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Full Length Research Paper

World scenario of green patents: Perspectives and strategies for the development of eco-innovations

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The purpose of the present research was to analyze the global scenario for green patents connected with waste management areas, alternative energies, agriculture, transportation, energy conservation and the prospecting about hybrid cars. The patents analyzed were filed from 1979 to 2011. The data collection method consisted of a technological forecast about the Green Technologies. The research was carried out on the patent base Derwent Innovations Index from Web of Science. Only, 123 Green Technology patents were found in nine countries, including the United States, China, Russia, Germany, Spain, Australia, Canada, Britain and Taiwan. Indeed, 727 technological patents related to hybrid cars in sixteen countries including the United States, Japan, Germany, Spain, France, Russia, India, South Korea, Britain, Canada, Austria, Belgium, Holland and Hungary were found. The United States is leader in the ranking of Green Technologies and in hybrid car patents. However, countries such as Japan, China and Germany demonstrated a considerable increase. This study contributes toward other studies that focus on the acceleration of decisions in applications for inventive patents and aims to identify new technologies which can be quickly used by the productive sector and universities stimulating the licensing and encouraging the innovation in many countries.

Key words: Green patents, eco-innovations, intellectual property, hybrid cars.

INTRODUCTION

If on the one hand, the theme of innovation has remained strictly connected with the concern of economic order such as competitiveness, demand pressures and investment, on the other hand, the environment area has found difficulties in incorporating the technology processes. There are many studies in the innovation management area and their processes as well as in the environmental sustainability area. However, there is little research and few actions that deal with the interface between these two areas which result in theoretical and methodological uncertainties (Andrade, 2004; Andersen, 2006, 2008; Baumgarten, 2008; Kim and Park, 2008; Arundel and Kemp, 2009; Sánchez et al., 2011; Srivastava, 2011; Rodríguez and Gómez, 2011; Crane and Meyer, 2011; Torrecillas and Brandão, 2011; Sen and Ghandforoush, 2011; Sanchez and Bisang, 2011; Silva et al., 2012). The absence of studies in the green technology area indicated by researchers was also found during this study, especially in relation to the international publications.

The green technologies assumed a very important position in the development of global sustainability. In agreement with several countries about the importance of developing these technologies to avoid global climate change, other governments began to see the relevance of patents to stimulate green technologies in their countries. In 2009, the national patent offices in Japan, Israel, South Korea, the United States, Australia and Canada created pilot-programs to accelerate the examinations of patents directed to green technologies, initially concentrated on some specific areas with the

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purpose to decrease the time of patent examinations in two years.

Only the areas that reduced the climate change impact and emitted less or removed the CO_2 out of the atmosphere are part of these programs. Also following these principles, the inventions should be related to waste management, alternative energy, agriculture, or energy conservation.

The purpose of this work was to analyze the global scenario of the green patents, indicating the strategies created by some countries searching for an increase in those technologies as the promotion for eco-innovation mechanism. Also, a technological forecast was made about the currently global scenario of hybrid cars.

LITERATURE REVIEW

Eco-Innovation

The literature of innovation focused on eco-innovations has shown that increasing investments in eco-innovation are influenced by the ability of firms (Kemp et al., 1992). In particular, companies that build their practices of organizational capabilities such as the reduction of resources, recycling, pollution prevention, and green product design tend to invest more in eco-innovation (Georg et al., 1992; Winn and Roome, 1993; Hsieh et al., 2012). Additionally, Florida et al. (2001) show that two types of organizational factors, that is, organizational resources and performance and monitoring systems, play an important role in the adoption of eco-innovations.

Eco-innovations are the combination of processes, new or modified systems, practices and products that benefit the environment, whose positive environmental impact is the central element. In order to evaluate environmental innovations, greenhouse gas emissions, energy use, water pollution, noise, waste and soil contamination are measured, standing out in the new era of clean production, seeking to strengthen and improve the sustainable functioning and competitiveness of the organizations (James, 1997; Rennings, 1998; Belin et al., 2009; Foxon and Andersen, 2009; Hsieh et al., 2012).

According to Carrillo-Hermosilla et al. (2009), the term green technologies or eco-innovation has been increasingly used in the environmental management policies of companies and governments, although in different contexts and situations and with varied connotations that unfortunately resulted in the reduction of its practical value. The definitions of eco-innovation are very general and, therefore, many types of green technologies can be considered as eco-innovations (Falk and Ryan, 2006).

