013; Ghisetti and Quatraro, 2013; Griliches, 1990; Lovely and Popp, 2011; Miao and Popp, 2014; Nemet, 2012; Popp et al., 2011).

As innovation is undoubtedly difficult to measure, patents, like any other indicator, are only an indirect measure with its specific shortcomings. Furthermore, since there are several ways to analyse patents (count, citations, and patent families) their use must also be suited to the research objectives (de Rassenfosse et al., 2013). As such, patent counts can be used as proxy (imperfect measure) for innovation (de Freitas and Kaneko, 2012; Lanjouw et al., 1998); the analysis of citations made by each patent (mandatory to its granting) can also be an interesting indicator, enabling the examination of knowledge flows (Nemet, 2012; Popp and Newell, 2012); and patent families (patents filled in multiple countries associated to protect the same single invention) can be used to determine the pathways of technologies dispersion across countries (Dekker et al., 2012; Popp, 2005).

Admittedly, patents reflect the investment in time and money that entities commit to protect an invention in the countries where they expect it to be profitable (Diaz Arias and van Beers, 2013; Popp et al., 2011). As such, patenting requires at least a strategic intent; a willingness to market an idea and prevent competitors from catching up. Consequently, while patents do require a very careful analysis, sensitive to possible noise and biases in the data, they seem a valuable proxy for innovation and technological achievements (Grant et al., 2014). Furthermore, regarding eco-innovation activities, patents, having standard technological classification, enable the identification of specific "environmental" technologies (Haščič and Migotto, 2015).

In the present analysis, patent counts of technologies for clean energy and environmental impact mitigation will be specially addressed as an eco-innovation indicator, since they can prove invaluable for refining our understanding of the intellectual progress in tools for promoting sustainability across countries and over time.

2.3 The new Y02 classification: an eco-innovative patent?

Another major difficulty while searching patents in the specific subset of environmental technologies, is that they tend to intersect several categories within the existing classification schemes, not falling under one single dedicated classification section (EPO et al., 2010). Using the existing *International Patent Classification (*IPC)[4] or the European classification system (ECLA)[5] classifications, results would have too much "noise" and incomplete information.

This led to a joint project, in 2009, of the United Nations Environment Programme (UNEP), the European Patent Office (EPO) and the International Centre for Trade and Sustainable Development (ICTSD), to analyse and establish a new patent classification for climate change mitigation technologies, to be included in EPO's Worldwide Patent Statistics Database (PATSTAT) and regularly updated (EPO et al., 2010; Veefkind et al., 2012). This new categorization was released at the Copenhagen Conference of Parties (COP) and at the Bonn UN Climate Change Talks of 2010 (EPO et al., 2010) yielding a new classification scheme, the Y02. It became a basis for a comprehensive, detailed and regularly updated database, acknowledged by official international stakeholders, but accessible to non-expert users. The **Y02** class comprises:

- Y02C[6]- Greenhouse gases capture and storage/sequestration or disposal technologies
- Y02E[7] -Technologies related to energy generation, transmission or distribution

[4] *International Patent Classification* (IPC) was established by the Strasbourg Agreement 1971 and provides a classification of patents and utility models according to the different areas of technology (WIPO, 2014), it has approximately 70,000 description codes of inventions, depending on their characteristics and technical areas (EPO, 2010).

[5] The European Classification (ECLA) is a European patent classification system that extends the IPC classification system. It has around 140 000 subdivisions and is in permanent update and review (EPO, 2010). ECLA has been replaced by the Cooperative Patent Classification (CPC) as of January 1, 2013 (EPO, 2013a; Haščič and Migotto, 2015).

[6] To see indexing scheme relating to capture, storage, sequestration or disposal of greenhouse gases http://bit.ly/1FQ7XKc

Other environment mitigation technologies subclasses were introduced later (2013) and are not yet complete, including:

- Y02B[8] - referring to Buildings, comprising the residential sector (i.e. environmental impact mitigation technologies related to the construction of buildings, construction elements, appliances, integration of renewable energy sources, etc.)
- Y02T[9] - for the transportation of goods and persons (e.g. ways to reduce emissions of greenhouse gases from transport)

In May 2015[10] it was also added the category:

- Y02W[11] - for Waste processing concerning solid and waste water treatment, and reuse, recycling or recovery technologies

In the future, these categories should keep growing, in order to include for example industrial processes and agriculture (I) (Veefkind et al., 2012).

Nevertheless, the Y02 scheme is a complementary classification scheme, a parallel taxonomy, not replacing any existing or future classes in CPC/ ECLA and/or IPC classification (Veefkind et al., 2012). Moreover, tagging is done by search algorithms that use descriptive attributes in the DOCDB, EPO's internal schemes of in-computer-only classification symbols and keywords on English titles and abstracts. As a result, this patents population is considered imperfectly defined (Haščič et al., 2015). Additionally, even though the Y02 category refers to technologies for clean energy and environmental impact mitigation, it should not be understood that all technologies with this classification are ecologically positive, sound or 'green', as they may have other unfavourable environmental aspects when appraised more generally, e.g. nuclear energy (Veefkind et al., 2012), ultimately it will depend on the technological use in practice (Haščič and Migotto, 2015).

In spite of these limitations, the growing scope of the Y02 category, referring to technologies for clean energy and environmental impact mitigation (i.e. technologies with significant potential to reduce emissions of greenhouse gases), may enable its use as a proxy for "green patents", described as those covering "*waste management, air and water pollution reduction, renewable energies, hybrid/electric car technologies and energy efficiency in lighting and building*" (OECD, 2011a, 2011b).

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[7] To see indexing scheme relating to reduction of greenhouse gases [ghg] emission, related to energy generation, transmission or distribution http://bit.ly/1vlPCOY

[8] To see indexing scheme relating to climate change mitigation technologies related to buildings http://bit.ly/1zV9T1U

[9] To see indexing scheme relating to climate change mitigation technologies related to transportation http://bit.ly/1tsra7k

[10] After the sample has been collected, and because of that not yet integrated in this analysis.

[11] To see indexing scheme relating to climate change mitigation technologies related to wastewater treatment or waste management http://bit.ly/1AAbcsH

It can also be considered in line with the EU definition of eco-innovation as "*any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development*" (EC, 2011).

Since these definitions are in tune with the Y02 rationale, we will take them to be the operational concept-data nexus, i.e. Y02 are taken to indicate technological learning and achievement in "eco-innovation", never forgetting its importance to the sustainability "big picture".

3 Methodology

3.1 Data search, chronological span, and limitations

If EPO is one of the main sources of patent data (Smith, 2006), the EPO Worldwide Patent Statistical Database (PATSTAT) is one, if not the most, prominent database presenting bibliographic patent data as early as the nineteenth century with a worldwide coverage of around 100 countries patent offices, comprehending around 70 million applications (de Rassenfosse et al., 2014). It have however some limitations as it consists in a "snapshot" of the EPO master documentation database (DOCDB) at a single point in time, actualized 2 times a year in the spring (April), and in autumn (October). Specific details and differences can be detected at the data level such as different names or dates, as the patent granting authority may have corrected their databases in the time since this statistical database 'snapshot' was made (EPO, 2014). Also, as it is based on DOCDB, what is not in DOCDB will not be available, for example the application numbers from Espacenet may differ, as it displays application numbers in another format (namely EPODOC format) (EPO, 2013a).

Nevertheless PATSTAT is a broad database specifically developed for use by government/intergovernmental organisations and academic institutions which justify its use as to analyse patenting dynamics in clean energy and environmental impact mitigation technologies (all technological contributions eligible for protection within the Y02 category).

The research was then carried out in PATSTAT on line [12] in its Spring 2014 version, using the one month free of charge online trial (http://bit.ly/1yrZ45J), through the following SQL query:

```
SELECT appln_auth, year (publn_earliest_date), count(distinct(tls201_appln.appln_id))
FROM tls224_appln_cpc join tls201_appln on tls224_appln_cpc.appln_id =
tls201_appln.appln_id
where cpc_class_symbol like 'Y02%' and year (publn_earliest_date) between 1990 and 2014
group by appln_auth, year (publn_earliest_date)
order by appln_auth, year (publn_earliest_date)
```

[12] The query was run in 07-12-2014

This query was design with the following reflections in mind:

- Regarding the chronological time span, public and governmental awareness to the detrimental effect of environmental degradation emerged during last third of the 20th century. Momentum was gained particularly in the 1990s with the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro (UN, 1992). In addition, harmonisation of patent offices' routines just happened from the early 20th century onwards (Lerner, 2005). As a result, the chronological period considered interesting was from 1990 to 2013.
- Innovation activities can be analysed using patents counts by the country of applicant, of inventor, or by country where the patent was filed, presenting specific readouts and aiming to different features (Table 1).

Table 1. Country analysis: inventor, applicant or country

Country of applicant	Country of inventor	Count by patent office country
• Focus on "ownership" (number of patents owned by residents of a given country). • Addresses the innovative performance of a country's companies (regardless of where the research is done).	• Focus on innovative performance. • Addresses researchers in a given country	• Focus on the attractiveness of a country's patenting process. • Enables considerations regarding the quality of intellectual property regulations; rules, cost of patenting of the patent office; and general economic features (size/importance of the market).

(Guellec et al., 2011)

As to ascertain major dynamics on innovation activities, patent counts by application authority (meaning the national or regional agency where they were filled) can be understand as a measure of patenting activity, having particular advantages. As patents are submitted where there is an intention to safeguard and commercialize the invention, this approach enables the study of a country's technological innovation performance, quantifying its relative technology market share in innovation (Haščič and Migotto, 2015).

Still some limitations for comparisons of technology performance between countries have to be considered. Usually an invention is first patented in its home country, benefiting from the so called "home advantage", which can skewer that country's patent total. Also, international patents are subjective to trade flows between countries (patents will be filled in the countries with more trade connections) (Guellec et al., 2011).

Nonetheless, an exploratory analysis on this basis seems useful in order to achieve a broader picture of the eco-innovation dynamics and trends, enabling considerations regarding regional innovation patterns.

- In patent count analysis one can use: a) the (earliest) priority date, as the date closest to the act of invention; b) date of the first publication, when the patent is made available to the public (Guellec et al., 2011). The priority date is closest to the date of invention and typically applications are published 18 months after filing[13] and must be kept secret before publication (EPO, 2013a; Haščič and Migotto, 2015). Because of this, it is normal to see a dip in filings for the last 2 years (known as "publication lag"), due to the lack of available data on the non-published applications.

  To minimize this "lag", and considering that only after the publication date that technology starts to be publicly disclosed, becoming part of the prior art, in this paper the choice fell on the publication date. However, it is necessary to keep in mind that the publication date is the reflection of previous research (at least 18 months and sometimes as further as more than 36 months) and influenced by other external parameters, for instance, productivity of the patent offices worldwide, due to eventual changes in the application & granting procedures (EPO, 2013a).

The raw data retrieved from PATSAT[14] was then compiled in a general table (Appendix A) by application authority, per year. To ensure comparability the United Nations M.49 was chosen as standard code of countries, continents, and areas (UN Statistics division, 2013). Various graphs and tables were afterwards prepared in order to examine specific aspects of the patenting dynamics.

Regarding global activities in Y02 category patents, between 1990 and 2013, it was observed: the number of patents published per year; the average annual growth rate of published patent.

As for countries' patterns and participation (countries patent office's involvement in Y02 patenting), it was considered: top 10 ranking Y02 published patents per patent office; percentage of published Y02 patents per country, per decade; distribution per developed and developing areas, distribution by Continent. Regarding intensity, the Herfindahl-Hirschman Index (the sum of squares of Y02 published patents) was used as a measure of geographical concentration, to the top 6 countries, and continents.

In order to seek a more in-depth analysis of countries' specialization, a disaggregated search into Y02 sub-classes (Y02C; Y02E; Y02B and Y02T) was also carried out[15], focusing on eco-innovation technology diversity. Engaging in specific technological components within the broader field of clean energy and environmental impact mitigation technologies enables a deeper and more detailed analysis of different technologies that are registered in each country, through the construction of a revealed technological advantage (RTA) index. Some caveats have, nevertheless, to be made since such further analysis comes at a cost. A patent may be published with more than one sub classification (for example a patent can be assigned the Y02C and Y02B classes

[13] However, a bigger delay is possible, since patent authorities may take more time to send EPO the information about applications.
[14] The full list is included in Appendix B.
[15] The full SQL queries are included in Appendix C.

simultaneously). If for the analysis of the Y02 as a whole this does not constitutes an issue (as it give us the total number of patents Y02) in the desegregated data we can expect duplicated counts per year, as a patent can be in more than one of those sub categories[16]. Thus, we will have more classifications than patents. Notwithstanding, this disaggregated analysis enables an indication of a given economy's relative specialisation in those technology domains.

