Analysis of the Electric Car Via Patents

Fernandez de la Bastida E¹, Gavilanes-Trapote J², Rio-Belver R³, Cilleruelo E⁴, Larruscain J⁵

Abstract The automotive sector is one of the most relevant economic activities in terms of generating prosperity and work. This activity is characterized by a strong competition with the tendency of multiplication of business alliances. In 2030 it is expected that the number of cars worldwide would double provoking a shortage and high cost of the sources of energy. Taking this into consideration a technological U-turn has to be made in order to guarantee the long term sustainability of mobility. The systems of electric propulsion and the car battery seem to be the most promising options. The present study tries to sketch the business and investigation outlook of the electric car via patents giving information to the interest of the Spanish agents involved.

Keywords: Patents, Innovation, Electric car, Citations.

¹ Endika Fernandez de la Bastida (✉ e-mail: efernandezde011@ikasle.ehu.es) has obtained a degree in Industrial Management Engineering.
² Javier Gavilanes-Trapote (✉ e-mail: javier.gavilanes@ehu.es) Foresight, Technology and Management (FTM) Group. Department of Industrial Engineering, University of the Basque Country UPV/EHU, calle Nieves Cano 12, 01006 Vitoria, Spain
³ Rosa Rio-Belver (✉ e-mail: rosamaria.rio@ehu.es) Foresight, Technology and Management (FTM) Group. Department of Industrial Engineering, University of the Basque Country UPV/EHU, calle Nieves Cano 12, 01006 Vitoria, Spain
⁴ Ernesto Cilleruelo (✉ e-mail: ernesto.cilleruelo@ehu.es) Foresight, Technology and Management (FTM) Group. Department of Industrial Engineering, University of the Basque Country UPV/EHU, alameda Urquijo s/n, 48030 Bilbao, Spain
⁵ Jaso Larruscain (✉ e-mail: jaso.larruscain@ehu.es) Foresight, Technology and Management (FTM) Group. Department of Industrial Engineering, University of the Basque Country UPV/EHU, calle Nieves Cano 12, 01006 Vitoria, Spain
1 Introduction

The competitiveness of a nation is based on the capacity of its industry to innovate and continuously improve its products, services and processes. (Porter 1990).

Nowadays one has to acknowledge that innovation does not exclusively come from companies but that we can find its source in the interaction with other organizations that present complementary resources: competitors, suppliers, clients, investigation centers or universities (Bayona et al. 2003), giving space to what is called a “Innovation and Development Network”, a context in which institutions the individual and the market collaborate creating a scientific technical knowledge flow that results in a technological innovation (Cunningham et al. 2006).

The success, when it comes to innovation, is mainly dependent on the capacity of an organization to transform information into knowledge and afterwards let this knowledge circulate in a continuous flow through the whole organizational structure (Escorsa and Maspons 2001).

Summing up we can confirm that the competitiveness of a company depends to a large part on its capacity to innovate and that innovation in the current context is primarily based on adequate management of knowledge obtained through analyzing information.

The databases of patents, to pay for or for free, are a very good source of information, Dou (2004). These patents are the main channel to learn about scientific progress that neither can be found in the form of publications nor anywhere else. The benefits gained from studying patents in the sector of research and development have been analyzed and demonstrated in several studies, Ernst (1998), Acs et al. (2002). In scientific literature numerous empiric studies analyzing technical fields or sectors based on patent studies can be found: the analysis of the sector of recycling of waste in order to find out about new technologies (Rio and Cilleruelo 2010), the understanding of the knowledge flow between science and technology in the Basque Country (Gavilanes-Trapote et al. 2011).

The aim of this study is to analyze the sector of the electric car via patents finding out about the tendencies in the sector, the knowledge flow, the most important companies and researchers as well as the existing network of collaboration and the capacity of retaining and attracting knowledge from countries and facilitating the opening of new ways of technical and industrial diversification in key sectors of its activity.

2 Methods and Procedures

The source of the information selected is the database Esp@cenet of the European Patente Office, one of the three most important databases in the world (Michael and Bernd 2001), together with American and Japanese Patent Office among them.
they process 86% of the Patent Applications of the world (Trilateral Co-operation 2005).

In order to search for the parameters we have done an advanced search with key words, IPC codes and ECLA codes. The IPC codes or International Classification Patent and ECLA codes or European Classification Patent help classify the register’s by technological areas.

First records which the search came up with and returned were exported to an Excel sheet and there to the VantagePoint 7.0 program, which integrates all the necessary steps for the analysis of patent and their graphic representation.