A tentative concept for eco-innovation is based on an evolutionary innovation perspective (Dosi et al., 1988; Arthur, 1994; Nelson and Winter, 2002; Witt, 2009), whereby innovation occurs through a systemic process with regard to the interrelationship and interactions between different factors, internal and external factors that influence the innovation process. These assumptions motivate the exploration of the wide range of eco-innovation and analysis of changes in various dimensions of eco-innovation, which consist of the aspects of design, user, products, services and governance (Carrillo-Hermosilla et al., 2009).

Eco-innovation can be an important tool for the success of the innovation system. It can assist in the renewal of the system in general considering local, social, cultural, ecological and economic aspects (Pujari, 2006). The long-term survival of the economic system depends on its ability to create and maintain sustainable economic processes, which do not involve short-term value creation over the long-term wealth.

By identifying the different dimensions of eco-innovation, showing their diversity and addressing the process and impact of the expected results, we intend to show the different number of ways that eco-innovation can have in the process of improving economic, social and environmental aspects by the industry worldwide .

Also, by focusing on the environmental impact of eco-innovation, we observed pros and cons. There are problems with definitions that reflect on the innovators' intentions (Pujari, 2006). As the industry adopts the methodology type “end-of-pipe” products, with solutions for integrated technologies and product innovations, the motivation for environmental innovation can engage itself with other motivations (Jänicke, 2008).

However, it may be difficult to establish relationships between the specific environmental activities of companies with the industry environmental performance. To sum up, it is certainly more difficult to verify an environmental motivation than an environmental outcome, although the latter should also be a challenge (Edwards-Schachter et al., 2011; Gehani, 2011; Dalmarco et al., 2011; Balbinot et al., 2012; Salami and Soltanzadeh, 2012).

This does not exclude the fact that there may be technologies to reduce the environmental impact by the activities of production and consumption, as well as technologies that produce environmental gains as an adjuvant effect. As reported by the OECD (2009), eco-innovation can be environmentally motivated, but can also be a consequence of other goals, such as reducing production costs.

For Christensen (1997), the distinction between radical and incremental changes that are provided by eco-innovation is needed:

(i) Incremental changes refer to gradual and continuous improvement of competence and modifications that preserve existing production systems and maintain existing networks, creating and adding value by adding to the existing system in which innovations are rooted.
(ii) Radical changes, in contrast, are competence substitutes, discontinuous changes that seek to replace

existing systems and components and / or the creation of new networks.

This distinction between radical and incremental innovation can also be related to the environmental functions (Cohen-Rosenthal, 2004). It is increasingly understood that a focus on incremental innovation along established paths is not sufficient for achieving demanding targets for environmental sustainability. The need for radical technological change or innovation system has been identified as the solution (Tukker and Butter, 2007; Smith et al., 2005; Nill and Kemp, 2009). However, systemic changes usually incorporate major potential benefits than radical changes (OECD, 2005).

Integrated sustainable production initiatives such as closed-circuit production, can produce better environmental outcomes in the medium and long term, with simple modifications in processes and products.

Companies that adopt eco-innovation enjoy the first-mover advantage, which allows them to incorporate higher prices to their products, improve corporate image, new market development and performance improvement. It also allows the generation and implementation of new ideas, processes, products and services by creating positive effects on organizations (Fong and Chang, 2012).

The adoption of eco-innovation is influenced by the technological, environmental and organizational context. The technological context includes the relative advantages, compatibility and complexity of green practices. The organizational factors cover the organizational support, quality of human resources and the company size. The environmental factors include pressure from stakeholders, the government stimulus and environmental uncertainties. Thus the adoption of green innovation is directly related to the complexity of the interconnection between both contexts (Weng and Li, 2011).

The adoption of green innovation is perceived when it becomes consistent with the values, needs and with the results of the organization. In regard to the green innovations are additions to existing technologies and practices in the organization. It is not a single event but rather a process of cumulative knowledge and integration (Weng and Li, 2011).

However, the potential benefits of implementing eco-innovation include the reduction of waste of resources, pollutant emissions, improvement of environmental and economic performance and greater responsiveness to social and environmental expectations (Weng and Li, 2011).

METHODOLOGY

The method used for data collection consisted of a technological forecasting about green technologies. The research was carried out on the patent base Derwent Innovations Index from Web of Science. The mining data was treated using the Vantage Point.

The choice of using the base of patent Derwent Innovations Index was done because it is a powerful patent research tool, combining with Derwent World Patents Index®, Patents Citation Index™ and Chemistry Resource, a database of chemical structures that can be used to locate patents which contain chemical information. Furthermore, the Derwent Innovations Index is weekly updated and it contains over 16 million practical inventions from 1963 to the present day. Patent information was collected with 41 patent issuing authorities worldwide. Then information was classified into three categories or sections; Chemical, Engineering and Electrical/ Electronic.