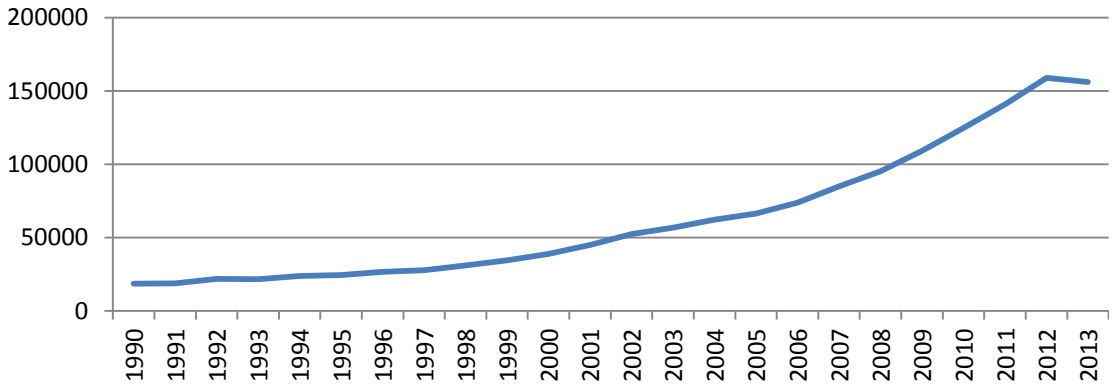
4 Exploring the structure and the dynamics of the Y02 global landscape

4.1 General Y02 styled facts regarding eco-innovation activities

The overall patenting activity in Y02 technologies enables a glimpse on the international dynamics of eco-innovation following a market view, namely the intention to economically explore these technologies according with the emerging demand and growing attention to environmental issues in some areas of the globe.

In aggregated terms there seems to be a growing interest in patenting in this area (Figure 1). The post-2013 apparent decrease may result from delays in the transmission of patent information between the national patent offices and PATSTAT.

Figure 1. Y02 published patents per year



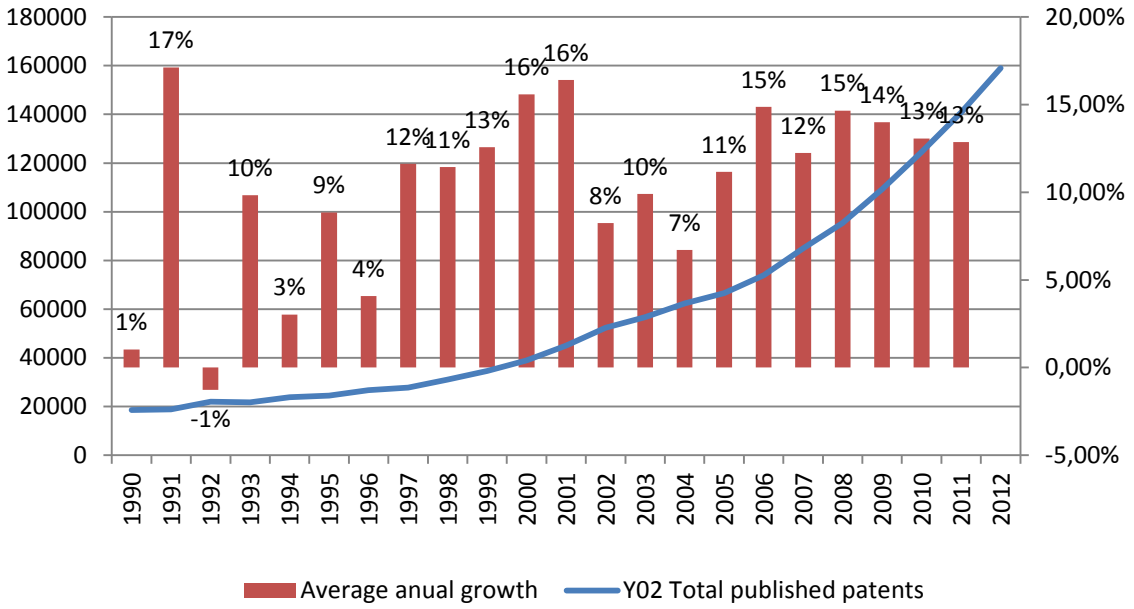
Source: PATSTAT Spring 2014

Between 1990 and 2013, published patents grew by an average annual rate of 9,7%. In fact, since 1997 an upward trend in the average annual growth rate of published patents can be observed (Figure 2), a possible consequence of the growing awareness regarding sustainable development, emerging on the early 1990's from the Earth Summit in Rio de Janeiro (1992) and subsequently the Kyoto Protocol (1997).

[16] The full Y02 disaggregated tables are included in Appendix D.

This trend was interrupted between 2002 and 2005, possibly as a result of the stock market downturn of 2002, aided by rising volatility in crude oil prices in international markets, recuperating in 2006 maintaining a regular growth rate.

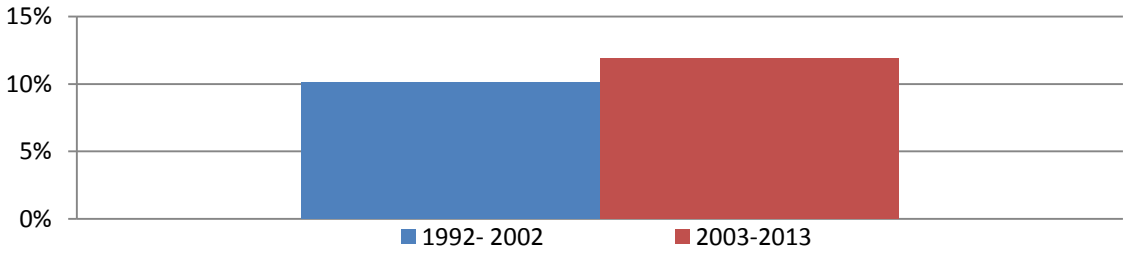
Figure 2. Trend in total Y02 patent published 1990-2012



Source: PATSTAT Spring 2014

By disaggregating data of the last two decades, the last decade (2003-2013) can be confirmed as the most dynamic (Figure 3).

Figure 3. Average annual growth rate of published patents two last decades



Source: PATSTAT Spring 2014

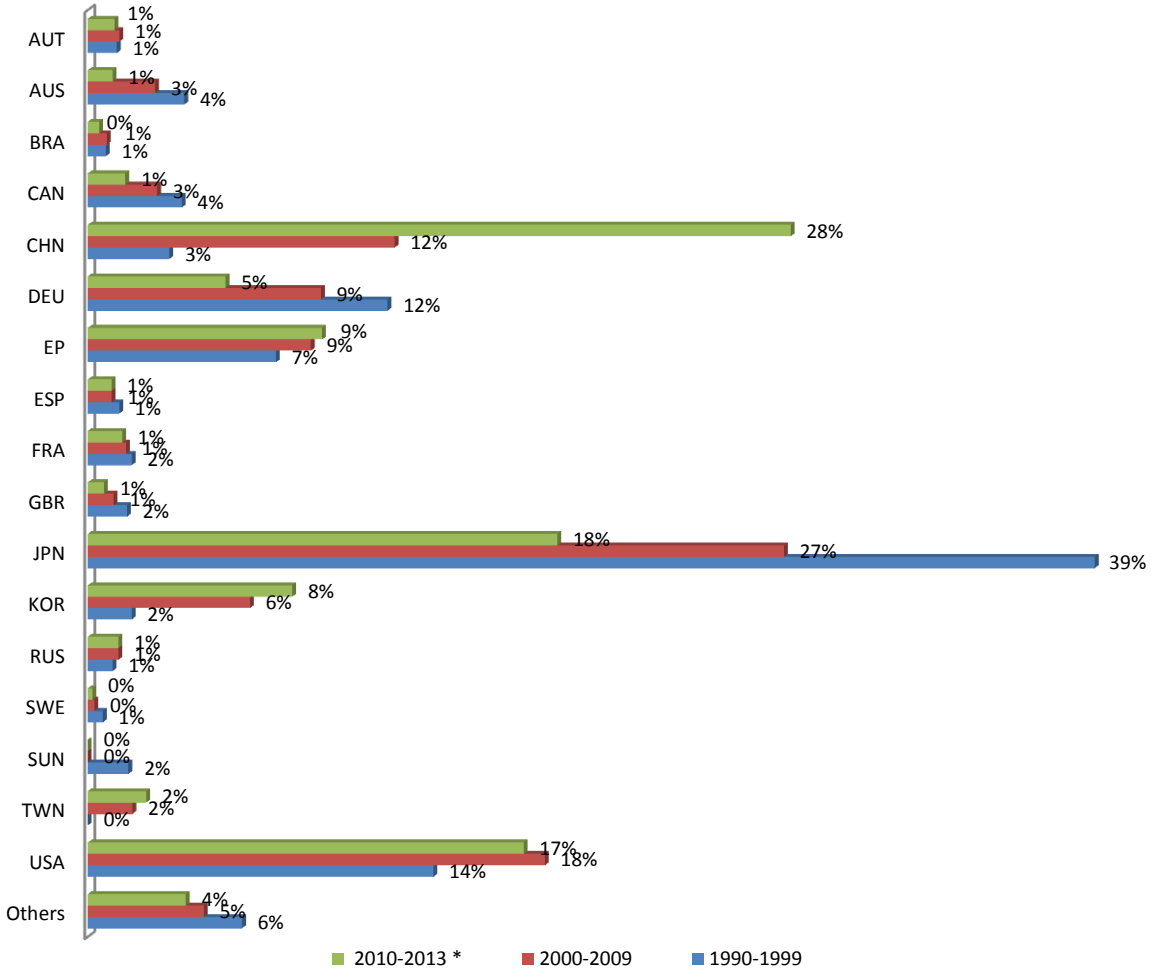
4.2 Countries participation in the eco-innovation processes

Looking into the countries with at least 1% of published Y02 patents, in at least one of the considered decades (Figure 4), it is possible to ascertain that:

- only one South American country, Brazil, and one from Oceania, Australia, are represented, while no country from Africa is present in this list;

- This list also includes the European Patent Office (EP)[17], 7 European countries (Austria, Germany, Spain, France, Great Britain, Sweden and Russia, not including the former Soviet Union), 4 Asian countries (China, Japan, Korea and Taiwan) and 2 North American countries (Canada and USA);
- The countries on this list, excluding both the EP and the former Soviet Union (SUN), amount to 91% of all Y02 published patents in 1990-1999, 92% in 2000-2009 and 91% in 2010-2013, showing that these are the more appealing markets for this kind of patents.

Figure 4. % of published Y02 patents per country, per decade



Note: Time interval 10 years, except (*) 4 years.
Source: PATSTAT Spring 2014

[17] The European Patent Convention of 1973 enabled the use of a single application to provide easier, cheaper and stronger protection for inventions in the contracting states, namely: Albania, Austria, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and Britain. "I*n each contracting state for which it is granted, a European patent gives its proprietor the same rights as would be conferred by a national patent granted in that state"* (EPO, 2013b).

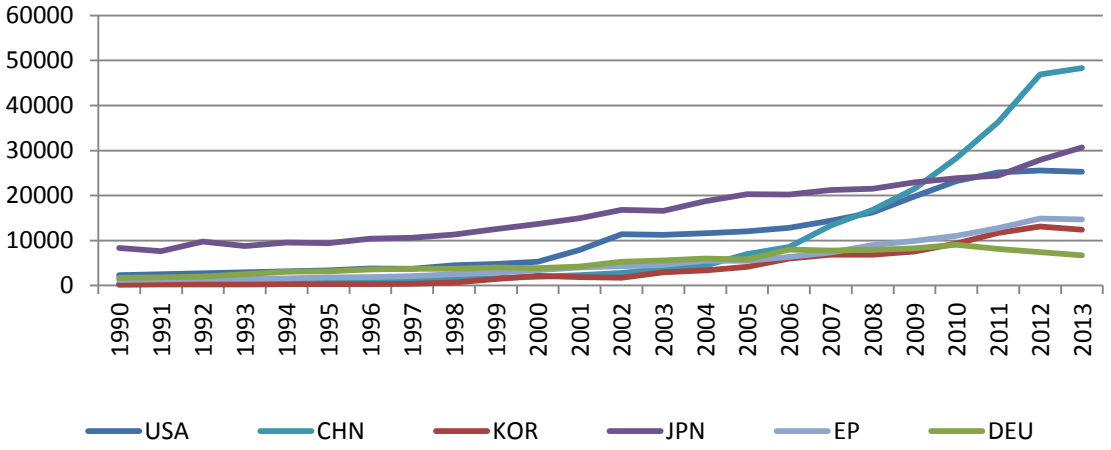
Focusing on the top performer patent offices, as to verify eventual changes in the top 10 ranking, per decade (Table 2 and Figure 5), Japan and the United States were the countries displaying the greater number of published patents between 1990-1999 and 2000-2009. As a matter of fact, the US and Japan are not only considered very technologically advanced countries in the world, but also particularly important markets, significantly attracting applicants' efforts to protect and commercialize their technologies. In the other hand, both countries have been making steps in regard to environmental sustainability, which can catalyse market demand for more "eco-innovations". For example, in the United States, at a local level, the City of New York restricted the sale of single plastic-foam (New York City Council, 2013) and Chicago defined a recycling target of 50% for all construction and demolition waste (City of Chicago, 2014), creating a potential demand for eco-innovations.