The indicators used in the study case are grouped under three criteria: that determine the size and characteristics of the scientific and technological production, that evaluate the impact of the publications by citation and that define the structure of the Science, indicators in relation with first and second generation (Escorsa and Maspons 2001). The indicators used are:

- Number and distribution of patents by year application
- Inventions productivity by country, applicants and researchers
- Autocorrelation between applicants
- Capacity indicators for retaining and attracting
- Identification of technical knowledge flow between countries

3 Case Study

The electric car is a great opportunity for Spanish Industry. Its implementation involves the development of new technologies, innovative activity, generating high added value, quality employment, possibilities of increasing exports, improving efficiency and energy savings, control of CO2 emissions and reducing dependence on oil and its derivatives.

The technological development, the market development and policy support aimed at increasing hybrid and electric vehicles in the mobility of the future. The current market situation seems to confirm this outlook, still available in the market several models of hybrid vehicles with a large-scale production. Also, the most car manufacturers are developing electric vehicle models.

The new developments involve technological innovations, fact that will be reflected in the application for patent documents. In addition, the electric vehicle will also favor an advance even of Information Technology and Communication (ICT) sector, which will invest in the development of smart grids and meters and other services.

The realization of a technological analysis of the electric car through patents provides valuable information to the sectors involved, either to their current developments and to identify future research.
4 Data Analysis

A total of 105,167 patents were downloaded until October 31, 2012, of which 32,035 patents were taken through a word search, 21,109 by the ECLA codes and 52,023 records through a combined search of the IPC code B60L11/18 and different ECLA codes.

Once all the information was imported to VantagePoint, the data was cleaned, which means, eliminating the duplicated records, unify inventors or companies and so on. Those patents which carry the words: Locomotive; Railway; Hydrogen; Children; Bicycle; Trolley-Bus; Rail Road; Monorail are also eliminates. However, remain those with the word "train" in its title, and which do not relate to the train as transportation but refers to the various devices making up the car. 56,506 records were kept after these actions were made.

The first indicator was the activity that can be seen in the number of inventions by application date. In the aforementioned figure a nearly nonexistent inventive activity can be observed until 1992 as well as in the last two years when the number of patents decreased considerably due to the time passing from the application to the publication of the patent, which can be up to 18 months. That is why the analyses are limited to the time 1992-2010 and to the final sample to 50,852 patents.

In the figure 1 we can divide the curve into three parts in function of its gradient: The first one between 1.992-2.003, coinciding with the impulse of Bill Clinton’s government to buy green cars and with the Zero Emission Vehicle Mandate legislation that developed California obliging the manufacturers to develop electric vehicles. The second one in 2003, the year in which, due to pressure from the automotive sector and the nearly nonexistent political strength of the Bush administration, the Zero Emission Vehicle Mandate was changed into the Zero Emission Vehicle Regulation, which was less restrictive and only obliged the manufacturers
to sell electric vehicles in case it was profitable for these companies. That is why the EV-1 and other electric vehicles that were put up for leasing before disappeared.

The third period corresponds with the years 2.004-2.010. During this time the number of applications increased considerably due to the coming into force of the Kyoto protocol, the price of petrol as well as the sensitization of the public for ecology and the development of renewable sources of energy. This in turn lead to a change in the attitude of the automotive industry and governments again counting on the electric car, giving rise to more autonomous batteries and better features allowing the electric car to start becoming a reality.

The following chart shows the transformation of applications by nationality of those countries represented most often including Spain.

![Total number of patents per country during the period of the study.](image)

One can see how China overtook Japan as the country with the most applications for patents in the sector of electric vehicles worldwide reflecting the change of the geography of innovation before the leading countries were Japan and the USA. In Spain, however, the applications have stayed more or less the same over the years, clearly beaten by Germany.

The following analysis gives information about the number of patents per applicant. The ranking shows the country of origin of the major automotive companies in Asia: Toyota Motor Corp, Honda Motor Co Ltd, Nissan Diesel Motor Co and Mitsubishi Automotive Engineering, all of them Japanese. The Japanese company Hitachi Chemical Ltd does, however, appear too though it has no direct relations to the automotive sector but also offers solutions for the energy management of electric motors.
The first European and German company, Bosh Corp. is to be mentioned here too, as it is not a producer of cars but the main supplier of electric motors and batteries for companies like Daimler Chrysler, BMW, GM and Ford.

As far as the national area is concerned the company Acumulador Tudor SA So occupies the first place of the ranking with four patents. This company, located in Guadalajara, devotes itself to producing batteries for automobiles, motorbikes and industrial machinery and belongs to the group of companies called Exide Technologies (USA).