At first, the research consisted of a technological forecast about green technologies related to the areas of waste management, alternative energy, agriculture, transport and energy conservation. As a breadth subject, various forms of technologies related to green technologies were detected. The analyzed period of patent generation was from 1979 to 2011.

Secondly, the research consisted of a forecast about an example of green technology related to alternative energy, in which hybrid cars were analyzed. The analyzed period of patent generation for hybrid cars was from 1980 to 2011. Finally, data was analyzed in details and tabulated using Microsoft Excel 2007.

RESULTS AND DISCUSSION

Green technology

According to the results, it was possible to visualize the role of green technologies in a worldwide context; many green technologies were found but only in nine countries, in addition to WO "world patent applications" via the PCT. The countries were: United States (U.S.), China (CN), Russia (RU), Germany (DE), Spain (ES), Australia (AU), Canada (CA), Great Britain (GB), and Taiwan (TW).

Only 123 "technology patents" were found in the areas of waste management, alternative energy, agriculture, transport, and energy conservation.

Figure 1 illustrates the forecast of these technologies. The largest number of patents is WO, via PTC, comprising 37.40%. This elevated number is due to PCT which is a treaty that allows simultaneous submission of a patent in several countries, extending the deadline by which the holder may choose the country/region. It aims to simplify the process of filing out patent applications in other countries in order to make it more efficient and economic, both for the user and for the government agencies in the patent system administration.

The United States is the country that has the largest number of green technologies, comprising 35.77%, followed by China with 13% and Russia with 6%.

Figure 2 illustrates the evolution of green technologies comprising the period from 1979 to 2011. In recent years there has been a significant increase due to the creation of programs in order to promote green patents in many countries.

The protection of intellectual property and environmental matters cannot be interrelated in a first approach. However, the need for effective action (and global) for sustainable technologies is not new, and neither is the

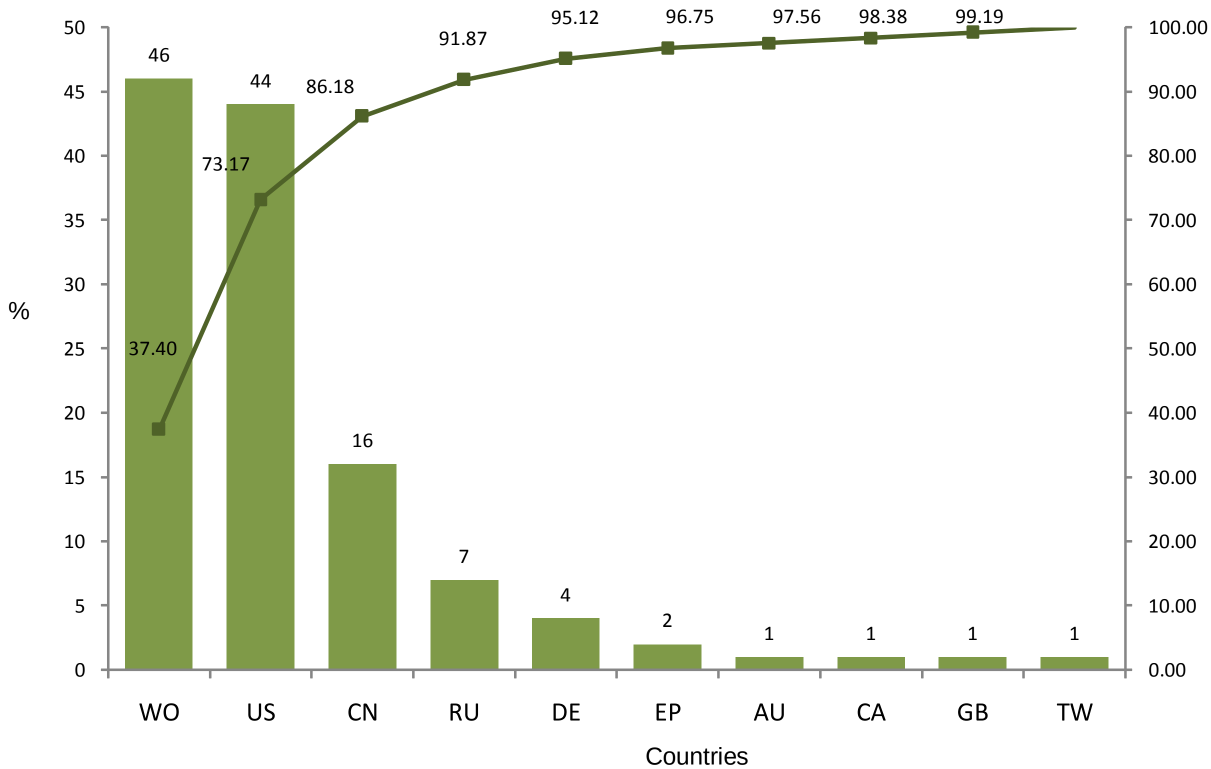

Figure 1. Green patents per countries. Source: Derwent Innovations Index (2012).

