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The impact of stronger patent protection on innovation's level

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Abstrato

O objetivo principal desta tese é estudar o impacto que uma maior protecção das patentes tem no nível de inovação, utilizando dados transversais para Portugal, Europa e Estados Unidos da América. Como medida do nível de inovação foi usado o número de pedidos de patentes e para avaliar o nível de proteção do sistema de patentes foram usados vários índices de direitos de patentes, como é o caso do Índice de Ginarte e Park e o Índice de Direitos de Propriedade Intelectual. Os resultados evidenciam um efeito positivo entre o nível de protecção das patentes e o nível de inovação.

Abstract

The main objective of this thesis is to study the impact of stronger patent protection on the innovation level using cross-sectional data for Portugal, Europe and United States of America. To measure the innovation level, this study uses the number of patent applications and for the strength of patent protection it uses a combination of patent rights index, including Ginarte and Park Index and Intellectual Property Rights Index. The results point to a positive effect between the level of patent protection and the innovation's level.

Aknowledgments

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1. Introduction

The study of the relation between innovation and patent protection is far from new. A great number of academics spent years delving into this matter, though most of the studies presented show an ambiguous relationship between the two. On the one hand, it might be argued that there is a positive relationship between innovation and patent protection, since companies are motivated by monopoly profits from the patent grant. On the other hand, some believe that the existing system issues too much patents, many of which are just trivial improvements over prior art, and others as a mean to block new firms to enter the market (Hovenkamp and Bohannan, 2010).

Article 7 of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) talks about this relationship: "The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge in a manner conducive to social and economic welfare, and to a balance of rights and obligations."

When a new invention appears, it is common sense that, if the innovation is any good, it should be available to all from a welfare point of view (Arrow, 1962). But if all the new inventions became accessible to public free of charge, the firms will not have a sufficient incentive to innovate due to the cost of creating and developing a new invention being too expensive.

The origins of patents, in the modern sense, date back to 1474, when the Republic of Venice enacted a decree where new and inventive devices had to be communicated to obtain the right to prevent others from using them. The Statute of Monopolies (1623) and the British Statute of Anne (1710) are seen as the backgrounds of patent and copyright law respectively[1]. However, it was only in the 19th century that the term intellectual property started to be used, and not until the late 20th century that it became commonplace in the majority of the world.

[1] Sullivan, E. Thomas (2000), "The Conference of Antitrust and Intellectual Property at the New Century", Intellectual Property Review, Vol. 1, No.5.

The five main forms of intellectual property are patents, copyrights, trademarks, mask works and trade secrets. Regarding patents, the U.S.A make a distinction between patents for invention and patents for design. Also in Europe, there is a similar distinction, the design inventions are separated from patents and the organism responsible for the design creations is the Office for Harmonization in the International Market. Likewise, the new vegetable inventions cannot be patentable, they also have their own international organism that protect them.

The focus of this paper will be on patents for invention. A patent is a government grant of certain rights given to an inventor for a limited time in exchange for the disclosure of the invention. This way, patents confer the right to prevent third parties from making, using or selling the invention without their owners' consent. Usually this consent is given in return for the payment of a royalty. When a patent is obtained through registration, the law grants the patent owner an exclusive monopoly on the use and commercial exploitation of the invention for 20 years from the date of first filing, in the Portuguese case, as well as in the case of U.S. and the majority of countries of the European Union. This 20 years rule only started in 1992 for European patents and from 1995 for Portugal and the U.S.A.

There are three requirements that need to be fulfilled, in order for a patent to be granted: novelty (the innovation must be new and not already in the public domain), usefulness (it needs to have applicability, practical use, and in the case for Europe, must have industrial applicability) and non-obviousness (it is necessary some inventive step). Despite these three statutory requirements, two other conditions must be met: the disclosure of information – it is necessary that the patent applicant describes all the steps of the creation and development of the innovation – and eligibility – in first place it is necessary to distinguish what is an invention and what is a mere discovery from nature, only the inventions can be patentable. Also there are several areas that are not covered by patent protection, as in the case of inventions that go against the public health. In the Portuguese case the cases that are not covered by patent protection are listed in the articles 52 and 53 of the National Industrial Property Code.

The protection given by the patents deters potential imitators – who could otherwise copy the product, or take advantage of the benefits arising from the innovation. The disclosure of information that the patent application requires also helps the diffusion of information of new processes and methods, which can help new inventors to improve their own innovations, simultaneously reducing "redundant R&D investments by firms who might otherwise continue try to develop the same technology."[2] On the other hand, the monopoly created by the patent grant may distort competition, which can result in inefficient allocation of resources, especially since this is a race – lot of independent laboratories invest billions of dollars to create a new invention with the objective to obtain patent protection for the invention, but since the rule is "first come, first served" (the first company to apply for a patent grant is the one that have the exclusive rights of the patent protection), the ones that lose the race waste a lot of money and a lot of resources. There is an exception for the U.S.A., the rule there is "first to invent, first to file" – they give one year to the creator of the innovation to raise sufficient funds to obtain a patent grant. In Europe, although the system was created to protect the invention and not the inventor, when the inventor proves that he already had been using the innovation before someone else applied for a patent, he beneficiates of "pre-use" rights, and he has the exclusivity of the patent.

This work aims to explain the effect, if there is one, of patent protection in the level of innovation by analyzing the existing literature and using some data to understand if there is any correlation. Although there are already some studies concerning this matter, it remains one of the most controversial questions in the economics of technology. Therefore, this paper is divided into five sections. Section 2 is a thorough analysis of the existing literature, focusing on some of the most important works. In Section 3, I explain the methodology adopted for the study and introduce the collected data. More detailed and additional data can be found in the appendices. The results' analysis and the interpretation of the data are in Section 4. Finally, Section 5 presents the main conclusions and analyzes some limitations of this study.

[2] Andrew J. Nelson, *Measuring Knowledge Spillovers: What Patents, Licenses and Publications Reveal About Innovation Diffusion*, 38 RESEARCH POLICY 994 (2009).

2. Literature review

In the economics theoretical literature there are two current views concerning patent protection and innovation, one regards the firm's perspective – it is profitable to patent the innovations or not? Are patents the best method for firms to protect the profits from their innovations –, and the other one concerns welfare economics' perspective – is the patent system from the welfare point of view, the best method to promote innovation and help economic growth?

With respect to the firm's perspective the question is should a firm patent or not patent? There are several studies concerning this question, some point out that in some industries, as pharmaceuticals there is a benefit in patenting the innovations and in other industries, as the case of software, the costs associated to the patent process do not compensate the benefits.

The first papers regarding this theory showed that in industries where it is easy to use reverse-engineering to discover the process of innovation, as in the pharmaceutical industry, the imitation costs increase significantly if compared with any other technological field (Mansfield, Schwartz and Wagner, 1981).

Further on, Mansfield (1986), in a survey done through 1981-1983, showed that around 82% of patentable inventions in pharmaceuticals were patented. Later, in a study conducted also by Mansfield (1990), it was found that an important number of innovations would never have taken place if patent protection didn't exist (60% in pharmaceuticals and 38% in chemicals) – this happens because the investment social return's rate far exceeds the private return.

However, in some industries, due to the "cumulative" nature of the innovations, patent protection can do more harm than good, such as the case of software industry and business methods (which are already patentable in the U.S., not the case for Europe). Merger and Nelson (1990) link this potential harm to patent breadth, using examples from aircraft, radio and pharmaceutical industries to claim for narrow patents. Others believe IP protection should only be used for isolated innovations because it can create incentive problems with cumulative innovations: in some cases the subsequent innovations can be the destruction of the first innovation (creative destruction[3]), therefore it is essential to have a trade-off between "achieving static efficiency through competition and achieving long-run efficiency through optimal investment in research, development, and diffusion of innovation" (Schumpeter, 1943). In the same line of reasoning, Gallini (1992) showed that when patent awards are short, increasing the length of a patent award will raise the profits earned by innovators, and therefore increasing the incentive to innovate, but only until a certain level, since after that level, increasing patent length will raise the level of imitation by rivals.