Table 2. Top 10 ranking Y02 published patents per country

	1990-1999			2000-2009			2010-2013*		
Ranking	**Patent Office**	**Total number**	**% of total**	**Patent Office**	**Total number**	**% of total**	**Patent Office**	**Total number**	**% of total**
1º	**JPN**	98354	39%	**JPN**	186958	27%	**CHN**	159912	28%
2º	**USA**	33779	14%	**USA**	122687	18%	**JPN**	106803	18%
3º	**DEU**	29306	12%	**CHN**	82359	12%	**USA**	99195	17%
4º	**EP**	18403	7%	**DEU**	62597	9%	**EP**	53345	9%
5º	**AUS**	9424	4%	**EP**	59903	9%	**KOR**	46504	8%
6º	**CAN**	9180	4%	**KOR**	43526	6%	**DEU**	31325	5%
7º	**CHN**	7945	3%	**CAN**	18644	3%	**TWN**	13292	2%
8º	**FRA**	4291	2%	**AUS**	18120	3%	**CAN**	8569	1%
9º	**KOR**	4277	2%	**TWN**	11964	2%	**FRA**	7791	1%
10º	**SUN**	3968	2%	**FRA**	10202	1%	**RUS**	6975	1%

Note: Time interval 10 years, except (*) 4 years; AUS - Australia, DEU - Germany, JPN - Japan, SU - Soviet Union (USSR), CAN - Canada, EP - European Patent Office, KOR - Republic of Korea (South Korea), TWN - Taiwan (Province of China), CHN - China, FRA - France, RUS - Russian Federation, USA - United States of America
Source: PATSTAT Spring 2014

Figure 5. Y02 published patents per country



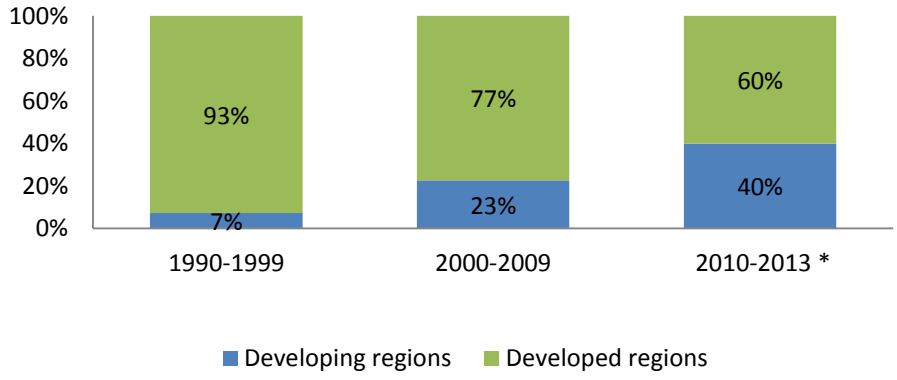
Source: PATSTAT Spring 2014

Other markets seem to be emerging recently. Since 2005, China has taken off, rising from a 7th position in 1990-1999 (only 3% of the global total), to a second post in the period 2000-2009 (12%), and claiming the number one post in 2010-2013 (28%). This increase in active patenting registration in China may point to new perceptions of the potential market that this country represents for this kind of technologies. Also, it may be linked to China efforts to further uphold protection of intellectual property rights in alignment with the international standards.

As for Europe, in the EP (European Patents) format, it appears in the 4th / 5th place in these periods. Considering the European countries isolated, Germany appears in the 3rd place in the decade 1990-1999, dropping to 4th in 2000-2009 and to 6th in 2010-2013, while France gets the 8th place in the decade 1990-1999, the 10th in 2000-2009 and the 9th in 2010-2013. Especially in the last 2 periods, it can be argued that some of the variations might be contingent to the economic environment, as economic problems tend to have a negative impact in patents, due to the reduction of R&D investment and the decline of financial markets (Kim and Lee, 2015). Also, it may be worth of further consideration and study the fact that while European countries can be important producers of these technologies, nowadays, they may not be the most important markets for their commercialization, since in the last decades several environmental considerations were already applied and many polluting industries were outsourced.

Focusing on the evolution trend between developing and developed regions[18] (Figure 6), there is still a significant asymmetry between markets, even if seeming rapidly equalising. The apparent catching up by the developing regions can however be explained for the most part by the growing role of the China market within the global environmental technology trend.

Figure 6. Distribution per developing and developed regions

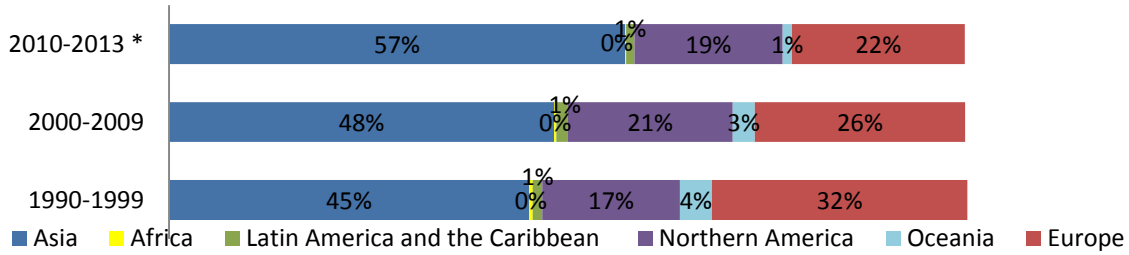


Note: Time interval 10 years, except (*) 4 years.
Source: PATSTAT Spring 2014

[18] Using the UN M49 composition of macro geographical areas stressing that in the United Nations system there is no convention to account on "developed" and "developing" countries (UN Statistics division, 2013) and adding to Africa the African Regional Industrial Property and the African Intellectual Property Organization; to Asia the Organization Eurasian Patent Organization, and the Gulf Cooperation Council; and to Europe the European Patent Office.

Re-aggregating the collected data, per continent[19] (Figure 7), Asian countries amount to a percentage of 57% of the world's market Y02 patents, in the period of 2010-2013, followed by Europe (22%), Northern America (19%), Latin America and the Caribbean (1%), Oceania (1%) and Africa (0%).

Figure 7. Distribution per Continent



Note: Time interval 10 years, except (*) 4 years.
Source: PATSTAT Spring 2014

Applying the Herfindahl-Hirschman Index[20] to the top 6 performer country patent office (in the 3 considered periods), as a measure of geographical concentration (Table 3), it is possible to ascertain that this is a moderate concentrated technological arena (if we take the usual thresholds employed in the appraisal of competing markets) in all the periods.

Table 3. HHI Index regarding Y02 top performance patent offices

	1990-1999	2000-2009	2010-2013 *
USA	0,018346046	0,032066093	0,02920703
KOR	0,000294122	0,004035956	0,00641931
JPN	0,155536725	0,074462406	0,03385904
EP	0,005445354	0,007644448	0,00844686
CHN	0,001014931	0,014450108	0,07590491
DEU	0,013808992	0,008347492	0,00291266
HHI	**0,19**	**0,14**	**0,16**

Note: Time interval 10 years, except (*) 4 years.
Source: PATSTAT Spring 2014

It seems interesting, however, that using the same index to an analysis by continent, the market seem rather concentrated, especially in Asia (Table 4). The way it is tightening can be compatible with the perception that some global actors are receptive and deploying green strategies (as well as fierce state-sponsored patenting strategies, e.g. China).

[19] Using the UN M49 composition of macro geographical (continental) regions, (UN Statistics division, 2013) and adding to Africa the African Regional Industrial Property and the African Intellectual Property Organization; to Asia the Organization Eurasian Patent Organization, and the Gulf Cooperation Council; and to Europe the European Patent Office.

[20] Herfindahl-Hirschman Index is computed by squaring the market share, and then summing the resulting numbers: unconcentrated markets have HHI below 0.15; moderately concentrated markets between 0.15 and 0.25; and highly concentrated markets above 0.25 (U.S. Department of Justice and the Federal Trade Commission, 2010).

Table 4. HHI Index regarding Y02 top performance patent offices' continents

	1990-1999	2000-2009	2010-2013 *
Asia	0,203158786	0,232268302	0,325931467
Africa	0,000018858	0,000007618	0,000001652
Latin America and the Caribbean	0,000148690	0,000209470	0,000103537
Northern America	0,029672711	0,042552377	0,034471103
Oceania	0,001582240	0,000769620	0,000130635
Europe	0,102397023	0,069307075	0,046860305
HHI	**0,34**	**0,35**	**0,41**

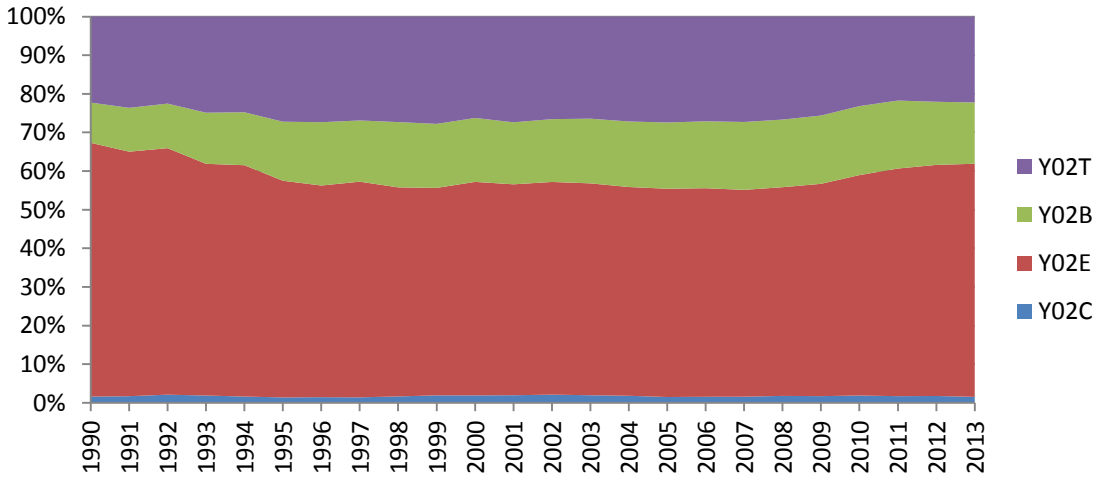
Note: Time interval 10 years, except (*) 4 years.
Source: PATSTAT Spring 2014

4.3 Disaggregating the Y02

The disaggregation of the Y02 patents in its sub-categories allows for some considerations.

The Y02E, related to energy generation, seems the technology category that capture more (at least 50 %) of the market in Y02 technologies. This may be related with the role of renewable energies as alternatives to minimize countries dependence on carbon base fuels and their receptivity to alternative technologies. As for Y02B (solutions regarding minimization of environmental impact on buildings), a new "market" seems to be slowly emerging (Figure 8).

Figure 8. Y02 patents disaggregation per sub categories (%)



Y02C - Storage/sequestration or disposal of greenhouse gases
Y02E - Energy generation, transmission or distribution
Y02B - Building
Y02T - Transportation of goods and persons
Source: PATSTAT Spring 2014

To compare a given economy's relative specialisation in each of those sub technology fields, a revealed technological advantage (RTA) index was calculated.

For this assessment, only the countries with at least 1% of the total of Y02 publications in the period of 2000-2009 and/or 2010-2013 were considered (Figure 4), namely, the USA, Taiwan, the Russian Federation, the Republic of Korea, Japan, Britain, France, Spain, Germany, China, Canada, Brazil, Australia and Austria (excluding the EP).