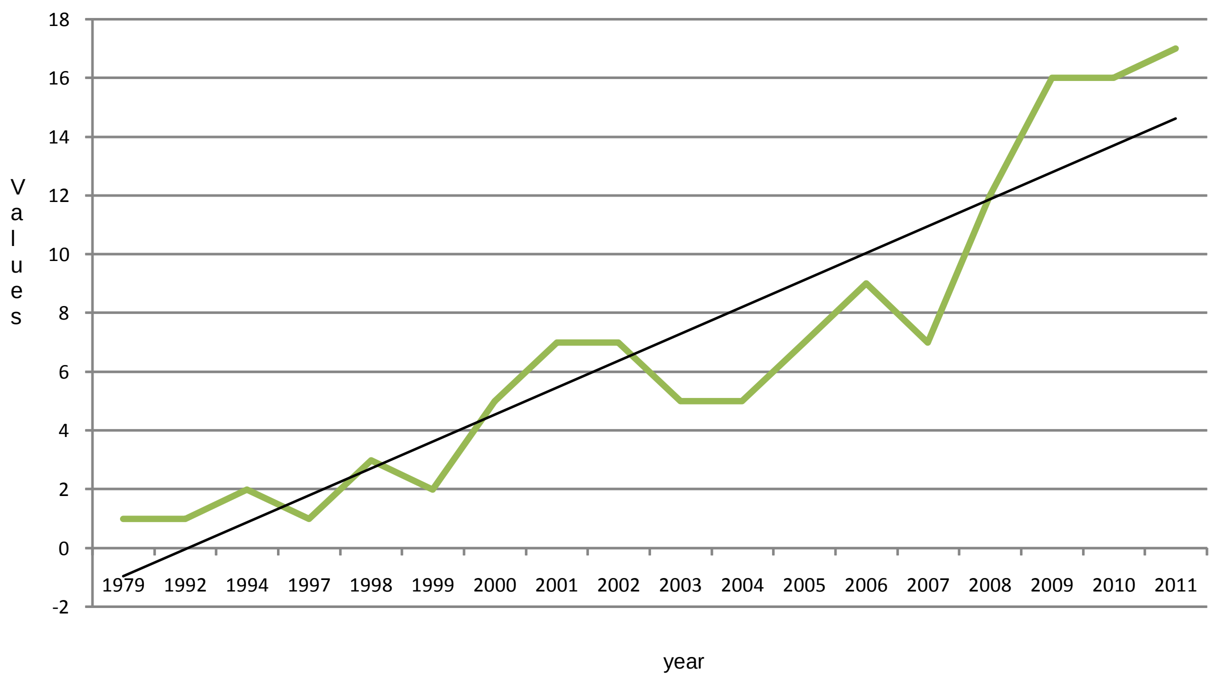

Figure 2. Evolution of the green patents. Source: Derwent Innovations Index (2012).

need for new green technologies, bringing the issue of environment and climate change to intellectual property. Not coincidentally, this interrelationship was identified by the European Patent Office (EPO) in 2006. Thus a major international effort was formed, with cooperation among many organizations, including the EPO itself, the environment program of the United Nations (UNEP), the International Center for Trade and Sustainable Development (ICTSD), and the international trade organizations such as the OECD, the International Chamber of Commerce (ICC), Licensing Executives Society International (LESI), among others. Such effort culminated in a presentation in Copenhagen in December 2009, ranking the green technologies in June 2010.

With the consensus of the international community about the importance of developing green technologies in combating global climate change, national governments have also begun to recognize the importance of the procedures for granting patents as a mechanism to stimulate green innovation. Thus, in 2009, the national patent offices of Japan, Israel, South Korea, UK, U.S.A, Australia and Canada created pilot programs to acelerate the examination of patent applications related to green technologies, initially concentrated in some specific areas.

The U.S. Patent Office (USPTO) attested the effectiveness of its program in 2010, when, after examining a large number of patents and granted just over 300 cases, it decided to expand the scope of the technologies for which it could be requested expedited review. Surprisingly, more than a thousand "Green patents" have been granted by the USPTO so far.