Worried about the monopoly power conceded to firms by the patent grant, some academics were afraid that the costs associated to the monopoly do not outweigh the benefits linked to the information disclosure. Scherer et al. (1992) found that once firms have patent protection or compulsory licensing decrees they tend to patent less, and use other methods of appropriability, as secrecy, although there is no proof when more competition exists in a market, more likely firms will innovate, since the presence of competition is not the only motivation for firms to innovate. The possibility of appropriating the results of their investment is also a reason to innovate. Hall (2003) stated that the patent system is a good incentive scheme to promote innovation when "1) considerable funds are needed to develop an invention, as in the case of pharmaceuticals, or complex modern information technology, and 2) it is difficult to keep the innovation secret, or imitation is easy".

In the same line of reasoning, Motta (2004), in his book Competition Policy: Theory and Practice, stated that a monopolist would have fewer incentives to innovate than a competitive firm, since the monopolist only considers the "additional" profit by the new invention, while a competitive firm would consider the whole profit. Furthermore, he proved that, in fact, patents improve welfare, as patents remove the negative externality created by spillovers, restoring the incentives to invest in R&D.

Likewise, surveys done on U.S. firms found that a significant number of patentable inventions were not patented (Mansfield, 1986) and that secrecy and lead-time advantages were viewed as the most important appropriation methods to the

[3] Term used by Schumpeter.

innovator (Cohen et al., 2000; Levin et al., 1987; Arundel, 2001; and Arora et al., 2003). Arundel (2000) goes further, saying "there is no reason to strengthen IPRs when other appropriation methods provide an adequate incentive to innovate. Doing so would simply increase the ability of firms to extract monopoly profits without providing any social benefits." Similar results have been obtained by other academics studying European and Japanese firms. The explanations behind this are the possibility of invalidation of the patent when challenged, the disclosure of the innovation method, due to the ease to invent around the patent and the high fees charged by the patent system. Nevertheless, when the value of the investment in R&D is too high, patents proved to be the best method of appropriation of the profits from innovation. Moreover, these studies showed that the reason to use the patent system by companies is not only to appropriate the profits from their innovation, but also for strategic reasons, as for example, to block some new competitors from entering the market, and the prevention of lawsuits from other companies.

Although there are some academics that do not believe in the veracity of these studies saying that several of the previous theoretical did not count innovation as a continuous process (Maurer and Scotchmer, 2002). And, some are not convinced that these results would persist if the focus of the studies were small firms and new entrants (Breitwieser and Foster, 2012). In fact, Mazzoleni and Nelson (1998) believe that these studies missed some important determinants to explain the relationship between innovation and IPR, since small firms and new entrants do not have the same mechanisms at their disposal.

The relationship between patents and innovation, as was showed above, is not so linear. Baldwin et al. (2000) says there is a relationship between patent use and innovation, but this relationship is not bidirectional: "Firms that innovate take out patents, but firms and industries that make more intensive use of patents do not tend to produce more innovations."

As regards the economics welfare's perspective, on one hand the disclosure of information implied by patents applications helps the diffusion of technical knowledge to the society, which stimulates innovation by channeling resources through productive process, and therefore generating a race to be the first to patent the invention. On the other hand, it creates an inefficient allocation of resources, since there are a lot of companies "fighting" for the same patent, when one applies for a patent – winning the race – the others lose the investments made in the discover of that innovation. Although sometimes, not all the investments are lost in the process, for example, in the case of pharmaceuticals, when two or more firms are competing for the discovery of a new drug which cures cancer, they can find other drugs that cure other diseases in the process. As well, there is the deadweight loss associated to the monopoly created by the patent protection, and the costs associated to the patent system.

Hereupon, are the benefits of disclosure information enough to overlap the costs associated to the patent system and the deadweight loss and misallocation of resources created by it? There are some scholars that believe that the answer to this question is yes, and others believe that if there were no patent system, there would be no reason to implement one today.

As a matter of fact, in 1958, Fritz Machlup in a report to the Congress stated,

> *If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it.*

In addition, Barzel (1968) said that intellectual property rights can stimulate too much innovation, which can replicate in wasteful duplicative or uncoordinated innovation activity, hurting competition.

Early, academics decided to study if, in fact, stronger patent protection helped or not to stimulate innovation and economic growth. But what is the meaning of stronger patent protection? Stronger patent protection is sometimes associated with an increase in the patent length or breadth. For Nordhaus (1969), the longer the patent protection, the higher the innovation, but also the deadweight loss associated to the monopoly created by the patent protection. Hence, he argues, it is essential to balance both. Likewise, Gilbert and Shapiro (1990) showed that the socially cost-effective way to reward innovation is to have infinitely-lived patents and the optimal patent scope is the indispensable to cover the investment. In a similar study, Acemoglu and Akcigit (2011) show that a decrease in the patent length (from 50 years to 9 years) will reduce the rate of innovation (from 1.1% to 0.15%). Kamien and Schwartz (1974) and Klemperer (1990) also agree that an increase in patent protection unambiguously increases the rate of innovation. However, when patents are already strong, increasing the patent length further can, in fact, contract the level of innovation (Horowitz and Lai, 1996).

In an important contribution, Ginarte and Park (1997) constructed an index of patent rights for 60 countries between 1960-1990. The results of their study showed no relationship between the strength of patent rights and economic growth, with the exception being rich countries, where they found a positive relationship between stronger patent protection and investment and R&D.

Later, Kanwar and Evenson (2003) studied, at the aggregate level, the effect of stronger IPR protection (measured by Ginarte and Park (1997) index of IPRs) in R&D expenditure and they discovered that stronger IPR protection has a positive and a significant impact on the share of R&D investment in GDP. Furthermore, Lederman and Manoley (2003), Chen and Puttitanum (2005), and Falk (2006) also found a positive and significant effect between innovation and patent protection.

Nevertheless, there are some studies that show that this relation between patent protection and innovation is not so linear. On one hand, the costs of information disclosure more than offset the private gains from patenting (Horstmann, 1985). Other studies show that approximately 50% of all patents lapse due to failure in paying the renewal fees through the mid-point of the 20 years, in the case of U.S., and in European jurisdictions with annual renewal requirements, approximately 95% of all patents lapse due to failure in the payment of renewal fees previous to the end of the statutory term[4]. There are also several studies showing the "worthless" of the patents granted (Schankerman and Pakes, 1984; Pakes, 1985).

[4] See Kimberly, A. Moore, *"Worthless Patents"*, Vol. 20 Berkeley Tech L.J., pages 1521-1526 (2005).

On the other hand, some studies showed that an increase in patent protection have a negative effect on innovation. Sakakibara and Branstetter (1999) and Bessen and Maskin (2000) found a negative correlation between the strength of IP system and innovation. Their results were not supported in Kortum and Lerner (1998), however. Lerner (2002) shows that when a country reinforces its patent system it will increase the number of patents registered by foreign inventors; yet, there is no proof of an increase in patentability of the domestic inventors, neither in their country itself or in the foreign country. Moser (2005) found a similar result in her work: "I find no evidence that patent laws increased levels of innovative active but strong evidence that patent systems influenced the distribution of innovative activity across industries".

Moreover, Boldrin and Levine (2009) estimated that the optimal patent term would be somewhere between 5 to 10 years. In their example, if a world economy is growing at 4% a year, then patent protection should be reduced, approximately, 1% per year. In a different work, although with similar results, Krasteva (2012) showed that patent protection may impede R&D investment even in the context of independent innovations.

Some academics are convinced that intellectual property protection, including patent protection, is essential to stimulate innovation. Lemley (2001) stated that the goal of patent system is to promote innovation by giving inventors economic rewards. However, this relation is ambiguous, since over the years were several studies that pointed out a positive relationship between them, and others that do not see the positive effects of the patent system, and several asking for a reform of the current patent system (Boldrin and Levine, 2013).

3. Methodology and data collection

In this section I will explain the main reasons for the choice of the data used in this thesis, and also I will present the data collected and some data that I used from other research papers. The analysis of these data will be made at Section 4.