The extent to which these economies markets have specialised in particular fields within the clean energy and environmental impact mitigation technologies can be inferred by looking at the changes in their RTA in those fields (Appendix E).

$$RTAij = \left[\frac{patij}{\sum patij} \Big/ \frac{\sum pati}{\sum pat}\right]$$

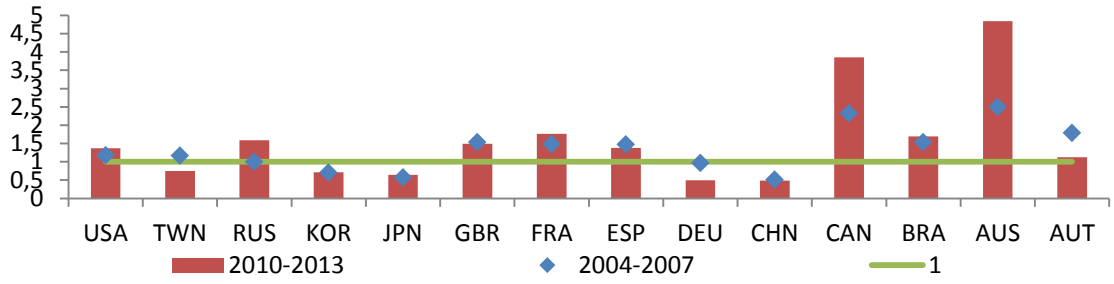
The RTA index indicates the share of an economy's patents in a particular Y02 technology (E, C, B or T) in comparison to the relative weight of that particular Y02 technology field within the reference area (that is, global patenting in the Y02 category). The index is equal to zero when the economy has no patents in a given field; is equal to 1 when the economy's share in the sector equals its share in all fields (no specialisation); and is above 1 when a positive specialisation is observed (OECD, 2013).

In terms of specific Y02 classes a number of patterns emerge.

Y02C refers to capture or disposal of greenhouse gases [GHG] other than CO 2 (nitrous oxide -N2O, methane, perfluorocarbons -PFC, hydrofluorocarbons -HFC, sulfur hexafluoride -SF6; and CO 2 capture (by biological, chemical, absorption, membranes or diffusion, rectification and condensation) and or storage (subterranean or submarine). Canada and Australia seem to have the most intensity levels in Y02C, while Taiwan, Britain, Spain, Germany and Austria became relatively less specialised in this field (Figure 9).

Australia's intensity in these technologies may be explained by a tendency towards market focus on mitigation technologies instead of energy or resource efficiency solutions.

Figure 9. Change in RTA in Y02C, 2004-07 and 2010-13



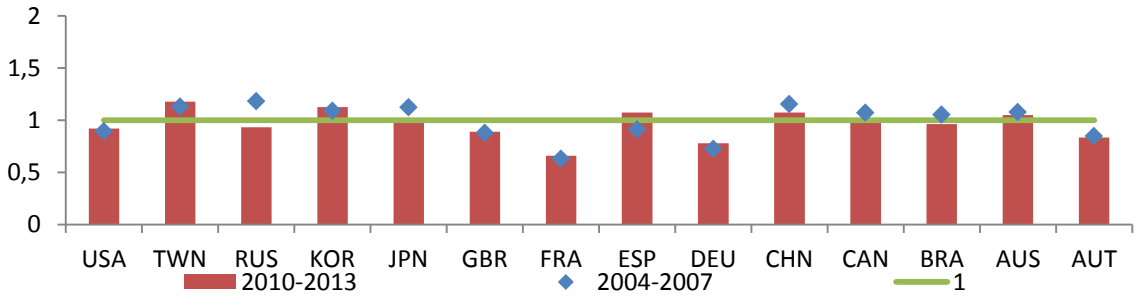
Source: PATSTAT Spring 2014

Regarding Y02E, referring to energy generation through renewable energy sources and technologies for an efficient electrical power generation, transmission or distribution,

most economies are generally relatively unspecialised. South Korea and Spain increased (slightly) their specialization in these technologies. Russia, Japan, China, Canada, Brazil and Australia and Austria became relatively less specialised in this field (Figure 10).

Korea's slight specialization in 2010-2013 may be accounted as results from the national green growth development strategy of 2008, and the goal to increase the country's renewable energy to 11% by 2030 (IEA, 2012). As for Spain it is possibly related to the effort to promote the country's energy production sector in anticipation of a European single energy market.

Figure 10. Change in RTA in Y02E, 2004-07 and 2010-13

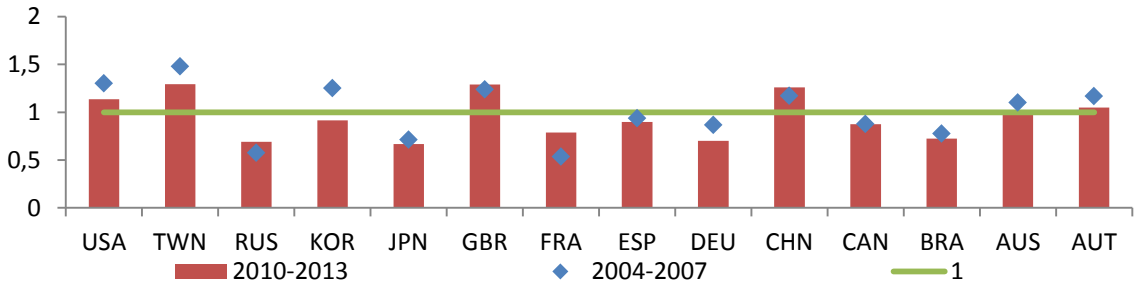


Source: PATSTAT Spring 2014

In Y02B technologies (related with integration of renewable energy sources in buildings; energy efficient lighting, heating, ventilation or air conditioning technologies; technologies aiming at improving the efficiency of home appliances, architectural or constructional elements improving the thermal performance of buildings among others), Britain and China became slightly more specialised markets in the 2010-2013 period (Figure 11).

This is rather interesting in the context of the 2014 agreement between Britain and China to implement in the latter the former's green construction standards (UK government, 2015). Green construction seems to be a focus issue in both countries agenda.

Figure 11. Change in RTA in Y02B, 2004-07 and 2010-13

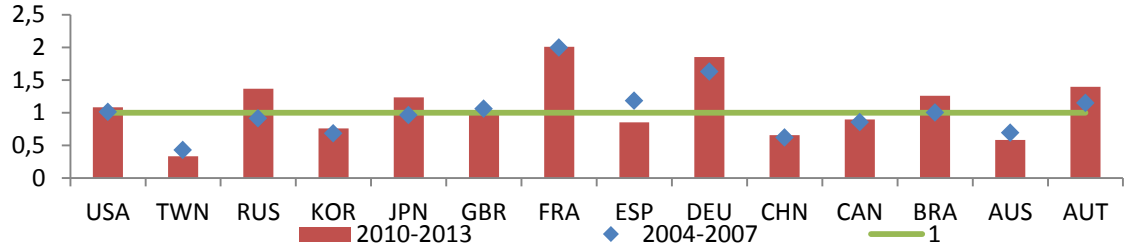


Source: PATSTAT Spring 2014

In Y02T technologies - for the transportation of goods and persons (e.g. ways to reduce emissions of greenhouse gases from transport) - France emerges as the most specialised in 2010-13, and Russia, Japan, Germany, Brazil and Austria became relatively more specialised in this field (Figure12).

France, Germany, Austria and Japan's specialization can be considered in the broad context of both the necessity and the intense strategic focus in green development by the automotive industry, due to regulatory and environmental policy constrains and increased costumer awareness to environmental issues.

Figure 12. Change in RTA in Y02T, 2004-07 and 2010-13



Overall, the level of technological specialisation in the Y02 subclasses changes substantially across economies and technologies, suggesting a pattern of international division of labour.

5 Concluding remarks

Yardsticks for assessing progress towards sustainability are on demand, especially those that may trace factors that impact upon shared climate-related goals, not only to appraise environmental innovation policies helpfulness, but also to identify new business and market opportunities.

The present paper constituted an exploratory study, adding on to the discussion of the potential of the indicator patents in eco-innovation studies. Most especially, through the analysis of the European Patent Office Y02 patent category for climate-change mitigation technologies, as an eco-innovation proxy.

Notwithstanding the patent limitations and potential biases that emphasize the need of a careful analysis of this kind of data, patents strategic intent make of this indicator a valued proxy for innovation and technological achievements. The EPO's Y02 category enhance the interest of this indicator as technologies for clean energy and environmental impact mitigation can be considered "*innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development"* (EC, 2011).

Starting from these assumptions, and using PATSTAT database it was possible to gather information of Y02 published patents, by application authority, from 1990 to 2013 regarding eco-innovation activities; protagonists and specific technologies.

This data allowed the observation of a rising trend in patenting in Y02, likely to intensify in a growingly competitive, complex, global economic system. These trends can be underlined specially in Asia (China, Japan, Korea and Taiwan), Europe (Austria, Germany, Spain, France, Great Britain, Sweden and Russian) and North America (Canada and USA), which emerge as the most dynamic market continents with South America, Oceania and Africa for the greater part excluded of these processes. Also worth of special note is the growing preponderance of China as a patenting market. Nevertheless, as the economic value of patents varies greatly and in this investigation the quality of the inventions was not accessed, these results may be slightly less sticking.The exam centred on the Y02 subclasses, allowed for some considerations regarding leading markets for specific kinds of technologies. In the last decade, Australia and Canada seem to be particular intensive markets in technologies for capture or disposal of greenhouse gases (Y02C), while Spain and South Korea markets are more focused on energy generation through renewable energy sources (Y02E). As for technologies related with green construction (Y02B), particular efforts appear underway in China and Britain. Finally, technologies for the transportation of goods and persons (Y02T) received particular emphasis in European (France, Russia, Germany and Austria) and Japanese markets.

This study sought to contribute to further the debate regarding eco-innovations role in sustainability transition, through an initial understanding about the Y02 technology market landscape. This paper is, however, mostly descriptive, with recognized limitations, inherent to patent analysis; with a technological innovation focus (other types of innovations except those indicated by patent counts were not analysed); giving equal weight to low and high quality inventions, and not addressing cooperation, and/or knowledge transfer or spill-overs between countries.

The importance of the challenges at hand recommends considerable additional research, possibly using econometric analyses regarding eco-innovation diffusion. One other idea that we intend to pursuit is a comparison between the data acquired in this study regarding markets and Y02 technological production (analysis of patents by date of priority-invention, and inventor-country) as to infer geographic considerations between "technological development" and "market" countries.

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Appendix A

Table A. 1 Y02 per application authority and year, from 1990-2013

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
AMF																					1	1		2	4
AP	1	1	1	1			3	2	2	3	2			4	3	5	6	9	13	15	5	1	1	5	83
ARG	13	4	9	35	27	11		22	17		73	98	134	142	92	140	72	150	118	178	150	148	105	91	1829
AUS	631	625	690	757	834	876	1002	999	1458	1552	1883	2554	1990	2555	2825	1163	1076	1234	1345	1495	1000	1193	1867	1601	33205
AUT	167	151	151	173	322	371	379	402	371	356	345	361	576	710	795	901	1114	1091	1320	1263	1876	2525	1407	239	17366
AZE																1			1	1		1	1	1	6
BEL	5	20	27	31	22	34	31	16	18	24	27	29	23	25	16	15	29	26	22	31	33	32	31	31	598
BGR	28	18	11	19	30	48	40	33	44	31	34	38	23	31	25	20	18	22	21	23	23	14	18	24	636
BIH										3				1			1	3		1		1	2	2	14
BLR						1				1						4		1		5	1				13
BRA	115	202	150	143	132	162	91	201	192	392	520	495	453	394	589	502	567	586	556	419	418	961	459	702	9401
CAN	658	1068	1126	963	880	810	759	803	913	1200	1308	1404	1550	1789	1795	1883	1953	2220	2300	2442	2485	2805	2501	778	36393
CHE	66	52	46	48	49	49	38	38	25	27	38	61	38	52	45	47	45	45	50	106	147	136	153	92	1493
CHL																9			37		1	5	4	6	62
CHN	351	425	462	468	639	681	891	1048	1340	1640	1932	2298	2823	3739	4407	6968	8552	13329	16795	21516	28365	36328	46922	48297	250216
COL						1	3	11	7	13	4	14	4	13	3	5	8	3	8	4	34	61	95	60	351
CRI				1			1	1	1		1				5	10	2	5	11	16	9	3	13	5	84
CSK	56	55	146	107	60	4	1	5	3																437
CUB		2	3	1	1	1	2				1	2	3	1	4		2	1	3	3	1	4	15		50
CYP	1					1		1						1			1						10	19	34
CZE				23	84	101	93	76	102	89	83	109	139	139	89	45	48	59	67	111	76	84	115	74	1806
DDR	103	149	49	2	11	3	4	1	2																324
DEU	1696	1773	1986	2514	3102	3177	3560	3741	3728	4029	3866	4223	5261	5595	5965	5779	7988	7739	7931	8250	9070	8160	7410	6685	123228
DNK	54	35	26	45	81	119	158	132	120	199	179	135	197	224	248	186	253	292	286	347	348	439	697	673	5473
DOM																		2	2	3	5	6	9	4	31