Hybrid cars

Hybrid cars refer to a distant reality for most of the world population. But in fact, this is an erroneous view of reality as many people have already had a hybrid car. For example, a motorized bicycle is a type of hybrid because it combines the power of a gasoline engine with the pedal power of its rider. Indeed, hybrid vehicles are scattered everywhere.

Most hybrid cars that currently exists works by using gasoline and electricity, although the French factory PSA Peugeot Citroen has two diesel-electric hybrid cars in their plans, since gasoline hybrids are the most common.

Figure 3 illustrates the scenario of hybrid cars in the global context; several technologies were found in 16 countries, in addition to WO "world patent applications" via the PCT. The countries were: United States (U.S.), Japan (JP), Germany (DE), Spain (ES), France (FR), Russia (RU), India (IN), South Korea (KR), Britain (GB), Canada (CA), Austria (AT), Belgium (BE), Hungary (HU), and the Netherlands (NL). 727 related technologies for application in hybrid cars were found.

The countries with the largest number of patents related to hybrid cars technologies are the United States with 234 patents, followed by Japan with 190 and Germany with 99. The patents WO were 190.

Figure 4 illustrates the evolution of hybrid cars patents in the period from 1980 to 2011 in 16 forecasted countries.

After 1998 there was a significant increase in patents granted to nearly 60 in 2001. In 2010 there was the highest apex of this kind of technology, thanks to the programs created in offices in many countries in 2009 to accelerate the green patent applications.

The benefits of hybrid cars

Analyzing the example of California's emissions standards, which dictate the amount of pollution that a car emits in this State. The level is usually specified in grams per kilometer (g/km). For example, the pattern for a low emission vehicle (LEV) is 2.1 g/km carbon monoxide.

It is important to highlight that the quantity of allowed pollution does not depend on how many kilometers a car runs with one liter of fuel. But how much a car burns gasoline in a kilometer. This quantity will generate, approximately, twice much pollution. This pollution will need to be removed by the car´s emissions control equipment. Therefore, the decrease in the fuel consumption of a car is one of the most secured ways of reducing emissions.

Carbon dioxide (CO_2) is a type of pollution produced by a car. The U.S. government does not regulate this kind of issue, but scientists know that it contributes to global warming. Because of this lack of regulation, a car does not have devices to remove CO_2 from its exhaust system. A car that burns fuel twice dumps as twice the volume of CO_2 to the atmosphere.

Automakers in the U.S. have another strong incentive to produce vehicles that consume less fuel. They are required by law to meet the standards of Consumption Corporate Average Fuel (CAFE). The current standards require that the average fuel consumption considering all new cars sold by a manufacturer makes about 11.7 km/L. This means that if a manufacturer sells a hybrid car that makes 25.5 km/L, is authorized to sell four large luxury cars that makes 8.5 km/L.

Conclusions

Results show the scenario of green technologies, because it is a very new area in the field of scientific and technological research. Patents were only found in 9 countries in areas such as waste management, alternative energy, agriculture, transport and storage energy, and technology of hybrid cars patents were found in 16 countries.

The United States leads the ranking in both green patents and hybrid cars. However countries like Japan, China and Germany showed a considerable increase in patent deposit.

The increase in granted patents between 2009 and 2011 was due to the development of strategies which