To study the relationship between patent protection and innovation I decided to focus on Portugal (PT), Europe (EUR), and United States of America (USA). The reason for the choice of these three economies was simple, Portugal is the country that I am natural off, and it was of my special interest compare Portugal with the other two economies to understand the importance of the patent system in Portugal. Europe and the U.S.A. are the two major case studies, already analyzed by the most important papers, concerning this topic, and second, since they were already the focus of many papers, there is more data available.

Some of the data used in this paper were collected in World Intellectual Property Organization (WIPO) Statistics Data Center and World Bank's site. I also used data presented in Cohen, Nelson and Walsh (2000) relative to surveys made to U.S firms, and from Ginarte and Park (1997), Park (2008) and Intellectual Property Rights 2012 Report to compute the patent rights index, that will be explain further on.

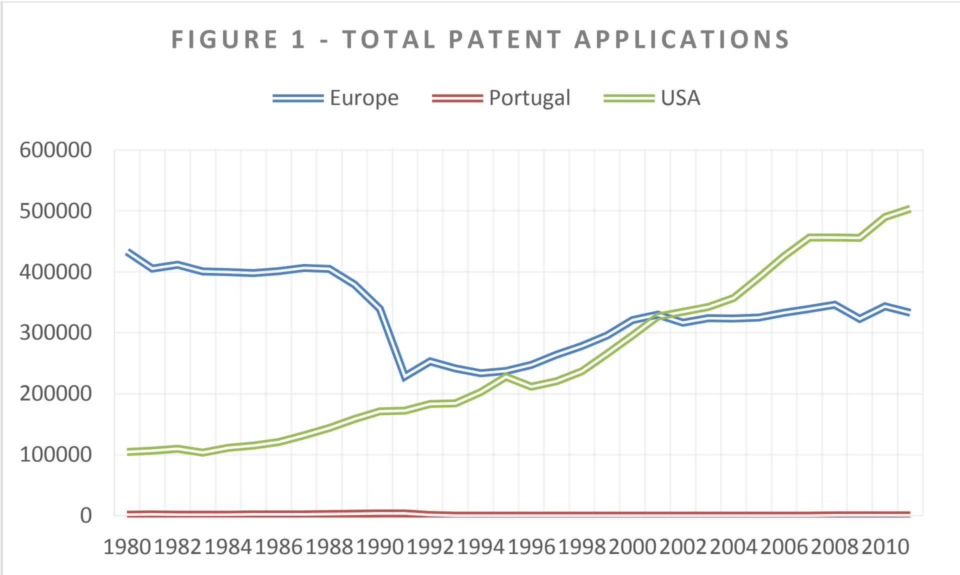
To measure the rate of innovation I used the number of patent applications, since it removes the "vagaries" of patent offices, which can affect the number of patents granted, leaving only the creations of the inventors. Although it is not an effective measure of innovation, due to the fact that not all patents filed are effectively patentable, this measure was already used in many papers, and is the one that gathers more consensus.

The number of patent applications is not the only way to measure innovation. The other measures usually used are new products or products improvement - but not all products are guarantee to succeed -, the patent citations - however, patents can be self-cited-, and inventions disclosure or suggestions – yet, ideas are seldom realized.

The number of patent applications between 1980-2011 is not uniform between the economies in analysis, as we can see in figure 1. In Portugal the number of patent applications are decreasing over time (-64.56%). Portugal registered 1823 patent applications in 1980 and only 686 in 2011. However, Portugal didn't always recorded this decreasing path, between 1980-1990, Portugal noted an increase in patent applications of 95%, with the maximum number of applications of 3642 listed in 1990, but after that, the number of patents applications decreased, significantly.

In Europe, if we look throughout the years in the sample (1980-2011), we observe a reduction in the number of patent applications (-23.19%), however after 1990, patent fillings at the European Patent Office (EPO) registered an increase of more than 45%.

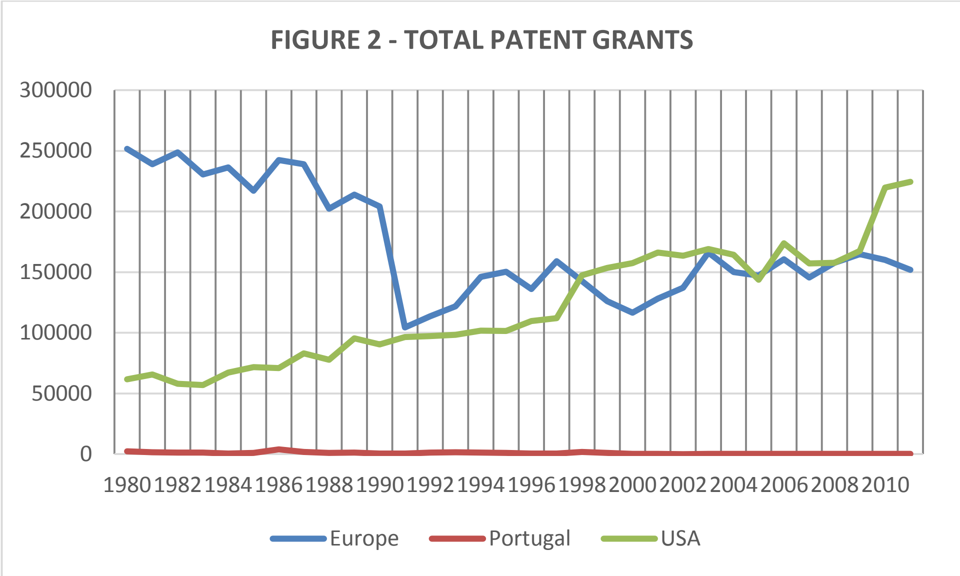
In the case of United States of America, the story is different, the number of patents applications increased more than 380%, throughout 1980-2011.



Source: WIPO Statistics Database

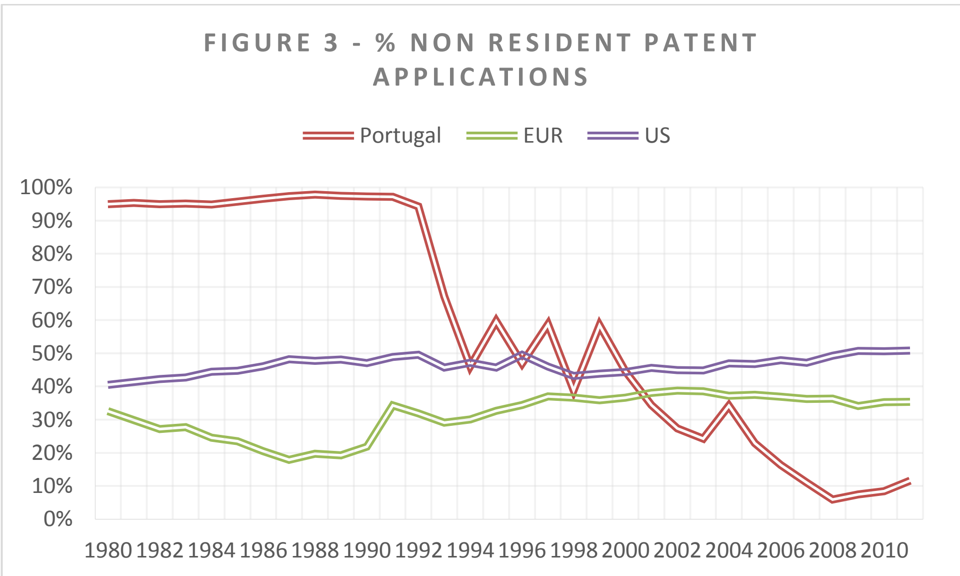
In figure 2 are showed the number of patent grants for Portugal, Europe and the U.S.A.: we observe the same path as patent applications, with a declining path recorded by Portugal and Europe, minus 93.68% and minus 39.58%, respectively, and once more, US showing more than 263% increase between 1980-2011.

It is important to mention that I could use the number of patent applications and the number of patent grants to compute the percentage of the number of patents effectively granted, however that analysis cannot be done since when a patent is filed it takes in average 2 to 5 years to be conceded with a grant.