Next a technological auto-correlation map was created in which shows the existing relations between applicants of patents related to the electric car, specifically those who own more than fifty patents. Due to the size of the map and the space limitations it could not be included.

The aforementioned map showed that there is a big group of companies that works together – especially the Toyota Motor Corp and the Nissan Diesel Motor CO. Other companies as for example Ford Motor Co or GM Global Technology Operations Inc hardly interrelate with each other. On the other hand important companies as for example the group Peugeot&Citroen or the Siemens AG do not develop any patents with any other company.

This same map on a national level shows how practically all patents are developed individually, except those specific cases in which there is a collaboration with the Technical University of Madrid, the Technical University of Catalunya, the Foundation Circe and the Foundation Robotiker.

The analysis of the origin and the destination of the inventions is essential to determine the capacity, the retention and the attracting of knowledge of the countries (Escorsa and Maspons 2001). Spain has therefore a limited capacity of retaining knowledge given that their own country protects only 17% of the patents applied for by Spanish companies. Japan on the other hand has the highest retention rate, 90%, as well as high numbers of attraction, in Spain; there are 30% of patents protected in Japan.

Finally the analysis of citations can show us the different flows of knowledge between countries (Jaffe et al. 1993) or the measurement of the quality of the patents (Harhoff et al. 2002).

The Japanese patents have a high auto-citation rate that shows a good internal transfer of knowledge. However, in the Republic of Korea one can observe a higher diversification in the geographic origin of its sources of knowledge, dominating Japan as far as patents registered by themselves are concerned.

Chinese patents stand out as regards to their nearly non-existing citations despite their large number. This could be partly due to their novelty and quality, which would show that its inventions are not of a high enough quality in order to achieve a knowledge flow from China to other countries.

The Spanish patents are hardly ever cited by the other countries which show that Spain is mainly an importer and not an exporter of knowledge.
5 Conclusions

A major increase in patents can be observed from the year 1992 onwards which this is due to a change in legislation, the sensitization for the environment taking place in society and the increase in the price of petrol.

Patent applications are mainly made to national offices as opposed to international ones such as the WIPO, EPO and EAPO. This is mainly due to the lower cost of translation, processing and validation of the documents. That is why it is advisable to create a single European patent as it reduces the cost of translation to German, English and French exclusively.

Most patent applications are being made to national offices in Japan, China and the USA and the Republic of Korea being mainly due to the lower cost to be paid in these countries and because of the presence of big automotive companies producing electric batteries and motors (such as Toyota, Honda, Nissan and Hitachi Chemical in Japan; Hyundai and LG Chemical in the Republic of Korea; and General Motors y General Electric in the USA) and the stimulus based economic policy especially in China (Guangzhou et al. 2009).

The ability of investment in research and development can be found centralized in only a few applicants mainly from big Asian companies, especially Japanese ones as these companies from the automotive and electric motor producing sectors are the leading organizations in research, development and innovation.

With the help of autocorrelation maps, networks of collaboration between different applicants, mainly Japanese, can be discovered due to their commercial relations, the partaking of some companies in others or their country of origin. In Spain, however, the collaboration between companies is rather an exception then the rule and this is why it would be interesting to observe policies implemented by countries such as Japan and to try finding collaboration and synergies between companies and/or technological centers in order to improve innovative activities.

For Spanish applicants, the inventors are more than companies due to lack of national companies in developing patents, so must find ways to effectively support the protection of intellectual property developed in Spain, especially for companies or research institutions which is a key element in its strategy and that because of its size have funding problems.

Asian countries such as Japan and the Republic of Korea are those who patent most in relation to their per capita GDP. One of the main reasons lies in the industrial structures of the analyzed countries: Japan and the Republic of Korea dispose of big industrial companies that have to make a tremendous effort in R&D in order for them to survive, whereas in Spain for example this circumstance this is not the case. A good example for this is the comparative effort made by the public and private sector in the respective countries: in the Republic of Korea and Japan the major part of the money spent on research comes from the private sector while in Spain the share of the investment from private companies is far lower.
The countries cited most often are the USA, Japan and Germany which corresponds to the extremely high level of industrial development of the electric car in those countries and the culture of protection of intellectual property where the USA and Japan are the major exporters of knowledge. Considering the retention of knowledge it is surprising that there are not many auto-citations in Spain which can be related to the lack of relevance of the patents or necessity to improve the existing system of knowledge management.

6 References