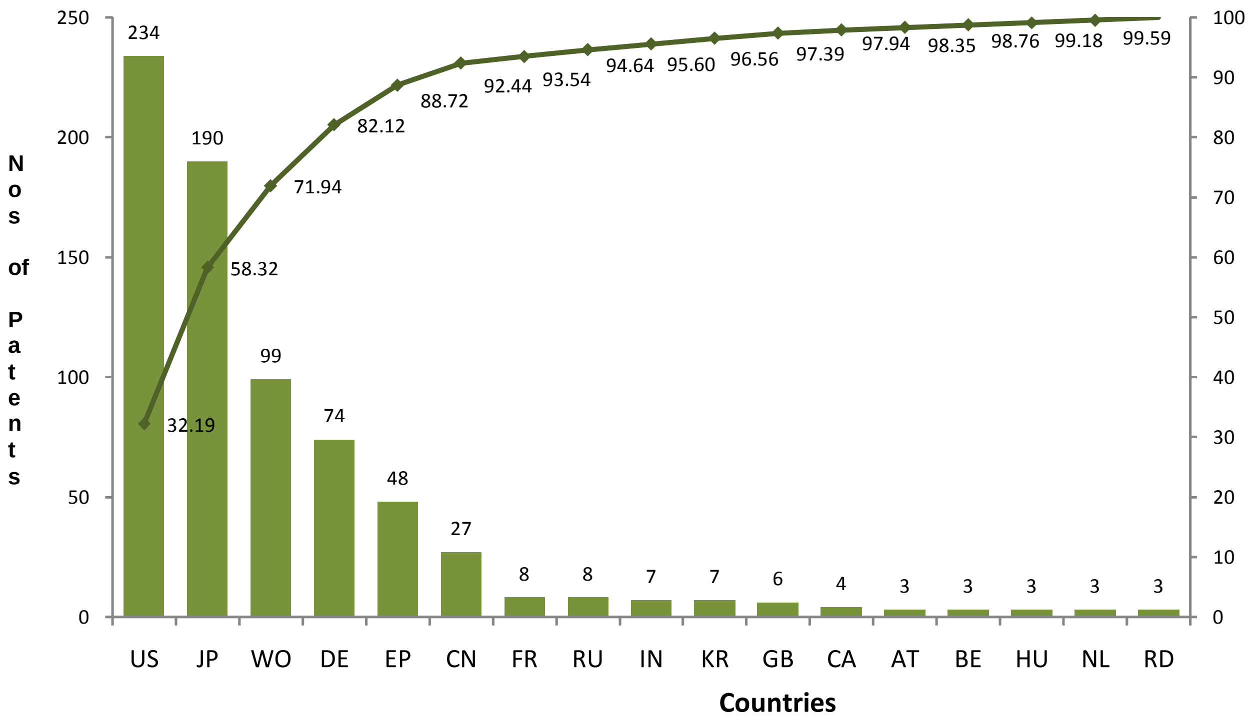

Figure 3. Hybrid cars per countries. Source: Derwent Innovations Index (2012).

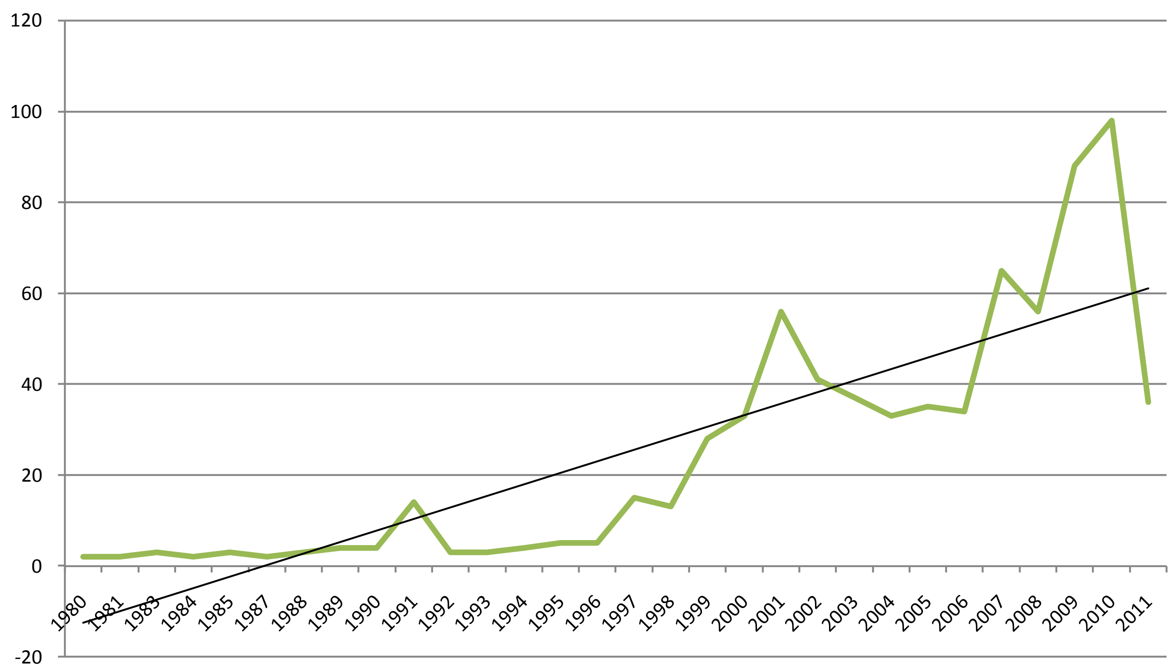

Figure 4. Hybrid cars evolution. Source: Derwent Innovations Index (2012).

facilitate these requests. In 2009, the program launched by several countries in order to reduce the time of granting a patent for two years collaborated with such increase.