Source: WIPO Statistics Database

If we look closer to the origin of patent applications, as shown in figure 3, it is easy to perceive that until 1992, almost all patent applications in Portugal were made by foreign innovators. After 1992, we see an increase in domestic patent applications, and in 2011, only less than 12% of the patent applications were non resident patents. In Europe, the majority of patents applications are done by domestic inventors, with 38.78% (2002) as the maximum of patent applications registered at (EPO) by foreign innovators. In the U.S., the ratio between non resident and resident patent applications is very close but from 2009 the percentage of foreign patent applications is larger than the domestic ones.



Source: WIPO Statistics Database

I also decided to look to the amount of research and development expenditure, since the majority of innovations involve a large sum of research and development spending, especially in the first stage of the creation of the invention.

Figure 6 presents the total of the research and development expenditure in percentage of GDP per year, throughout 1996-2010. These expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.

Table 1 - Research and Development Expenditure (% of GDP)

Office	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EUR	175.87%	178.01%	175.26%	183.71%	180.65%	186.59%	183.48%	186.13%	182.51%	182.15%	184.42%	184.50%	194.20%	203.89%	202.65%
Portugal	55.62%	57.04%	63.04%	68.66%	72.78%	77.22%	73.20%	71.07%	74.36%	77.86%	98.66%	116.51%	150.31%	164.04%	159.12%
USA	255.18%	257.63%	259.62%	264.00%	270.86%	271.88%	261.63%	261.28%	254.53%	259.41%	263.57%	270.45%	283.89%	289.66%	N.D.

Source: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.

As expected, the United States of America is the country where the expenditure in research and development, as percentage of GDP has the higher value, recorded almost 300% in 2009. In Europe this ratio is also high, with the spending in R&D hitting the 200% in 2009 and 2010. Portugal despite being the one which spends less in research and development is the one where this ratio exhibits greater increase (more than 180%), between 1996-2010.

The next three tables present the patent publications by technological field. In Europe, in 1980, the field of technology with higher percentage of patent publications was the electrical machinery, apparatus and energy, with 20,778 patent published. But, over the years this field changed, after 1980, the industries which registered a higher number of patent publications were measurement, civil engineering and transportation.

At the INPI the industries that registered the higher number of patent publications were pharmaceuticals and organic fine chemistry, and after 1994, civil engineering also counts as one of the industries with the higher percentage of patent publications.

The United States recorded medical technology as one of the fields with high number of patent publications, but also as electrical machinery, apparatus and energy and organic fine industry. After 1995, we can add computer technology as one of the industries which registered high number of patent publications, recorded almost 58,000 patent publications in 2008.

Table 2 - Patent publication in Europe

Technology	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1 - Electrical machinery, apparatus, energy	20778	20279	18228	16927	15490	16560	14845	14857	14497	13714	13200	14137	12994	11410	10588	11139	10758	11873	12715	13483	14724	15540	14942	14768	15588	15826	16020	16661	17810	18332	18351	19171
10 - Measurement	19085	21206	18174	17919	15941	17952	17295	16973	17327	16920	16340	18191	16593	12664	9683	9952	9334	10432	10794	10756	11583	12142	12597	13096	14799	15664	15327	15752	16366	16736	16059	15514
26 - Machine tools	18120	20759	17959	16865	14458	17075	15757	15178	14562	14291	13528	13634	13121	10974	7927	7819	7603	7814	7932	8090	8496	8374	8473	8821	9527	10077	9272	9269	9308	9310	8774	8845
35 - Civil engineering	20778	19999	19576	18004	15815	17380	16559	14942	14980	15971	15726	16495	15832	13298	11427	12285	12097	12292	12986	12880	13218	13405	13489	13142	15060	15172	14061	14193	14361	14562	14354	14004
14 - Organic fine chemistry	17691	16625	15411	15844	15331	15967	13804	12319	11998	11857	10825	10518	10523	9272	8943	10184	9858	9941	10394	10752	12111	12361	12897	13104	13990	13946	12213	11808	12171	11264	10613	10283
29 - Other special machines	16554	17365	15692	15601	14054	16234	14366	14051	14462	14882	14271	14844	14739	11677	9389	10313	9778	10282	10590	10596	10916	10902	11089	11442	12813	12349	11193	11361	11254	11423	10947	10669
31 - Mechanical elements	15434	15444	13428	13579	12158	14329	12256	11744	11287	11747	11402	11269	11330	9619	8495	8756	8979	9699	10332	10680	10975	11379	11702	11663	13156	13065	12409	12828	14002	13915	13009	12699
25 - Handling	15089	14896	14067	13664	12486	13785	12615	12488	12586	12656	12304	11963	11524	9964	8864	8995	8648	8516	8841	9570	9791	9901	9575	9543	10533	10696	10073	10254	10110	9869	9465	9347
32 - Transport	14546	14005	12617	12661	11845	13479	12102	11679	11539	12000	11599	11599	11851	10937	10791	11522	11343	13298	14152	15025	15436	16447	16532	16656	19375	21271	20389	20857	21331	22074	20664	20443
23 - Chemical engineering	13048	13789	12527	11835	10305	11866	10694	10353	10375	10780	10481	10827	10789	8737	7698	8836	7796	7870	7868	7972	8223	8349	8240	8439	9099	8606	8009	8020	8436	8285	7960	7727
20 - Materials, metallurgy	12857	13759	12351	11142	9509	10836	9624	9189	9052	9082	8948	9438	9411	6949	5868	6678	5880	6110	5852	5633	6005	5731	5794	6027	6745	6585	5945	6698	7719	6973	6626	6729
19 - Basic materials chemistry	11385	11118	9689	10473	9588	10178	9086	8552	8400	8194	7963	8029	7798	7200	6930	7698	7393	7795	8056	7925	8365	8278	7908	8057	8448	8283	7626	8050	8562	8188	8207	7881
28 - Textile and paper machines	11175	10387	9031	8996	8265	9315	7611	7646	7847	7925	7750	7990	7684	6772	6131	6401	6481	6354	6652	6816	6957	7246	6905	7055	7294	7213	6554	6537	6137	5879	4976	4555
27 - Engines, pumps, turbines	10512	11382	10321	10013	8289	9403	8683	8185	7778	7671	8236	7616	7807	6672	6348	6876	6974	7658	8167	8666	8964	10369	10537	11307	12572	12845	11931	12527	13192	14698	14212	13976
30 - Thermal processes and apparatus	8115	9381	8918	7801	6586	7245	6450	6137	5544	5707	5346	5263	5308	4392	3943	4457	4225	4189	4462	4462	4613	4472	4521	4566	5329	5308	5407	5422	5617	6034	6347	6475
17 - Macromolecular chemistry, polymers	7839	7532	6235	5965	5399	6560	5587	5471	5585	6003	5900	6041	5650	4961	4555	4666	4820	4899	4984	5229	5493	5378	5246	5084	5435	5212	4867	4812	4983	4936	4783	4543
2 - Audio-visual technology	6885	7116	6804	6990	6379	6932	6543	6155	6076	6380	6790	7114	6625	5607	5293	5089	5337	6117	6770	7057	8020	8664	8487	8374	9512	9848	10197	9805	9412	8367	7779	7504
9 - Optics	6781	6440	5913	5924	5441	6029	5353	5453	5418	5583	5993	6362	5903	5217	5090	5027	5370	5392	5675	5491	6036	6406	6891	6713	6907	6531	6491	6626	6428	6126	5826	5750
16 - Pharmaceuticals	6757	6542	6578	7345	7556	7798	7827	7343	7405	7515	7147	7470	7825	6948	6936	8012	8115	9024	9493	10275	12937	13365	14737	15065	16548	16336	14476	14662	14677	13871	12581	13100
13 - Medical technology	6405	7081	6920	7051	7098	7855	7758	7975	8024	8749	8651	9151	9001	8863	8277	8357	8989	9574	10131	11083	12579	12399	13201	14715	17212	16897	16298	17206	18164	18437	17815	17913
34 - Other consumer goods	6231	6158	5786	6001	5398	5985	5529	5336	5435	5326	5201	5093	5292	4702	4464	4868	4665	4804	5361	5562	5950	5922	5693	5847	6646	6969	6475	6810	6919	7297	6874	7267
33 - Furniture, games	6216	5723	5526	5812	5297	5918	5597	5662	5871	5780	5818	5611	5800	5214	5167	5513	5523	5827	6184	6533	6787	7086	6968	6953	7755	7820	7364	7603	7566	7335	7125	6957
5 - Basic communication processes	5845	5687	4945	4507	3879	4644	4243	4323	4034	3945	3621	3830	3392	2521	2217	2100	2078	2231	2372	2358	2593	2945	2900	2821	2972	2790	2627	2595	2466	2247	2183	2211
12 - Control	5841	6118	5356	5345	4755	5030	4819	4935	4795	4682	4364	4500	4285	3654	3409	3354	3644	3798	4301	4548	4991	5266	5588	5507	6187	5994	5663	5457	5421	5596	5305	5023
6 - Computer technology	5622	5773	5434	5133	5008	5628	5940	6063	5739	5920	6273	6482	5779	5131	4475	4762	4955	5509	6501	7195	9342	10668	11746	11899	13097	13449	13899	14295	14159	13147	12810	13201
21 - Surface technology, coating	5287	5348	4903	4682	4315	4989	4254	3962	3829	3963	3934	4217	4003	3613	3256	3352	3410	3576	3658	3612	3866	4342	4176	4431	4826	4823	4485	4564	4599	4547	4385	4202
24 - Environmental technology	4601	4792	4327	3944	3590	4355	4107	4235	4068	4207	4403	4676	4799	4064	3828	4164	4016	4154	4167	4098	4219	4238	4301	4468	4754	4675	4518	4958	5039	5295	5316	5196
3 - Telecommunications	4184	4238	3788	4016	3858	4293	3874	3768	3647	3894	4235	4380	4538	4372	4426	4866	5198	5962	7552	8224	9983	10370	10067	8795	8983	8847	8274	8272	8159	7749	7003	6566
18 - Food chemistry	3102	3141	2967	2895	2858	3193	2882	2894	2875	3134	3081	3299	3327	2702	2438	3079	2849	3335	3342	3631	3761	3836	3710	4458	4671	5633	4132	4699	5610	7866	7014	7460
8 - Semiconductors	2514	2529	2321	2493	2210	2691	2397	2346	2294	2625	2804	3139	3038	2689	2627	2797	2977	3162	3676	3804	4537	5209	5236	5211	5795	5625	5714	5940	6229	5875	6395	6695
15 - Biotechnology	2447	2681	2601	2948	3476	3881	4013	4265	4336	4607	4618	4670	4798	3917	3778	4283	4345	4817	5263	5725	7039	7718	8244	8803	8913	9408	7204	6854	7376	7143	7551	8431
11 - Analysis of biological materials	1346	1365	1176	1243	1375	1634	1667	1806	1957	2046	1776	1999	2025	1619	1455	1485	1587	1768	2042	2128	2447	2663	3064	3201	3387	3462	2924	2873	2996	3002	2926	3223
4 - Digital communication	1139	1177	1014	1032	1010	1154	1043	1076	1042	1159	1315	1490	1552	1575	1705	1939	2206	2747	3784	4581	6295	7362	8309	8389	9146	9688	10346	10745	11487	12047	11888	11693
7 - IT methods for management	65	77	74	62	65	69	86	74	58	84	87	118	124	112	107	155	217	299	408	564	1162	1934	2668	2544	2207	1865	1969	2043	2162	2134	2116	2134
22 - Micro-structural and nano-technology				2	2	5	1	4	6	9	9	8	20	19	24	47	45	54	88	85	106	162	271	321	386	409	437	550	522	664	657	749
Total	**314274**	**319912**	**290657**	**284714**	**259089**	**290247**	**265267**	**257439**	**254728**	**259008**	**253939**	**261463**	**255080**	**218037**	**196552**	**209826**	**207493**	**221172**	**235545**	**245089**	**268520**	**280829**	**286704**	**291285**	**319667**	**323187**	**304789**	**311606**	**320750**	**321223**	**308896**	**308136**