DZA												1	14	7	16					1			1		40
EA							1	3	1	12	17	19	23	26	36	37	41	111	111	128	155	139	175	180	1215
ECU			2	2	2	1		2		1	1	1	1	5		5	7	3	18	7	16	25	1	1	101
EGY	6	7	3	9	7	4	4	3	1	9	8	5	6	17	10		1	8	13	12	24	29	41	31	258
EP	1244	1387	1524	1517	1616	1824	1864	2070	2526	2831	3456	3978	4284	4588	5493	5512	6336	7371	8950	9935	11058	12764	14873	14650	131651
ESP	95	64	183	314	408	393	411	449	376	365	351	327	399	483	649	721	632	950	939	978	1039	1319	1515	1499	14859
EST						2	5	7	4	17	11	7	13	10	10	4	5	4	3	13	6	8	5	4	138
FIN	51	81	129	122	136	157	112	97	72	47	50	80	61	86	85	97	111	135	141	164	177	168	121	164	2644
FRA	377	355	395	395	415	447	404	414	520	569	579	679	660	816	886	1020	1144	1254	1467	1697	1853	1957	2069	1912	22284
GBR	397	374	360	353	378	375	348	378	415	449	467	454	628	646	563	602	706	867	1049	991	1085	1121	973	524	14503
GC																2	2	1							5
GEO						1					26	16	11	11	4	8	7	11	9		3	6	8	11	132
GHA											1														1
GRC	17	36	38	126	15	28	94	81	50	46	77	44	27	15	27	25	21	39	62	66	48	67	79	59	1187
GTM		2				1	3	1	2	2	2		1				1		2	7	4		1		29
HKG	18	7	8	16	20	30	29	24	57	50	53	31	63	88	112	209	172	146	148	178	229	210	190	261	2349
HND																					1	6		3	10
HRV					12	4	13	9	7	3	6	21	12	21	18	11	18	17	23	13	20	37	44	49	358
HUN	81	98	63	48	88	94	64	45	44	54	59	73	86	78	45	37	38	60	37	65	47	18	31	48	1401
IB					10	11	26	34	39	55	24	42	105	180	189	210	274	436	566	559	540	697	655	620	5272
IDN				1			1	55	91	69	69	108						1	1	1	1		1		399
IND	75	59	48	22	13	14	13	18	20	9	45	40	44	45	34	7	14	21	20	50	51	56	43	54	815
IRL	21	28	22	11	6	4	7	10	3	10	2	10	8	2	3	4	14	16	22	23	38	27	14	17	322
ISL	2		1		5	2	1	6	3	3	2	5	7	12	4	8	4	3	3	1	1	4	1	1	79
ISR	32	22	56	38	56	53	56	24	44	54	46	79	62	41	38	68	196	226	222	264	420	354	331	171	2953
ITA	119	117	74	119	110	95	90	64	113	140	165	128	131	145	246	147	139	222	250	255	465	489	492	410	4725
JOR		1			2		1	5		1	1					1				1	1	1	2		17
JPN	8343	7644	9735	8739	9525	9446	10373	10635	11366	12548	13704	14947	16837	16583	18732	20289	20219	21212	21530	22905	23851	24384	27921	30647	392115
KAZ										1	2		1	2	2		1	3	2	2	4		2	2	24

KOR	197	220	249	267	284	301	308	374	665	1412	2159	1892	1761	2947	3353	4140	6001	6883	6822	7568	9324	11670	13092	12418	94307
LBR						1																			1
LBY																					1				1
LTU				1	10	9	1	5	5	6	6	4	6	8	5	2	4	5	2	7	7	18	5	7	123
LUX	4	2	3	2	1	4	3	1	4	1		8	8	14			4	1	2	1	4	5	8	7	87
LVA				3	8	14	21	13	19	2	6	3	5	5	4	5	1	5	12	11	10	2	1		150
MAF	4	4	7	3	2	7	7	8	7	7	8	4	9	15	20	14	17	17	27	49	37	61	105	97	536
MCC		2	1	1										1					1			1	1		8
MDA					3	5	13	2	3	8	11	12	4	23	19	13	15	8	17	32	14	16	5	12	235
MEX	41	30	140	268	154	10		144	241	3	5	4	226	286	489	419	226	387	358	601	487	525	650	504	6198
MKI														2	1										3
MUS																					2	2			4
MWI		1																							1
MYS														26	51	55	113	133	43	96	100	117	99	20	853
NIC																		1	2						3
NLD	51	54	55	47	56	60	78	69	99	112	113	155	101	132	118	83	108	158	144	176	211	199	203	107	2689
NOR	102	80	82	81	100	98	92	107	141	122	188	168	165	183	156	193	144	258	268	217	143	143	95	69	3395
NZL	36	35	34	29	43	47	58	69	84	61	59	58	66	101	86	101	106	91	106	113	176	224	308	265	2356
OA	2	8	12	6	4	2	4	3				4	6	12	7	2	36	5			1		1		115
PAN										2	5	2	3	1	2	1		1	3	8					28
PER										16	15	17	13	12	5	8	13	18	17	29	15	19	34	36	267
PHL	13	10	10	2			1	11	6				1			1	5	3		2	4	2	3	2	76
POL	12	55	48	65	52	82	97	105	108	115	107	135	115	113	184	252	83	49	63	86	149	170	301	199	2745
PRK																1					1				2
PRT	31	18	16	40	36	6	10	5	1	7	48	40	90	92	138	101	112	170	130	134	139	151	174	197	1886
ROU	34	13	26	47	34	20	20	16	16	26	19	24	16	27	19	21	32	24	23	36	29	125	110	100	857
RUS				6	27	137	627	624	483	534	469	456	556	629	784	1097	917	753	1190	1430	1752	1537	1833	1853	17694
SDN												1	1				2								4
SGP	23	4	18	7	8	15	17	63	132	59	59	37	41	45	48	114	97	91	91	131	103	255	373	394	2225

SLV						1			2	1	1		1				2			2	2	3	2		17
SMR																			4	1	2	9	5	3	24
SRB																		1	11	22	18	19	19	21	111
SUN	624	658	785	466	510	550	223	127	19	6	4	1			2	3	6	6	2			1	13	6	4012
SVK				14	47	55	22	32	34	19	30	28	30	28	22	11	9	11	19	31	22	37	30	24	555
SVN					11	8	6	20	11	10	5	8	13	12	15	11	24	28	24	51	47	64	60	83	511
SWE	105	100	105	104	129	167	169	215	165	192	188	200	155	158	150	79	136	213	253	228	289	300	259	184	4243
SYR																	1				1		1		3
THA																					1	7	10	2	20
TJK									1		3			2				1							7
TUN																				1	1	2	1		5
TUR	8	6	8	13	8	26	25	13	40	47	60	66	60	24	34	21	27	59	49	68	84	72	92	15	925
TWN								1		2	470	767	676	970	604	788	775	835	2556	3523	2675	3159	4053	3405	25259
UKR						2	1			2	8	10	20	71	126	65	101	198	69	8	6	7	11	4	709
URY											1		3	1	2	2	6	7	10	13	4	13	14	16	92
USA	2295	2479	2753	2956	3122	3374	3796	3708	4511	4785	5302	7897	11396	11264	11584	12058	12798	14397	16214	19777	23243	25113	25575	25264	255661
UZB																		1							1
VNM															1	2		2				1			6
YUG	81	28	12	4	4	3	2	3	3	3	3	8	3	2	19	8	28	10	16		2			1	243
ZAF	75	83	74	88	63	93	125	85	124	104	44	58	119	159	150	111	122	138	280	276	278	8	5	6	2668
ZWE	2	1																							3
Total	**18563**	**18753**	**21962**	**21683**	**23814**	**24533**	**26702**	**27789**	**31021**	**34568**	**38916**	**44983**	**52367**	**56687**	**62306**	**66489**	**73909**	**84902**	**95302**	**109273**	**124569**	**140851**	**158975**	**156030**	**1514947**

Source: PATSTAT Spring 2014

Appendix B
Table B. 1 Country/ area designation/ code

Numerical code	ISO ALPHA-3 code	Country or area name
51	AMR	Armenia
	AP	African Regional Industrial Property Organization
32	ARG	Argentina
36	AUS	Australia
40	AUT	Austria
31	AZE	Azerbaidjan
56	BEL	Belgium
100	BGR	Bulgaria
70	BIH	Bosnia and Herzegovina
112	BLR	Belarus
76	BRA	Brazil
124	CAN	Canada
756	CHE	Switzerland
152	CHL	Chile
156	CHN	China
170	COL	Colombia
188	CRI	Costa Rica
200	CSK	Czechoslovakia (up to 1993)
192	CUB	Cuba
196	CYP	Cyprus
203	CZE	Czech Republic
279	DDR	German Democratic Republic
276	DEU	Germany
208	DNK	Denmark
214	DOM	Dominican Republic
12	DZA	Algeria
	EA	Eurasian Patent Organization
218	ECU	Ecuador
818	EGY	Egypt
	EP	European Patent Office
724	ESP	Spain
233	EST	Estonia
246	FIN	Finland
250	FRA	France
826	GBR	Britain
	GC	Gulf Cooperation Council
268	GEO	Georgia
288	GHA	Ghana
300	GRC	Greece
320	GTM	Guatemala
344	HKG	China, Hong Kong Special Administrative Region
340	HND	Honduras
191	HRV	Croatia
348	HUN	Hungary
	IB	wo *
360	IDN	Indonesia
356	IND	India
372	IRL	Ireland
352	ISL	Iceland
376	ISR	Israel
380	ITA	Italy
400	JOR	Jordan
392	JPN	Japan
398	KAZ	Kazakhstan
404	KEN	Kenya
410	KOR	Republic of Korea
430	LBR	Liberia
434	LBY	Libya
144	LKA	Sri Lanka
440	LTU	Lithuania
442	LUX	Luxembourg
428	LVA	Latvia
504	MAR	Morocco
492	MCO	Monaco
498	MDA	Republic of Moldova
484	MEX	Mexico
807	MKD	Former Yugoslav Republic of Macedonia
470	MLT	Malta
496	MNG	Mongolia
480	MUS	Mauritius
454	MWI	Malawi
458	MYS	Malaysia
558	NIC	Nicaragua
528	NLD	Netherlands
578	NOR	Norway
554	NZL	New Zealand
	OA	African Intellectual Property Organization
591	PAN	Panama
604	PER	Peru
608	PHL	Philippines

616	POL	Poland
408	PRK	Democratic People's Republic of Korea
620	PRT	Portugal
642	ROU	Romania
643	RUS	Russian Federation
736	SDN	Sudan
702	SGP	Singapore
222	SLV	El Salvador
674	SMR	San Marino
688	SRB	Serbia
810	SUN	Soviet Union (USSR)
703	SVK	Slovakia
705	SVN	Slovenia
752	SWE	Sweden
760	SYR	Syria
764	THA	Thailand
762	TJK	Tajikistan
788	TUN	Tunisia
792	TUR	Turkey
158	TWN	Taiwan, Province of China
804	UKR	Ukraine
858	URY	Uruguay
840	USA	United States of America
860	UZB	Uzbekistan
704	VNM	Viet Nam
891	YUG	Yugoslavia/Serbia and Montenegro
710	ZAF	South Africa
894	ZMB	Zambia
716	ZWE	Zimbabwe

Source: PATSTAT Spring 2014

* The code "WO" is used in relation to the international publication under the Patent Cooperation Treaty (PCT) of international applications filed with any PCT receiving Office. The code "IB" is used in relation to the receipt of international applications under the PCT filed with the International Bureau of WIPO in its capacity as a PCT receiving Office.