If time reducing for granting patents is a fundamental key in any area of knowledge, for green technologies it seems to be much more important. The granting of the patent, besides protecting and encouraging the creation, it also allows the inventor to have an additional warranty to demonstrate the feasibility of returns on investment requests for deployment of creation.

Currently there are few studies focused on this scientific field, even though it is a very recent topic considering the Academy. Analyzing banks of thesis from many countries there are few studies addressing this topic.

Green patents are a strategic way for eco-innovations developed countries. However, the greening of innovation systems have a broader focus, not only on the development of environmental innovations, but also covering organizational sustainability, institutions and practices appropriated to the reduction of environmental impacts. It is a process that involves new learning, creating new knowledge, values, rules and search capabilities, as well as the creative destruction of old practices (Foxon and Andersen, 2009).

Greening is best explained by the precepts of the innovation systems approach, where companies, institutions and individuals must change their strategic posture in order to face environmental issues. It takes a proactive positioning of companies and organizations for the changes to occur, being eco-innovation seen as an ally in the development of appropriate preventive technologies and sustainability.

It is expected that this research enables not only further studies aimed to accelerate decisions referred to applications for patents, but also the identification of new technologies that can be readily used by universities and the productive sector, stimulating and encouraging their licensing innovation in many countries.

REFERENCES

Andersen MM (2006). Eco-Innovation Indicators. European Environment Agency, Copenhagen. In: <http://130.226.56.153/ rispubl/art/2007_115_report.pdf> Access in: 12 jun. 2012.

Andersen MM (2008). Eco-innovation – towards a taxonomy and a theory. In: DRUID Conference - Entrepreneurship and Innovation – Organizations, Institutions, Systems and Regions, Copenhagen.

Andrade THN (2004). Inovação tecnológica e meio ambiente: a construção de novos enfoques. Ambient. Soc. 7(1):89-106.

Arthur WB (1994). Increasing Returns and Path Dependence in the Economy. University of Michigan Press, Ann Arbor.

Arundel A, Kemp R (2009) Measuring eco-innovation. UNU-MERIT Working Paper Series. In: < http://www.merit.unu.edu/ publications/wppdf/2009/wp2009-017.pdf >. Access in: 28 jun. 2012.

Balbinot Z, Dias JC, Souza RB (2012). Unique Organizational Competencies of Brazilian Technological Innovation Centers. J. Technol. Manage. Innov. 7(1):1-16.

Baumgarten M (2008). Ciência, tecnologia e desenvolvimento – redes e inovação social. Par. Estrateg. 26:102-123.

Belin J, Horbach J, Oltra V (2009). Determinants and specificities of eco-innovations – An econometric analysis for France and Germany based on the Community Innovation Survey. In: DIME Workshop on Environmental Innovation, Industrial Dynamics and Entrepreneurship, Utrecht University.

Carrillo-Hermosilla J, Del Río P, Könnola T (2009). Eco-innovation. When Sustainability and Competitiveness Shake Hands. Palgrave, London.

Christensen C (1997). The Innovator's Dilemma. HBS Press, Boston.

Cohen-Rosenthal E (2004). Making sense out of industrial ecology: a framework for analysis and action. J. Cleaner Prod. 12(8-10):1111-1123.

Crane FG, Meyer MH (2011). The Challenges of Innovation in American Companies: An Executive Ethnographic Investigation. J. Technol. Manage. Innov. 6(4):193-204.

Dalmarco G, Dewes MF, Zawislak PA, Padula AD (2011). Universities' Intellectual Property: Path for Innovation or Patent Competition? J. Technol. Manage. Innov. 6(3):159-170.

Dosi G, Freeman C, Nelson R, Silverberg G, Soete L (Eds.) (1988). Technical Change and Economic Theory. Pinter, London.

Edwards-Schachter M, Castro-Martínez E, Lucio FI (2011). International Co-operation between Firms on Innovation and R&D: Empirical Evidence from Argentina and Spain. J. Technol. Manage. Innov. 6(3):126-147.

Falk J, Ryan C (2006). Investing a sustainable future: Australia and the challenge of eco-innovation. Futures 39:215-219.

Florida R, Atlas M, Cline M (2001). What makes companies green? Organizational and geographic factors in the adoption of environmental practices. Econ. Geogr. 77(3):209-225.

Fong CM, Chang NJ (2012). The impact of green learning orientation on proactive environmental innovation capability and firm performance. Afr. J. Bus. Manage. 6(3):727-735.