Source: WIPO Statistcs Database

Table 3 - Patent publication by technology in Portugal (1980-2011)

Technology	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
14 - Organic fine chemistry	320	369	378	371	377	424	443	424	278	484	462	542	452	203	79	11	5	9	10	5	11	7	10	6	10	5	6	17	13	17	7	12
16 - Pharmaceuticals	172	215	224	230	246	314	366	395	266	490	469	557	476	203	78	11	4	8	11	4	11	7	7	5	8	5	2	19	20	11	14	17
19 - Basic materials chemistry	146	154	164	172	144	146	156	162	83	148	172	203	150	99	47	21	5	5	4	1	5	8	3		2	4	7	7	11	5	11	10
29 - Other special machines	81	88	102	101	104	107	99	76	55	212	111	108	94	94	78	7	11	11	10	6	5	6	12	10	10	12	9	19	6	22	13	13
23 - Chemical engineering	60	69	62	49	51	67	66	65	45	124	83	88	67	54	38	12	6	6	5	5	9	8	4	8	8	8	3	10	9	12	12	14
35 - Civil engineering	53	69	66	62	56	56	47	42	19	144	90	52	74	77	72	32	15	15	12	16	10	13	9	12	33	20	11	33	23	44	33	24
31 - Mechanical elements	49	57	38	40	38	42	35	26	26	94	41	25	46	44	32	4	5	7	7	1	11	2	8	8	12	6	1	14	4	7	5	3
17 - Macromolecular chemistry, polymers	48	50	47	64	55	71	75	64	65	98	124	139	111	40	15		1	5	4	2	1	1	2	2		3		2	6	2	4	3
28 - Textile and paper machines	47	45	46	50	48	58	55	49	32	101	89	88	68	65	41	4	6	5	3	5	2	2	11	8	6	4	3	6	3	5	5	10
20 - Materials, metallurgy	46	72	55	59	49	61	47	63	50	82	92	87	47	37	17	7	4	9	9	3	4	3	8	6	7	6	7	8	8	9	4	5
25 - Handling	46	79	66	70	62	69	86	48	47	180	106	71	51	72	63	9	8	9	9	5	6	12	4	7	6	12	6	8	8	13	8	17
32 - Transport	43	63	48	45	41	48	33	22	17	81	42	32	40	41	44	11	12	13	10	13	10	14	14	6	12	9	7	15	6	20	7	10
1 - Electrical machinery, apparatus, energy	40	56	68	54	39	30	68	36	31	126	38	29	41	69	39	9	4	9	8	8	8	9	14	6	5	6	8	8	8	13	18	11
30 - Thermal processes and apparatus	37	48	25	27	27	31	24	14	11	49	16	26	21	31	28	6	9	3	2	5	5	4	5	4	5	5	4	8	9	15	10	11
15 - Biotechnology	35	55	40	55	72	79	124	143	92	177	170	208	178	77	28	7	4	1	1	1	10	6	7	4	6	2	3	11	13	9	11	8
26 - Machine tools	28	35	43	37	28	42	37	22	31	73	39	43	39	44	29	10	4	8	8	6	4	5	5	2	13	6	9	8	7	11	11	9
18 - Food chemistry	25	32	33	42	43	40	55	52	38	81	67	99	62	27	10	4	3	3	3	2	1	6	1	3	5	1	6	6	14	4	7	7
2 - Audio-visual technology	23	29	24	25	30	27	17	17	13	54	33	22	37	35	25	3	2	5	1	1	3	5	4	2	2	2		3	6	1	6	1
13 - Medical technology	22	41	44	41	50	54	53	64	35	124	108	104	51	68	76	12	23	5	4	5	2	7	4	5	4	8	5	13	10	22	15	27
34 - Other consumer goods	21	31	35	33	32	38	31	34	31	93	68	36	27	30	28	6	6	2	3	6	5	2	4	4	5	9	3	15	7	7	9	3
3 - Telecommunications	20	30	15	23	12	16	24	13	13	51	21	18	25	25	17	4	4	1	4	11	5	2	3	4	5		1	4	6	6	4	8
21 - Surface technology, coating	19	41	32	28	36	31	26	19	16	44	33	41	20	26	16	5	1	2	6	2	1	1	1	3	2	2	1	2	1	9	5	2
24 - Environmental technology	18	20	23	19	19	22	14	20	17	58	32	39	18	23	25	7	2	6	3	7	2	4	7	4	7	4	4	19	4	4	11	9
27 - Engines, pumps, turbines	18	45	31	25	11	22	23	18	5	41	19	19	9	21	20	11	11	3	1	9	6	9	4	13	6	6	3	13	11	22	18	16
33 - Furniture, games	18	42	41	38	34	52	37	32	25	95	62	44	29	35	33	8	8	11	5	8	6	12	6	2	11	7	8	8	14	15	13	15
12 - Control	17	13	12	9	14	10	11	12	4	29	19	7	14	26	17	4	4	7	6	7	5	6	7	6	6	3	5	6	5	12	9	6
10 - Measurement	14	28	28	18	21	23	31	27	16	60	40	23	32	31	24	5	4	4	3	9	5	4	8	8	8	8	6	10	16	11	16	14
9 - Optics	8	7	14	9	18	11	13	11	10	26	16	11	15	14	11		5	1		2	2	2	7	1	4	2	1	5	4	4	6	5
4 - Digital communication	6	2	2	9	4	4	7	2	2	11	12	6	12	12	4	1	1			4	1	2	4	2		2	3	2	4	5	4	6
5 - Basic communication processes	6	12	9	6	14	7	4	3	7	10	14	6	11	4	5	1	1				1		1	1		1	1	1	1	2		2
6 - Computer technology	5	13	7	7	7	12	11	6	5	29	6	9	13	19	16	4	1	1	1	2	3	2	5	5		3	3	4	5	12	11	6
11 - Analysis of biological materials	4	7	7	5	8	12	16	33	10	36	23	29	16	16	7		1			1				2				4	5	4	5	1
8 - Semiconductors	3	3	6	2	4	4	3	1	2	4	6	7	1	3	2						1		1		1	1		1	4	3	3	8
7 - IT methods for management						1	1			1			1	1				1			6	8	7	1	4	1	3	6	4	5	4	2
22 - Micro-structural and nano-technology											1																		3	1	1	2
Total	**1498**	**1920**	**1835**	**1825**	**1794**	**2031**	**2138**	**2015**	**1397**	**3510**	**2724**	**2818**	**2348**	**1666**	**1064**	**236**	**180**	**175**	**153**	**162**	**167**	**179**	**197**	**160**	**213**	**173**	**139**	**315**	**278**	**364**	**320**	**317**