Appendix C

Table C. 1 PATSTAT Y02 disaggregation query - Y02C published patents, by application authority, from 1990 to 2013

SELECT appln_auth, year (publn_earliest_date), count(distinct(tls201_appln.appln_id))
FROM tls224_appln_cpc join tls201_appln on tls224_appln_cpc.appln_id = tls201_appln.appln_id
where cpc_class_symbol like 'Y02C%' and year (publn_earliest_date) between 1990 and 2014
group by appln_auth, year (publn_earliest_date)
order by appln_auth, year (publn_earliest_date)

Table C. 2 PATSTAT Y02 disaggregation query - Y02E published patents, by application authority, from 1990 to 2013

SELECT appln_auth, year (publn_earliest_date), count(distinct(tls201_appln.appln_id))
FROM tls224_appln_cpc join tls201_appln on tls224_appln_cpc.appln_id = tls201_appln.appln_id
where cpc_class_symbol like 'Y02E%' and year (publn_earliest_date) between 1990 and 2014
group by appln_auth, year (publn_earliest_date)
order by appln_auth, year (publn_earliest_date)

Table C. 3 PATSTAT Y02 disaggregation query - Y02B published patents, by application authority, from 1990 to 2013

SELECT appln_auth, year (publn_earliest_date), count(distinct(tls201_appln.appln_id))
FROM tls224_appln_cpc join tls201_appln on tls224_appln_cpc.appln_id = tls201_appln.appln_id
where cpc_class_symbol like 'Y02B%' and year (publn_earliest_date) between 1990 and 2014
group by appln_auth, year (publn_earliest_date)
order by appln_auth, year (publn_earliest_date)

Table C. 4 PATSTAT Y02 disaggregation query - Y02T published patents, by application authority, from 1990 to 2013

SELECT appln_auth, year (publn_earliest_date), count(distinct(tls201_appln.appln_id))
FROM tls224_appln_cpc join tls201_appln on tls224_appln_cpc.appln_id = tls201_appln.appln_id
where cpc_class_symbol like 'Y02T%' and year (publn_earliest_date) between 1990 and 2014
group by appln_auth, year (publn_earliest_date)
order by appln_auth, year (publn_earliest_date)

Appendix D

Table D. 1 Y02 disaggregation per sub classes - Y02 C per application authority and year, from 1990-2013

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
AP	1							1										1	1						4
ARG		1		1	2	1					5	4	16	7	3	1	1	10	7	9	5	17	7	9	106
AUS	23	29	30	20	13	16	17	19	42	65	62	95	90	73	112	38	51	69	115	127	101	99	169	155	1630
AUT	2	2	1		13	10	16	9	3	4	8	4	10	18	28	23	35	32	22	32	39	55	28	3	397
AZE																			1						1
BEL					1			2			1							1					1		6
BGR	1		1	1	1		1		1	1	3	3	1	1	1	1	1								18
BIH																				1					1
BRA	4	8	8	6	2	3	1	3	7	16	21	21	17	10	19	14	12	13	19	2	9	38	13	18	284
CAN	21	48	65	42	24	19	22	20	37	53	56	61	60	66	73	55	86	100	142	151	179	196	203	47	1826
CHE	1					1		1					1		2		1				2	2			11
CHL																1			4			1			6
CHN	10	12	7	10	6	9	12	14	28	30	34	24	58	49	44	76	74	91	159	210	260	312	454	374	2357
COL												4	1			1	1					7	9	7	30
CSK	2	1	1	3	2																				9
CZE					2		1		2	3	2	4	7	6			2			1		1	1	1	33
DDR	3	7	6																						16
DEU	20	25	40	46	69	54	66	68	72	65	55	47	73	100	115	100	116	119	99	98	116	85	54	41	1743
DOM																						1			1
DNK			1		3	2	9	5	6	6	4	3	4	8	12	3	15	9	5	14	8	9	15	21	162
DZA													1	3	1										5
EA										1	1	5		7	5	8	3	19	16	12	27	24	25	25	178
ECU														1		1			1			3			6

EGY		1			1							1	1	2	1							2	5	2	3	19
EP	36	41	44	41	35	37	38	52	62	80	102	126	104	117	110	113	115	140	230	249	353	307	416	360	3308
ESP	1	2	4	16	12	7	11	17	4	5	7	5	8	21	18	20	16	20	22	16	33	30	42	32	369
EST								1	1					1	1										4
FIN	3	3	6	2	7	3	1	2	1	1	3	4	1	2	3	2	1		1	1	1		2	2	52
FRA	6	6	1	5	3	2	11	9	10	22	19	27	19	19	20	20	30	39	43	37	88	61	63	53	613
GBR	3	4	3	3	5	8	3	3	3	20	12	3	18	6	13	10	23	27	26	28	36	42	19	7	325
GC																	1								1
GEO												2												1	3
GRC	2	1	1	7			3	1	1		4	2													22
HKG							1			1			1	1	1	1	3	6	2	4	4	4	2	4	35
HND																								1	1
HRV												2				1				1	1	1	2	3	11
HUN	4	2	2	3	2			2		2		5	1	6			4						1	1	35
IB							1	1	1		1		2	5	5		5	9	18	10	14	18	26	27	143
IDN								3	13	7	12	3													38
IND	7	5	4	2				1			1	2	1					1		1	3	1			29
IRL	2	2	2		1			1							1							1		1	11
ISL	1														1		2	2							6
ISR			1	2			2	1	2	2	1	4	2	1	1	2	5	6	10	8	22	13	14	5	104
ITA	2	3	1	3			1	2	2	1		1	1	1	1	1	2	5	1	4	7	7	3		49
JOR										1											1		2		4
JPN	59	62	123	117	107	92	91	70	100	127	140	162	197	149	180	194	192	204	208	261	281	300	339	368	4123
KOR	7	5	5	10	2	6	12	6	7	20	32	29	30	42	50	48	64	77	110	106	117	152	168	176	1281
LUX				1																		1		2	4
LVA									1																1
MAR										1					1	2			2		1	3	12	9	31
MEX	2		9	12	1			2	3	1			23	11	30	15	12	20	16	39	43	42	39	39	359
MYS															5	5	6	10	3	7	8	6	8	1	59

NLD		2	3	2	5	5	1		1	3	1	5	5	11	4	3	6	2	10	6	12	4	4	4	99
NOR	6	4	8	3	9	7	9	4	10	14	21	15	15	19	13	27	15	28	37	20	20	16	13	8	341
NZL	4	1	4		2	3		1	2	1	4	3	1	4	10	1	7	4	5	6	7	10	12	12	104
OA												1		2			2								5
PAN																				1					1
PER										3	1	2	1	1				1	2	1		1	5	2	20
PHL	1		1					1																	3
POL				3	3	3	7	4	3	1	6	8	4	4	9	11		3		2	9	6	10	2	98
PRT	3		1	1							2	2	1	3	6	2	5	1	2	4	6	3	6	6	54
ROU				1	2							1		1	2	4	1		1	1					14
RUS							2	8	2	6	1	1	7	11	22	15	15	7	16	30	37	46	64	52	342
SGP						1	1	2	6	2	6	3	3	6	2	7	4	2	4	4	6	12	18	32	121
SMR																					1				1
SRB																								1	1
SUN	8	5	10	3	3	7	5	4																	45
SVK					1	1	1		2	1	2	2	2									1			13
SVN														1						1			2	3	7
SWE		2	2	1	1		1		1	1	1	2	1		1		1	2	4	2	2	5	6	1	37
TUR				3	2	1	4		1	1	4				1		1							1	19
TWN											9	25	18	27	17	18	10	13	37	42	35	28	62	55	396
UKR													1	2	2		1								6
URY																			1	1		1	1	4	8
USA	53	35	67	45	52	54	47	65	90	119	137	200	345	312	234	200	261	324	404	460	608	635	693	615	6055
YUG		2								1	1	1													5
ZAF	8	7	11	6	2	2	6	4	8	11	3	5	12	31	7	6	8	6	15	11	25				194
Total	**306**	**328**	**473**	**421**	**396**	**354**	**404**	**409**	**535**	**699**	**785**	**929**	**1164**	**1168**	**1187**	**1050**	**1216**	**1423**	**1821**	**2021**	**2529**	**2612**	**3035**	**2594**	**27859**

Source: PATSTAT Spring 2014

Table D. 2 Y02 disaggregation per sub classes - Y02 E per application authority and Year, from 1990-2013

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
AMR																					1	1		2	4
AP		1						1	1	1	1			4		4	5	6	11	9	4	1		4	53
ARG	10	3	7	27	21	6		12	11		43	62	75	88	65	103	47	95	82	105	121	100	79	72	1234
AUS	359	308	355	389	444	480	564	567	841	938	1136	1556	1207	1590	1702	711	699	793	906	1011	691	856	1299	1049	20451
AUT	123	105	108	105	170	211	206	218	190	180	190	197	312	368	405	422	520	528	649	628	960	1339	745	148	9027
AZE																				1		1			2
BEL	4	12	21	22	15	23	27	7	12	15	17	18	14	17	8	8	25	19	14	23	22	24	22	22	411
BGR	24	10	6	17	23	43	34	30	39	26	25	26	19	19	22	18	14	21	16	22	18	14	17	23	526
BIH										3							1	3				1	2	1	11
BLR										1						4				5	1				11
BRA	70	114	80	70	70	74	45	109	105	196	253	254	251	244	346	297	354	339	319	268	262	569	260	429	5378
CAN	376	583	603	483	467	430	451	472	537	713	815	872	993	1139	1179	1128	1191	1370	1412	1495	1637	1916	1571	407	22240
CHE	34	28	27	28	32	25	21	22	14	18	24	40	22	25	24	29	27	28	32	59	99	82	103	75	918
CHL																6			31		1	4	4	5	51
CHN	248	325	361	303	431	464	570	680	880	1132	1393	1636	2012	2622	2931	4603	5745	8356	10704	13420	18615	24008	31213	33032	165684
COL						1	2	9	5	9	3	8	2	9	1	3	5	2	2	3	30	38	76	48	256
CRI							1	1	1						4	7	2	5	10	11	9	3	13	3	70
CSK	32	26	79	68	37	2	1	4	3																252
CUB		2	3	1	1	1	2				1	2	2	1	3		1		3	3	1	4	13		44
CYP						1		1						1			1						9	16	29
CZE				14	60	73	60	60	75	57	47	61	78	87	57	34	36	46	54	99	68	72	102	65	1305
DDR	54	101	37		6	1		1	2																202
DEU	830	860	983	1211	1512	1553	1790	1902	1729	1843	1844	1947	2419	2448	2494	2296	3219	3319	3580	3909	4475	4145	3858	3444	57610
DNK	37	17	17	23	51	70	91	80	76	125	140	92	120	159	161	137	174	222	215	257	272	349	568	564	4017
DOM																		1	2	2	5	3	7	2	22

DZA														13	4	11									1		29
EA								3		5	10	11	18	12	13	22	27	71	81	104	108	97	129	139	850	
ECU			1	2	2	1		2		1	1	1	1	3		2	5	2	13	7	16	21	1		82	
EGY	6	5	2	7	5	3	3	3	1	9	6	2	4	11	6		1	5	9	11	15	18	35	27	194	
EP	638	708	775	759	795	838	875	1018	1248	1317	1705	1847	2154	2221	2652	2542	3074	3531	4544	5252	6398	7661	9082	8689	70323	
ESP	59	47	120	181	242	232	244	270	219	208	201	194	218	254	307	357	339	531	588	638	695	885	1020	1063	9112	
EST						2	5	3	4	10	5	5	5	7	8	2	3	4	3	12	5	7	4	4	98	
FIN	25	33	65	72	68	83	62	48	37	24	27	37	27	29	44	44	55	83	77	90	111	105	84	96	1426	
FRA	184	175	203	198	185	204	173	151	204	200	230	242	245	285	313	398	420	425	456	599	717	931	924	828	8890	
GBR	165	148	169	136	158	129	132	126	172	154	165	185	252	249	279	273	381	468	547	539	604	626	556	342	6955	
GC																2	1	1							4	
GEO						1					23	13	10	9	4	8	7	9	9		2	6	8	9	118	
GHA											1														1	
GRC	12	27	29	78	11	20	58	49	36	29	55	28	22	11	21	22	16	34	54	53	41	62	70	55	893	
GTM		2				1	3	1	1	2	1		1				1		2	6	4		1		26	
HKG	10	5	5	12	10	20	11	15	33	32	36	20	30	49	67	120	96	72	82	99	135	112	107	156	1334	
HND																					1	6		2	9	
HRV					11	4	12	7	5	2	4	14	7	15	13	9	16	15	16	9	13	26	36	44	278	
HUN	56	62	29	29	52	59	52	30	27	39	41	46	54	36	34	28	28	47	33	48	36	10	24	39	939	
IB					9	4	15	18	14	14	11	20	49	54	59	89	102	200	286	285	300	419	371	365	2684	
IDN							1	32	57	39	44	72							1	1	1		1		249	
IND	54	42	41	18	10	10	12	15	19	7	26	21	19	27	22	5	9	15	14	33	33	34	32	38	556	
IRL	14	13	8	9	3	2	7	3	2	8	1	5	7	2	2	2	6	8	14	15	35	20	12	10	208	
ISL			1		4	2	1	5	2	3	2	5	6	11	4	7	4		2		1	2	1	1	64	
ISR	16	11	31	24	38	38	32	11	25	38	28	47	39	28	26	28	98	134	128	184	281	267	259	126	1937	
ITA	42	37	20	52	44	43	34	19	31	42	45	38	39	50	104	66	61	108	147	179	330	335	355	294	2515	
JOR		1			2		1	4			1					1				1		1			12	
JPN	6955	6180	7723	6621	7109	6339	6531	6858	7315	8134	8872	9874	11315	10981	12091	12967	12835	13254	13226	13969	14846	15919	18481	20469	258864	