Foxon T, Andersen MM (2009). The greening of innovation systems for eco-innovation – towards an evolutionary climate mitigation policy. In: DRUID Summer Conference - Innovation, Strategy and Knowledge, Copenhagen.

Gehani RR (2011). Individual Creativity and the Influence of Mindful Leaders on Enterprise Innovation. J. Technol. Manage. Innov. 6(3):82-92.

Georg S, Ropke I, Jorgensen U (1992). Clean technology innovation and environmental regulation. Environ. Res. Econ. 2(6):533-550.

Hsieh CH, Liao MY, Tsai CH, Huang HL, Chung NT (2012). A study of building the crisis prevention model for the innovation development of green marketing: A case of the automotive industry. Afr. J. Bus. Manage. 6(7):2644-2658.

James P (1997). The Sustainability Circle: a new tool for product development and design. J. Sustain. Prod. Design. 2:52-57.

Jänicke M (2008). Ecological Modernisation: New Perspectives. J. Cleaner Prod. 16(5):557-565.

Kemp R, Olsthoorn X, Oosterhuis F, Verbruggen H (1992). Supply and demand factors of cleaner technologies: some empirical evidence. Environ. Res. Econ. 2:614-634.

Kim J, Park Y (2008). The Usefulness of Patent Stage and Sectoral Pattern in Open Innovation Licensing. J. Technol. Manage. Innov. 3(4):41-51.

Nelson RR, Winter SG (2002). Evolutionary theorizing in economics. J. Econ. Perspect. 16(2):23-46.

Nill J, Kemp R (2009). Evolutionary approaches for sustainable innovation policies: from niche to paradigm. Res. Policy 38(4):668-680.

Oecd (2005). Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, third ed. OECD, Paris.

Oecd (2009). Sustainable manufacturing and eco-innovation: towards a Green economy. Policy Brief: 1-8.

Pujari D (2006). Eco-innovation and new product development: understanding the influences on market performance. Technovation 26(1):76-85.

Rennings K (1998). Towards a theory and policy of Eco-Innovation – Neo Classical and (Co) Evolutionary perspectives. ZEW Discuss 98-24.

Rodríguez JC, Gómez M (2011). Innovation Trends in NAFTA Countries: an Econometric Analysis of Patent Applications. J. Technol. Manage. Innov. 6(3):116-125.

Salami R, Soltanzadeh J (2012). Comparative Analysis for Science,Technology and Innovation Policy; Lessons Learned from Some Selected Countries (Brazil, India, China, South Korea and South Africa) for Other LdCs Like Iran. J. Technol. Manage. Innov. 7(1): 211-227.

Sanchez G, Bisang R (2011). Learning Networks in Innovation Systems at Sector / Regional Level in Argentina: Winery and Dairy Industries. J. Technol. Manage. Innov. 6(4):15-32.

Sánchez S, Francisco J, Cruz G, Montserrat, Sánchez-Sellero P (2011). Industrial Location, Relations with Regional Agents, Formation and Innovation in Spanish Aquaculture. J. Technol. Manage. Innov. 6(2):40-49.

Sen TK, Ghandforoush P (2011). Radical and Incremental Innovation Preferences in Information Technology: An Empirical Study in an Emerging Economy. J. Technol. Manage. Innov. 6(4):33-44.

Silva LCS, Kovaleski JL, Gaia S, Matos EASA, Francisco AC (2012). The challenges faced by Brazil's Public Universities as a result of knowledge transfer barriers in building the technological innovation center. Afr. J. Bus. Manage. 6(41):10547-10557.

Smith A, Stirling A, Berkhout F (2005). The governance of sustainable socio-technical transitions. Res. Policy 34(10):1491-1510.

Srivastava M (2011). A Case Study and Survey-Based Assessment of the Management of Innovation and Technology. J. Technol. Manage. Innov. 6(1):147-160.

Torrecillas C, Brandão FB (2011). How Attractive are Innovation Systems for Knowledge Intensive Services' FDI? : A Regional Perspective for Spain. J. Technol. Manage. Innov. 6(4):45-59.

Tukker A, Butter M (2007). Governance of sustainable transitions: about the 4(0) ways to change the world. J. Cleaner Prod. 15(1):94-103.

Weng MH, Lin CY (2011). Determinants of green innovation adoption for small and medium-size enterprises (SMES). Afr. J. Bus. Manage. 5(22):9154-9163.

Winn SF, Roome NJ (1993). R&D management responses to the environment: current theory and implications to practice and research. R&D Manage. 23(2):147-160.

Witt U (2009). What is specific about evolutionary economics? J. Evol. Econ. 18(5):547-575.