Source: WIPO statistics database.

Table4 - Patent grants by technology in USA (1980-2011)

Technology	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
13 - Medical technology	2091	2203	1953	1906	2333	2591	3050	3604	3437	4571	4642	5073	5525	5849	6831	6970	7572	7906	10305	10516	10918	14089	20019	20777	20999	21487	21191	22868	24565	23086	24440	23892
1 - Electrical machinery, apparatus, energy	3871	4181	4139	3960	4674	4805	4587	5749	5157	5874	5577	5783	5723	5647	5780	6030	6826	7186	9285	9951	10729	14635	19928	17534	18320	18569	20139	20430	20941	22513	23167	23405
10 - Measurement	3309	3515	3212	3056	3792	4056	4091	5034	4572	5705	5207	5524	5467	5383	5743	5964	6368	6037	7543	7677	8310	11079	16096	15624	15053	14885	15002	15283	16610	16548	16057	14637
9 - Optics	2563	2887	2453	2442	2853	3043	3107	3849	4007	4954	4988	5472	5464	5740	5731	5380	6138	6325	8451	8106	8357	11949	17578	16189	15302	15497	15534	15274	14628	14506	13090	12408
6 - Computer technology	1011	1075	1064	1188	1507	1532	1760	2252	2381	3271	3054	3391	3780	4484	5577	6326	8055	8696	13423	14049	14620	21096	33204	35651	36661	40781	47877	50283	57539	57357	55650	54966
2 - Audio-visual technology	1726	1786	1919	2073	2284	2759	2948	3932	3658	4514	3850	4499	4597	4910	5243	5506	6197	6336	8894	8800	9304	13790	20866	20008	20441	21742	21854	21244	21450	21191	20827	20409
32 - Transport	2808	3081	2723	2518	3106	3105	3387	4332	4236	4979	4714	4967	4739	4845	4915	4917	5432	5199	6893	7092	7917	10806	13834	11714	12058	11902	10874	10586	10771	10347	9933	9266
14 - Organic fine chemistry	3766	4008	3216	2854	3280	3477	3245	3343	3359	4293	4410	4581	4894	5386	4739	4952	5110	5728	6411	6403	6326	7799	10549	11094	10925	10290	10106	9703	10158	10857	12149	11638
29 - Other special machines	3402	3608	3033	2843	3384	3532	3440	3961	3954	4534	4475	4639	4829	4689	4723	4590	4656	4763	5838	5979	5861	7440	10071	9470	8879	8763	8097	7469	8129	8202	8740	8517
8 - Semiconductors	882	940	904	1010	1115	1395	1567	1918	1823	2375	2517	3104	3217	3537	4223	4376	4403	4952	6713	8403	9931	15970	21391	18188	18111	19312	18968	19638	19443	18840	19322	19774
25 - Handling	2669	2646	2447	2307	2786	3174	3111	3445	3316	3964	3785	4074	4028	3879	4085	3987	4046	3860	4939	5210	5123	6479	8084	7477	7535	7786	8197	8239	8578	8149	8156	8684
33 - Furniture, games	2225	2046	1871	1585	1887	2175	2323	2655	2671	3436	3390	3656	3644	3424	4021	3932	4354	4278	5419	5479	5644	6592	9266	8770	9142	9653	10260	10564	10369	9777	9171	8605
31 - Mechanical elements	2829	3057	2532	2313	3118	3410	3441	3953	3428	4167	3835	4103	3974	3726	3795	3591	3929	3865	4842	5190	5396	6918	9092	7594	7923	7638	7394	7440	8280	8119	8657	8672
19 - Basic materials chemistry	2551	2864	2397	2576	2853	2818	2434	2629	2618	3116	2977	3320	3480	3475	3661	3725	3772	3922	4594	4829	4673	5758	7319	7479	6876	6627	5802	5791	6266	6526	6970	6924
23 - Chemical engineering	2668	2781	2379	2251	2471	2621	2531	2765	2872	3419	3303	3404	3730	3685	3647	3578	3651	3833	4376	4693	4596	5750	7559	7354	7123	6890	6866	6706	7450	7468	7748	7596
35 - Civil engineering	2697	3035	2495	2512	3218	3002	3218	3795	3037	3945	3583	3830	3582	3495	3511	3392	3751	3675	4489	4717	5073	6216	8288	7461	8144	7872	7909	7721	8487	8375	8531	8462
17 - Macromolecular chemistry, polymers	2064	2414	1976	2116	2282	2450	2101	2307	2333	2794	2846	3363	3484	3698	3453	3114	3061	3028	3433	3477	3561	4706	6213	5904	5228	4648	4702	4890	4980	5124	5479	4975
26 - Machine tools	2561	2762	2321	2345	2864	3175	3289	3410	3056	3580	3339	3720	3598	3416	3374	3146	3399	3517	4292	4817	5021	6601	8075	7201	7321	7276	7380	7010	7282	7555	8402	8602
27 - Engines, pumps, turbines	2463	2572	2368	2617	3200	3158	2617	3218	3063	3350	3160	3341	3475	3425	3123	3001	3329	3175	3817	3877	4623	6734	8548	7399	7379	7103	6678	6744	7128	7810	8463	8241
3 - Telecommunications	1006	1032	1052	1023	1212	1410	1462	1884	1862	2254	2138	2235	2428	2677	3097	3508	4149	4020	6247	6980	7339	10407	16219	16143	16965	16380	17677	18031	18414	16636	15547	12285
28 - Textile and paper machines	2008	2212	1857	2125	2243	2559	2436	2590	2463	2954	2898	3066	3314	3152	3040	3251	3560	3534	4380	4479	4748	6420	8350	7312	6956	6996	6383	5983	5664	5240	4829	4918
16 - Pharmaceuticals	924	1002	950	889	1159	1147	1231	1515	1530	2198	2187	2473	2621	2732	2862	3157	4016	4689	5729	6300	6435	8619	12733	14285	14034	14486	15228	15096	15348	16078	16638	15182
34 - Other consumer goods	1885	1929	1620	1505	1774	2065	2091	2350	2073	2605	2676	2854	2710	2599	2815	2939	3079	3182	4066	4462	4256	5205	6493	6144	6713	7008	6793	6389	6615	6276	6148	5925
20 - Materials, metallurgy	1913	2003	1697	1877	1959	2037	1986	2048	2099	2532	2327	2588	2565	2578	2591	2216	2277	2238	2550	2749	2544	3664	4819	4435	4218	3696	3442	3434	3532	3529	3780	3485
15 - Biotechnology	518	596	567	559	642	645	737	1019	1060	1432	1562	1835	2265	2651	2590	2886	3768	4677	6543	6739	6524	8609	13330	15462	12117	11016	9436	8787	9189	10607	11194	10680
21 - Surface technology, coating	1145	1313	1142	1303	1434	1445	1401	1448	1367	1671	1756	1746	1856	1918	2018	2100	2102	2150	2636	3006	3182	4380	6102	6108	6370	6493	8026	7858	8538	9995	10528	9764
5 - Basic communication processes	928	1068	1123	1020	1189	1448	1442	1529	1376	1648	1522	1761	1846	1667	1968	2200	2304	2228	3064	3153	3482	4728	6426	6012	5794	5940	6011	6174	6310	6014	5836	5222
12 - Control	1048	1121	1034	970	1099	1272	1300	1561	1408	1849	1642	1720	1727	1863	1924	1994	2191	2186	2931	3070	3309	4483	6660	6849	6863	7028	7071	7510	7718	7123	7060	6175
30 - Thermal processes and apparatus	1555	1834	1500	1509	1758	1638	1455	1483	1335	1516	1477	1462	1388	1493	1592	1412	1461	1402	1822	1931	1918	2568	2830	2683	2859	3070	2981	2925	3101	3342	3675	3766
24 - Environmental technology	991	1078	862	775	892	920	891	1040	1056	1274	1273	1361	1519	1591	1568	1609	1649	1703	2071	2041	2046	2571	3363	3085	3118	3039	3204	3468	3443	3548	3693	3603
18 - Food chemistry	683	738	655	679	685	851	719	824	1043	1506	1179	1183	1175	1326	1353	1333	1436	1372	1825	2011	2202	2551	3911	3838	3932	3580	3826	3783	3833	3682	3612	3582
4 - Digital communication	192	232	255	258	336	405	447	531	515	688	615	729	866	1007	1269	1569	1996	2042	3290	3784	4587	7174	13819	15337	16464	15898	13773	14750	15558	14586	16845	16851
11 - Analysis of biological materials	301	361	320	278	349	325	373	488	493	684	608	654	833	914	903	932	1087	1270	1723	1742	1791	2316	3731	4559	3751	3607	3112	2963	2877	2955	3104	2876
7 - IT methods for management	29	22	32	27	26	42	37	48	56	88	78	92	110	172	204	174	243	367	673	920	1546	3893	7966	7190	6429	6891	5777	6451	8424	8181	7979	8533
22 - Micro-structural and nano-technology	1			1	2	3	3	4	3	5	3	9	9	17	28	41	65	62	81	89	128	250	508	527	558	444	219	225	256	242	239	167
Total	63283	68002	60068	59270	69766	74490	74258	86513	82717	101745	97593	105612	108462	111050	115997	117798	129432	133403	173588	182721	192020	262245	373240	362857	360561	364293	367789	371710	391874	390384	395659	382687