KAZ											1			1	1		1	3	2	1	4		2		16
KOR	92	146	148	113	137	123	118	235	381	713	1263	1069	991	1696	1894	2456	3729	4299	4199	4764	6252	8249	9487	9262	61816
LBY																					1				1
LTU				1	7	7		5	5	5	6	4	6	7	5	2	1	5	1	7	6	11	5	7	103
LUX	2	1	2	1	1	3	2	1	3	1		4	1	3			3	1	2	1	4	3	7	4	50
LVA				2	8	10	17	11	19	1	6	3	4	5	3	5	1	5	10	9	10	2	1		132
MAR	2	3	6	3	2	7	6	8	6	4	7	4	7	14	15	8	13	16	19	38	31	55	90	83	447
MCO		1	1											1					1			1			5
MDA					3	5	6	2	3	6	10	11	4	20	19	13	15	8	17	32	14	16	5	12	221
MKD														2	1										3
MUS																					2	2			4
MWI		1																							1
MX	24	19	83	121	76	5		77	138	2	3	2	129	181	283	211	119	215	237	378	318	372	462	360	3815
MYS														12	21	26	52	64	18	49	50	70	63	17	442
NIC																		1	2						3
NLD	27	35	32	22	26	25	44	34	62	77	78	115	71	71	61	50	63	86	72	116	144	141	139	67	1658
NOR	60	50	42	46	49	62	48	73	83	68	124	106	111	121	102	129	100	174	190	152	102	105	68	56	2221
NZL	25	25	17	16	28	25	29	40	49	48	33	36	43	67	48	77	69	67	74	83	130	168	241	195	1633
OA	1	7	11	5	4	2	4	1				2	4	6	5	2	28	4			1		1		88
PAN										1	5	2	3	1	2	1		1	1	7					24
PER										12	13	11	10	9	5	6	6	11	13	25	14	12	29	31	207
PHL	10	8	6	2			1	6	6				1			1	1	2		2	3	1	3	2	55
POL	11	48	40	45	36	58	73	78	74	78	71	77	71	77	108	173	62	39	47	70	126	124	217	161	1964
PRT	14	6	11	17	22	6	8	4	1	6	32	23	61	57	89	76	79	119	96	105	97	122	138	149	1338
ROU	25	10	20	38	22	10	16	11	11	15	13	19	13	19	15	11	20	7	14	30	24	96	95	83	637
RUS				1	20	101	417	404	289	349	318	290	375	416	510	721	573	523	785	898	998	892	1016	1106	11002
SDN													1				1								2
SGP	14		11	7	7	11	5	22	61	33	28	16	16	15	16	41	33	29	39	72	58	192	253	274	1253

SLV						1			1	1	1		1				2			2	2	3	2		16
SMR																			4	1		7	5	3	20
SRB																		1	10	20	16	18	17	17	99
SUN	384	439	543	375	319	330	156	73	11	5	4	1			2	2	6	6	1			1	13	6	2677
SVK				10	34	39	15	29	27	15	17	16	15	13	17	11	5	7	14	27	21	30	24	17	403
SVN					8	6	4	18	10	8	5	7	12	8	11	10	16	16	18	34	31	40	46	58	366
SWE	61	53	53	54	64	101	93	125	74	94	85	88	80	75	72	40	60	93	111	110	133	113	105	61	1998
SYR																					1		1		2
THA																					1	5	8	2	16
TJK									1		3			2				1							7
TUN																					1	2	1		4
TUR	4	3	2	3	2	15	12	9	31	21	35	42	36	19	25	17	21	53	45	59	74	64	85	11	688
TWN								1		2	297	552	441	654	344	512	504	527	1653	2620	1870	2310	3072	2479	17838
UKR						2				1	5	6	12	59	112	57	93	172	61	7	5	6	10	2	610
URY											1		1	1	2	1	5	6	9	10	4	11	13	14	78
USA	1152	1204	1336	1485	1626	1662	1905	1931	2124	2227	2526	3773	5617	5768	5959	6104	6540	7286	8550	10876	13697	15173	15334	14501	138356
UZB																		1							1
VNM																		1				1			2
YUG	66	23	9	2	1	1	1	1	3	2	2	6	2	1	13	7	26	6	16		2			1	191
ZAF	42	56	43	45	36	69	70	56	71	63	28	32	73	90	90	65	74	88	160	181	194	8	3	5	1642
ZWE	1																								1
Total Geral	**12454**	**12129**	**14325**	**13373**	**14636**	**14179**	**15179**	**16122**	**17517**	**19432**	**22493**	**25815**	**30273**	**32660**	**35332**	**37639**	**41972**	**48113**	**54865**	**64250**	**76461**	**89526**	**101616**	**101253**	**912614**

Source: PATSTAT Spring 2014

Table D. 3 Y02 disaggregation per sub classes - Y02 B per application authority and Year, from 1990-2013

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
AP			1	1			2		1	1	1				1	3	2	1		3	1		1	1	20
ARG	1		2	1	3	2		5	5		12	17	23	24	16	26	22	31	14	19	13	18	12	10	276
AUS	114	132	128	171	172	183	235	204	341	303	387	574	384	576	595	253	207	223	236	315	198	212	346	288	6777
AUT	14	22	19	40	81	84	87	91	104	98	83	92	131	146	180	183	222	241	300	266	342	494	268	38	3626
BEL		5	4	4	3	8	2	1	1	5	5	6	6	5	5	3	2	6	8	7	14	9	10	7	126
BGR		1	3		1	5	4	4	2	2	4	4	1	3	1	2	3		3		5	2	1	6	57
BIH										3												1			4
BLR																2		1		1					4
BRA	12	18	18	18	22	28	16	50	35	64	104	80	75	61	72	75	89	80	63	37	59	102	60	104	1342
CAN	104	178	186	181	176	182	161	146	172	212	211	221	205	252	239	336	353	349	326	449	394	416	414	163	6026
CHE	17	22	8	15	18	19	13	13	12	7	11	21	11	21	15	15	8	12	13	12	41	30	32	19	405
CHL																1			2						3
CHN	37	37	47	69	86	105	209	206	250	301	332	387	479	711	884	1426	1674	3069	3865	5118	6906	8528	10215	10084	55025
COL							1	2	3	3		1		4	1		1		3			6	7	6	38
CRI				1							1				1	2			3						8
CSK	2	5	19	13	3																				42
CUB													1		1								1		3
CYP	1																						1	3	5
CZE				3	12	13	23	14	21	20	9	14	30	13	8	3	3	12	9	7	6	10	7	3	240
DDR	11	18	3	2		1																			35
DEU	225	269	320	435	498	559	643	699	742	814	723	700	948	910	925	907	1295	1212	1177	1283	1339	1155	838	738	19354
DOM																						2	1	1	4
DNK	12	10	6	9	16	27	34	23	33	38	19	25	45	50	52	32	41	49	55	61	64	75	90	55	921
DZA												1	3		2										6
EA									1	1	5	2	3	5	11	3	10	15	11	9	15	15	23	18	147
ECU			1														2		3	1		1		1	9

EGY	1	1	1	2	1	2	1		1		1	2		5					2	2	1	3	5	10	4	45
EP	196	215	241	252	324	363	368	384	451	511	631	714	737	822	1023	1035	1178	1318	1588	1780	2069	2342	2480	2303	23325
ESP	7	4	29	47	57	71	60	77	79	73	76	70	67	91	114	113	105	173	161	178	193	216	244	218	2523
EST							1	2		6	6	1	5	1	1	2	3			2	1	1	1		33
FIN	20	30	31	33	41	51	37	39	24	16	14	26	17	25	24	24	34	29	32	30	31	17	11	36	672
FRA	63	41	75	51	73	49	61	67	81	78	66	91	86	83	84	117	94	130	135	206	290	364	280	223	2888
GBR	68	73	51	77	71	90	77	79	75	98	123	119	164	172	118	147	158	210	265	261	266	277	237	99	3375
GEO												2		1				1			1			1	6
GRC	1	6	2	21	4	4	17	15	16	9	14	6	2		5	2	3	3	2	5	3	12	13	11	176
GTM																							1		1
HKG	9	2	3	4	7	10	15	11	21	10	12	9	23	31	36	85	61	56	43	72	88	68	66	84	826
HRV					1		1		2			2	4		4	1	4	4	5	4	7	13	12	7	71
HUN	6	19	13	11	23	14	12	14	16	14	10	16	21	13	5	5	5	10	7	8	7	8	8	12	277
IB						6	10	13	18	31	11	14	47	95	94	90	112	122	130	157	150	178	171	153	1602
IDN				1				14	20	11	7	22													75
IND	3	3		3		2		3	1		8	5	7	7	5	2	1	2	2	12	8	7	8	4	93
IRL	4	7	5	1	1	1	2	6	1	2	1	2	1			1	7	8	18	16	8	9	6	6	113
ISL					1			1		1		1	1		1	1					1	2			10
ISR	4	6	5	4	17	9	18	10	7	11	10	19	18	7	6	26	65	58	78	61	113	72	49	36	709
ITA	13	24	20	25	17	17	18	10	17	28	37	21	26	22	43	22	21	40	63	63	98	95	101	83	924
JOR					1		1																		2
JPN	465	497	746	772	911	1128	1392	1392	1533	1705	1918	1951	2187	2222	2490	2636	2670	2610	2639	2979	2949	3284	3316	3470	47862
KAZ											1										1				2
KOR	45	31	47	72	52	66	76	67	110	308	468	378	344	616	798	911	1361	1495	1525	1568	2051	2098	1980	1567	18034
LBR						1																			1
LTU						2													1	2	1	9			15
LUX									1			1		6			1							2	11
LVA						1	2	1	1								1		2		1				9

MAR	2		1				2		1	2	1		3		3	1	3		5	7	5	9	10	15	70
MCO		1																							1
MDA						1	2			1				1									1		6
MEX	2	5	15	42	26	1		43	46				38	57	89	110	49	86	77	118	123	91	106	81	1205
MUS																						1			1
MWI		1																							1
MYS														9	15	14	35	36	14	26	20	29	16	3	217
NLD	11	8	18	16	19	9	13	11	23	38	40	29	33	42	33	26	35	37	32	49	54	48	54	24	702
NOR	24	16	19	21	23	21	26	20	21	22	27	31	27	27	30	25	18	34	32	24	9	17	6	5	525
NZL	4	4	13	8	7	9	15	23	23	10	16	12	16	22	18	11	27	23	29	25	33	36	51	64	499
OA			3			1	1	2					2	1			2	1							13
PAN																				1					1
PER											1	2	1			2	6	4		1	1	3	2	3	26
PHL	2	1	1					2												1		1			8
POL		2	2	2	3	12	12	16	25	19	18	21	14	14	24	30	9	5	6	8	18	31	58	26	375
PRT	6	5	2	13	3		1			1	9	6	15	19	22	20	23	31	28	25	28	31	30	21	339
ROU	1		1	3		3	1		3	3	2	2		2	1	3	6	6	3	3	5	21	10	11	90
RUS				1	1	6	28	39	40	38	30	35	57	56	82	126	85	71	120	136	190	196	242	219	1798
SDN												1													1
SGP	8	4	3		1	3	6	27	60	22	14	12	13	12	10	31	25	19	22	38	39	39	70	58	536
SMR																			2		1	3	2		8
SRB																		1	1	1	1	2	4	6	16
SUN	63	64	68	19	19	28	6	9	4										1						281
SVK				4	6	9	3	6	7	4	6	4	4	7	5	1	2	2	3	2	1	7	5	3	91
SVN					1	3		1		3		3	2		5	5	7	4	5	14	13	14	14	17	111
SWE	19	14	22	26	25	27	32	29	37	30	40	41	28	26	13	9	19	46	35	52	46	39	27	33	715
THA																						3		2	5
TUN																				1					1