Source: WIPO statistics database.

To comprehend the innovative activity of an economy it is necessary to look also at the scientific and engineering articles published and to the high technology exports.

Table 5 shows the scientific and engineering journal articles published, between 1985-2009, in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

By looking at table 5 we can see that until 1995, the United States were the economy with most articles published in scientific and engineering journals but after 1995, Europe started to be the economy with higher number of articles published in scientific and engineering journals.

In all the economies, the number of articles published increased throughout the period in analysis; in Europe this increase was almost 100%, in the U.S.A. more than 50% and for Portugal this increase was more than 1600%.

As concerns to the high technology exports, it includes products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. Data are in current U.S. dollars.

At table 6 is possible to see that Europe is the economy which exports more high technology products, followed by the U.S. and Portugal, throughout the years in analysis (1992-2011). These results are perfectly normal given the dimension of these three economies.

In Europe, in 1992, the value of high technology was US$ 174 billion, and during the period in question, this value increased significantly, recording at the end of 2011 more than US$ 623 billion.

The Portuguese case is different, throughout 1992-2008 we assisted to an increase of more than 500%, registering a value of high technology exports of more than US$ 3 billion. After 2008, this value decreased significantly, and at the end of 2011, the value of high technology products exports in Portugal was US$ 1,5 billion.

The U.S. also present a decrease in the value of high technology products exports after 2008. At the end of 1992, the value of high technology exports was US$ 104 billion, in 2008 the U.S. registered a value for the exports of high technology products of more than US$ 220 billion, and at the end of 2011 the value was only US$ 145 billion.

Table 5 - Scientific and technical journal articles published

Office	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EUR	125222	138007	134494	144541	156182	159455	162950	177236	178826	192108	196497	204588	209480	215389	217833	223366	221105	222439	225652	231355	236074	243833	247074	251145	249820
PT	232	370	378	429	510	587	640	712	794	914	990	1097	1255	1418	1711	1880	2081	2331	2423	2853	2912	3629	3424	3857	4157
USA	137771	178266	172585	177662	187224	191559	194015	198864	197397	199769	193337	193161	189752	190431	188004	192743	190594	190496	196445	202097	205565	209272	209898	212883	208601

Source: World Bank - National Science Foundation, Science and Engineering Indicators.

Table 6 - High technology exports (current US$)

Office	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
EUR	174070034486	167070853761	194847845955	247654955898	262637848847	290240794541	318171928404	353011769709	390586845865	386577244948	385754238828	421962672203	500677532489	552675181688	625286578697	555033949776	582689758547	511822842036	574822206058	623104881648
PT	542421793	340255692	538825399	996129912	812640868	817717777	826732783	1016354149	1291624925	1622596398	1601168874	2321708814	2701050865	2532380642	2960142714	3213323791	3262750836	1166259760	1221340165	1547407412
U.S.A.	104700910870	105184845720	115535095940	126759299130	138093562430	163407329180	171969190090	181431870160	197466008780	176163628690	162082323850	160291329040	176281664560	190737242710	219026015640	218115501900	220884471210	132406674890	145497804510	145273374430

Source: United Nations, Comtrade database.

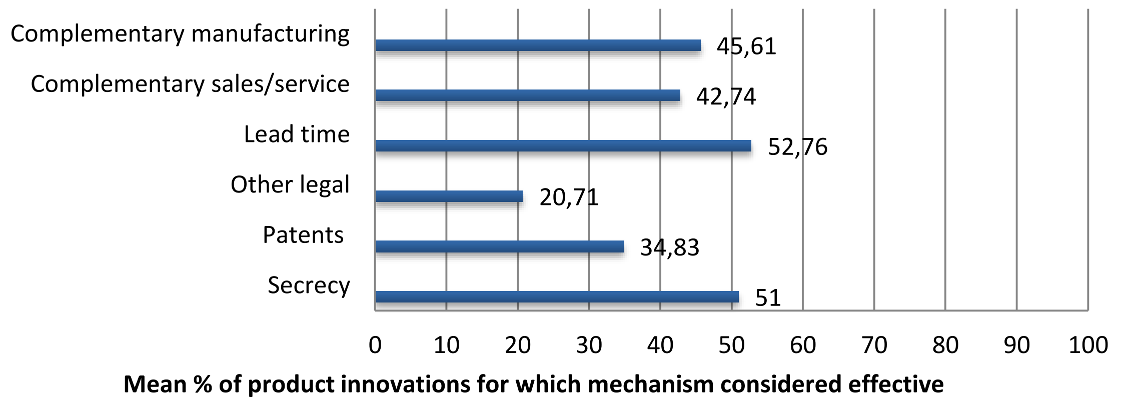
To do a thorough and more complete analysis of the relation between patent protection and innovation, I used data from the surveys presented in Cohen, Nelson and Walsh's (2000) paper.