TUR	2	2	5	6	3	6	6	1	9	15	11	20	22	3	5	2	3	5	4	3	3	5	6	3	150
TWN											81	136	153	196	184	173	195	239	749	754	711	725	804	803	5903
UKR											1	1	2	5	6	4	4	9	3		3			2	40
URY													2							1		1	1		5
USA	364	359	376	440	511	612	759	679	954	993	1111	1603	2392	2455	2662	2870	3062	3527	3762	4337	4851	5228	5196	5352	54455
VNM																		1							1
YUB	1	2		1	1			1		1		2	1	1	6	2	2	3							24
ZAF	10	11	6	10	9	11	27	7	17	12	8	13	17	20	16	15	24	28	53	53	48	2	1	2	420
Total	**1974**	**2175**	**2589**	**2951**	**3351**	**3865**	**4539**	**4579**	**5468**	**5998**	**6737**	**7591**	**8944**	**9975**	**11089**	**11972**	**13459**	**15790**	**17775**	**20673**	**23940**	**26735**	**28037**	**26617**	**26682**

Source: PATSTAT Spring 2014

Table D. 4 Y02 disaggregation per sub classes - Y02 T per application authority and Year, from 1990-2013

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
AP							1			1					2			1	1	6					12
ARG	2			7	1	3		5	1		17	21	21	26	17	26	5	24	18	51	20	25	15	12	317
AUS	169	178	207	216	248	246	256	265	347	349	406	507	417	510	579	256	192	243	246	198	123	162	262	269	6851
AUT	30	27	30	35	72	85	92	108	92	105	86	82	158	217	234	322	384	340	430	414	652	810	482	62	5349
AZE																1							1	1	3
BEL	1	3	3	6	3	5	3	7	7	7	6	5	4	5	4	5	4	4	3	4	6	6	2	6	109
BGR	3	7	1	1	7	2	3	2	5	4	6	8	3	9	2		1	1	2	2	1				70
BIH														1						1				1	3
BLR						1																			1
BRA	34	66	46	49	41	63	33	49	49	127	167	163	138	94	175	144	144	179	177	129	104	293	158	192	2814
CAN	173	288	298	284	242	217	172	195	215	294	307	362	405	425	415	497	450	601	620	582	504	556	574	242	8918
CHE	17	7	13	8	5	4	7	9	3	6	7	6	7	11	8	7	12	10	10	41	27	43	37	12	317
CHL																1			2					1	4
CHN	62	62	57	100	126	118	127	181	231	231	226	337	380	489	720	1143	1441	2537	3102	4177	4239	5546	7537	7172	40341

COL									1	3	1	1	1		1	1	2	2	3	1	5	13	16	14	65
CRI																1			1	5			3	2	12
CSK	20	24	52	29	18	2		1																	146
CUB													1				2	1					1		5
CYP																							1	2	3
CZE				6	14	19	19	12	15	22	27	36	36	40	26	11	7	7	8	13	7	7	16	10	358
DDR	37	28	6		5	2	4																		82
DEU	685	698	748	955	1134	1143	1230	1289	1395	1574	1485	1821	2102	2427	2727	2750	3796	3556	3662	3711	4000	3651	3476	3137	53152
DNK	8	10	6	17	18	24	32	34	13	46	29	19	36	27	35	23	42	27	34	34	33	46	62	66	721
DOM																		1		1			1	3	6
DZA													1		2					1					4
EA							1			7	3	4	4	4	12	10	5	10	13	23	16	22	12	21	167
ECU														1		2		1	2		1	3			10
EGY				1	1					1	1		1		3			1	3		7	3	2	1	25
EP	402	452	499	517	528	648	655	700	878	1067	1201	1508	1518	1660	1992	2082	2302	2825	3226	3426	3235	3565	4305	4629	43820
ESP	28	12	32	87	107	93	109	108	87	102	84	72	121	141	245	267	204	290	241	207	202	283	321	289	3732
EST								3		2	2	1	4	2											14
FIN	4	18	29	20	25	29	19	13	13	9	8	15	18	30	15	27	25	29	35	47	46	53	33	37	597
FRA	133	143	128	162	170	206	176	199	241	292	282	365	338	458	520	554	680	744	934	999	962	896	1084	968	11634
GBR	179	158	146	156	156	163	151	181	183	188	185	169	228	251	195	215	191	254	332	274	287	273	247	122	4884
GEO											4		1	1				1							7
GRC	3	5	7	26	2	7	23	24	7	13	9	10	4	4	3	3	3	5	6	9	6	5	4	3	191
GTM									1		1									2					4
HKG					3		2		7	7	5	8	9	9	13	15	14	17	29	13	19	36	29	47	282
HRV								2	2	1	2	4	1	8	3	2			3	1	2	2	2	3	38
HUN	16	18	21	10	16	24	8	8	5	7	10	14	14	27	9	9	3	8	4	15	8	4	3	5	266
IB					1	1	1	3	6	10	3	10	14	35	38	44	71	136	176	155	139	166	142	134	1285
IDN								6	7	15	8	23						1							60
IND	12	9	5	1	3	3	1		1	2	11	13	17	13	7	1	4	5	6	6	13	17	7	12	169

IRL	2	6	7	1	1	1						3				1	1	1		1				3	28
ISL	1								1			1	1	3	1	1		1	1	1					12
ISR	12	6	20	10	5	7	6	2	11	8	10	15	8	7	6	19	43	42	27	43	49	44	62	32	494
ITA	63	57	34	44	51	38	42	36	68	73	89	74	69	80	106	61	62	82	66	50	90	92	89	71	1587
JOR								1																	1
JPN	962	1001	1252	1348	1541	2086	2613	2605	2775	3081	3372	3675	3972	4053	4858	5455	5525	6286	6682	7139	7461	6979	8257	9192	102170
KAZ										1	1		1	1	1					1				2	8
KOR	53	40	53	78	95	110	107	68	174	383	444	442	433	679	693	854	1065	1312	1360	1546	1547	2007	2486	2393	18422
LTU					3	1	1			1				1			3				1				11
LUX	2	1	1			1	1					3	7	6				1				1	1	1	26
LVA				1		4	2	1		1			1		1					2					13
MAR		1												1	3	3	2	2	5	9	4	3	6	4	43
MCO				1																			1		2
MDA							7			1	1	1		2			1	1		1					15
MEX	15	7	35	97	53	4		32	67	1	4	2	54	58	127	104	62	89	57	107	58	81	94	84	1292
MYS														5	12	11	25	25	8	18	27	19	18	1	169
NIC																			1						1
NLD	14	11	7	11	12	22	23	28	21	13	19	18	13	25	28	14	21	46	38	29	28	31	37	22	531
NOR	15	12	17	16	21	13	17	20	38	24	28	24	22	30	23	26	24	38	32	29	15	15	17	6	522
NZL	5	5	2	6	8	10	17	11	15	12	7	13	12	15	19	20	13	15	15	12	21	24	27	20	324
OA	1	2		1								1		3	2		6								16
PAN										1									2						3
PER										1	1	2	3	3			3	4	3	2	2	4	1	4	33
PHL		1	2					3	1								4	1			2				14
PKR																1					1				2
POL	1	5	7	16	11	13	12	17	18	24	21	36	32	28	51	59	17	6	14	13	7	18	50	30	506
PRT	9	7	2	13	11		1	1			9	9	19	21	29	13	19	30	24	12	22	17	18	35	321
ROU	8	3	5	7	10	7	4	5	2	8	5	3	3	7	3	3	8	14	7	6	1	15	15	14	163
RUS				4	6	31	195	188	162	150	133	142	137	162	199	267	267	175	324	425	592	475	589	556	5179

SDN																	1								1
SGP	2		4				5	12	13	3	11	6	11	13	22	36	43	43	34	38	17	42	62	61	478
SLV									1																1
SRB																				2	1			3	6
SUN	177	160	177	71	173	190	58	43	4	1						1									1055
SVK				1	9	7	4	4	3	3	9	6	10	9	4		2	2	2	2	1	5	4	4	91
SVN					2	1	2	1	1					3			2	8	4	7	5	11	4	11	62
SWE	26	34	32	29	44	45	49	68	61	76	68	74	55	61	68	33	61	84	118	82	121	161	135	94	1679
SYR																	1								1
THA																							4		4
TUR	2	1	1	1	1	5	4	3	5	15	14	10	6	2	3	2	3	2	2	6	8	5	3	1	105
TWN											88	79	87	119	67	110	94	89	235	205	187	228	348	262	2198
UKR							1			2	3	3	7	6	9	6	5	24	9	1		1	1	1	79
URY																1	1	1	1	3		2			9
USA	798	938	1043	1066	1028	1159	1248	1189	1546	1655	1743	2695	3602	3373	3363	3586	3672	4198	4601	5548	6080	6249	6657	6928	73965
VNM															1	2									3
YUG	14	2	3	1	2	2	1	1				1	1		2		2	1							33
ZAF	18	11	18	29	19	12	28	21	38	22	8	14	27	30	44	32	30	28	68	55	38		1		591
ZWE	1	1																							2
Total	**4219**	**4525**	**5056**	**5545**	**6052**	**6877**	**7573**	**7764**	**8837**	**10052**	**10677**	**12936**	**14595**	**15731**	**17747**	**19140**	**21072**	**24512**	**27069**	**29943**	**31050**	**33015**	**37822**	**37310**	**399119**

Source: PATSTAT Spring 2014

Appendix E

Table E. 5 Change in revealed technological advantage in Y02 sub classes, 2004-07 and 2010-13Y02

			2004-2007	2010-2013
United States of America	USA	**Y02C**	1,174821759	1,373642457
		Y02E	0,892565273	0,920494874
		Y02B	1,302612453	1,135708975
		Y02T	1,010134332	1,079651343
Taiwan, Province of China	TWN	**Y02C**	1,163039371	0,747422766
		Y02E	1,13152782	1,176614847
		Y02B	1,478501888	1,292002968
		Y02T	0,42680683	0,329308932
Russian Federation	RUS	**Y02C**	1,001326444	1,588870813
		Y02E	1,180992039	0,932780525
		Y02B	0,575842924	0,691491209
		Y02T	0,911112403	1,366490011
Republic of Korea	KOR	**Y02C**	0,703006503	0,711753947
		Y02E	1,088776735	1,124201329
		Y02B	1,25164509	0,913697026
		Y02T	0,682421776	0,757595416
Japan	JPN	**Y02C**	0,566074869	0,645002105
		Y02E	1,124424313	1,01661037
		Y02B	0,71309263	0,666638879
		Y02T	0,961632728	1,235583208
Britain	GBR	**Y02C**	1,530048442	1,494245291
		Y02E	0,878106858	0,890314025
		Y02B	1,236701843	1,291353589
		Y02T	1,059524179	1,03273786
France	FRA	**Y02C**	1,474926789	1,761578773
		Y02E	0,629622836	0,658139787
		Y02B	0,536058113	0,786424973
		Y02T	1,998475536	2,011031068
Spain	ESP	**Y02C**	1,472935468	1,379163804
		Y02E	0,913070418	1,073779818
		Y02B	0,936962815	0,896563761
		Y02T	1,183892904	0,852894337

Germany				
	DEU	**Y02C**	0,965142258	0,497265629
		Y02E	0,726539065	0,778892254
		Y02B	0,867455978	0,699131519
		Y02T	1,626799607	1,854060445
China				
	CHN	**Y02C**	0,508227675	0,482292979
		Y02E	1,153711608	1,072046493
		Y02B	1,172374358	1,258693894
		Y02T	0,615833192	0,652872604
Canada				
	CAN	**Y02C**	2,314631111	3,851635156
		Y02E	1,073073872	0,992548684
		Y02B	0,87744926	0,873995765
		Y02T	0,855529273	0,894507089
Brazil				
	BRA	**Y02C**	1,530939581	1,695716566
		Y02E	1,054540901	0,962244158
		Y02B	0,777492337	0,722453274
		Y02T	1,001907257	1,256507514
Australia				
	AUS	**Y02C**	2,493262632	4,844073516
		Y02E	1,078331309	1,048503623
		Y02B	1,100054228	0,986842124
		Y02T	0,69337858	0,583653945
Austria				
	AUT	**Y02C**	1,787193039	1,122306312
		Y02E	0,849214971	0,834540293
		Y02B	1,166134062	1,048419859
		Y02T	1,14620385	1,39353586

Source: PATSTAT Spring 2014