In 1994, Wesley Cohen, Richard Nelson and John Walsh (2000) inquired 1478 R&D labs in the U.S. manufacturing sector to understand which were the methods used by companies to appropriate the profits of their invention. Although the surveys were conducted only in the United States, it is my opinion that they are essential to understand, in respect to the firm's perspective, the relationship between innovation and patent protection.

The reason to the choice of these surveys was the fact that they were already used in a large amount of academic works and they allow us to comprehend, with respect to the firm's perspective what are the main methods for the firms to appropriate the profits of their innovations, and if these methods of appropriation are or not related with the firm size and the level of investment in R&D. These surveys also enumerate what are the main reasons for companies patent and not patent their innovations. The next figures present the main results of the study. More detail data of these surveys can be found in the appendices.

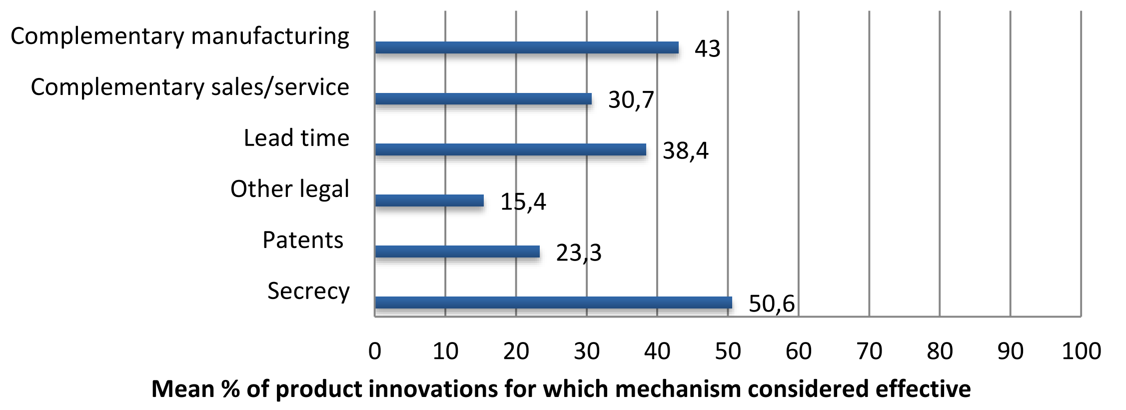
Regarding product innovations, companies considered lead time advantages and secrecy as the most effective methods to appropriate the profits of their innovations (52.8% and 51%, respectively), as it is showed in figure 4. The most effective mechanisms for process innovations considered by firms are secrecy (50.6%) and complementary manufacturing (43%) – figure 5.

Figure 4 -Effectiveness of appropriability mechanism for product innovations: Mean percentage of product innovations for which mechanism considered effective



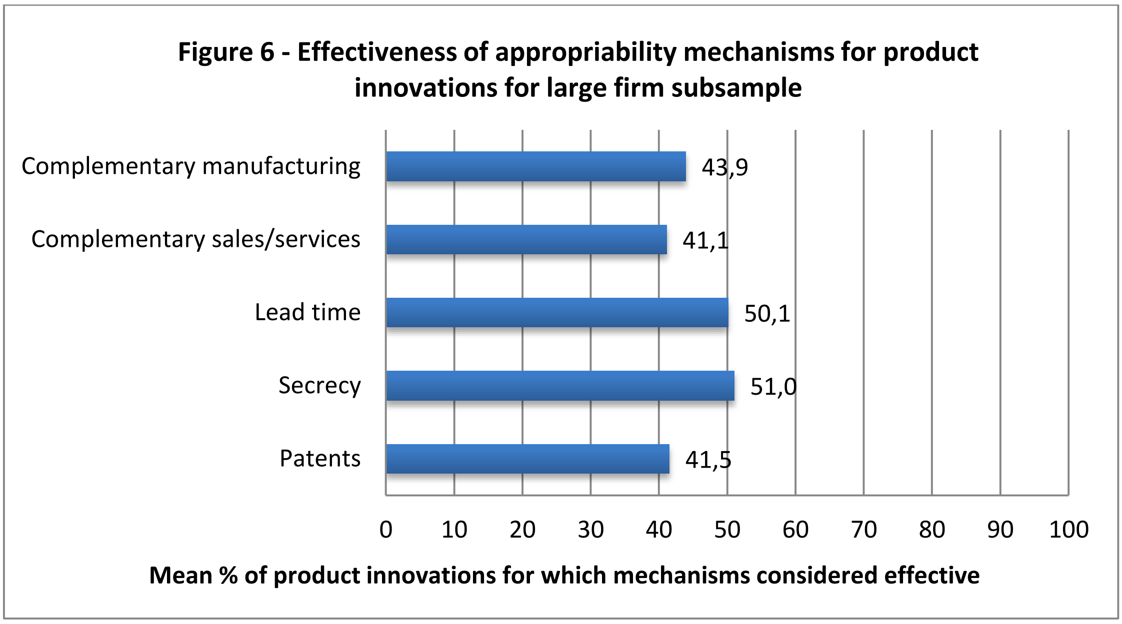
Source: Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.

Figure 5 - Effectiveness of appropriability mechanism for process innovations: Mean percentage of product innovations for which mechanism considered effective

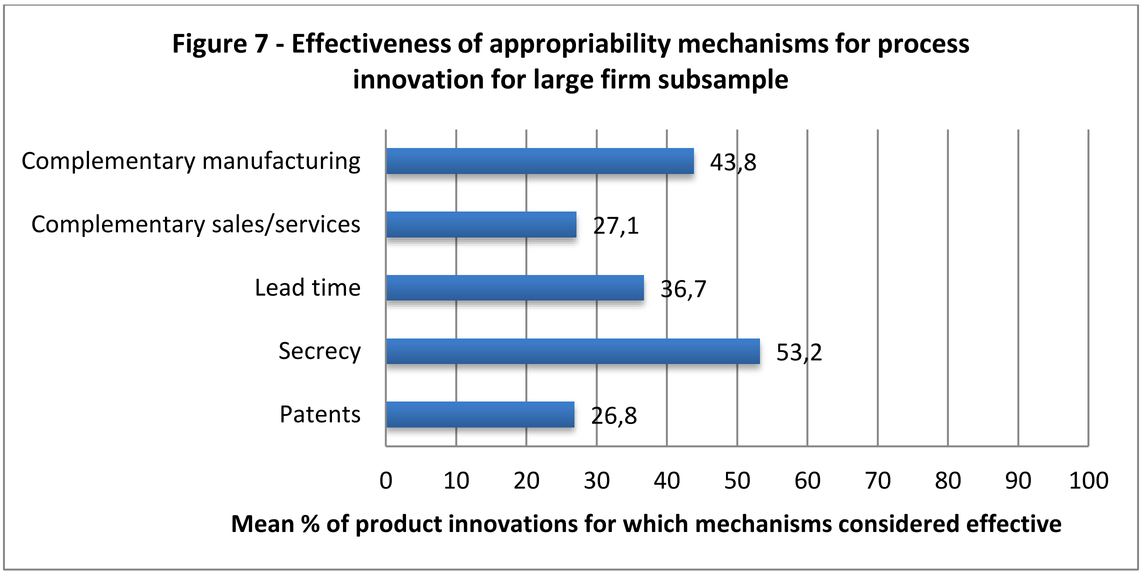


Source: Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.

Considering only the large firms, secrecy, lead time advantages and complementary manufacturing remain as the most efficient mechanisms of appropriation, as it is presented in figure 6.

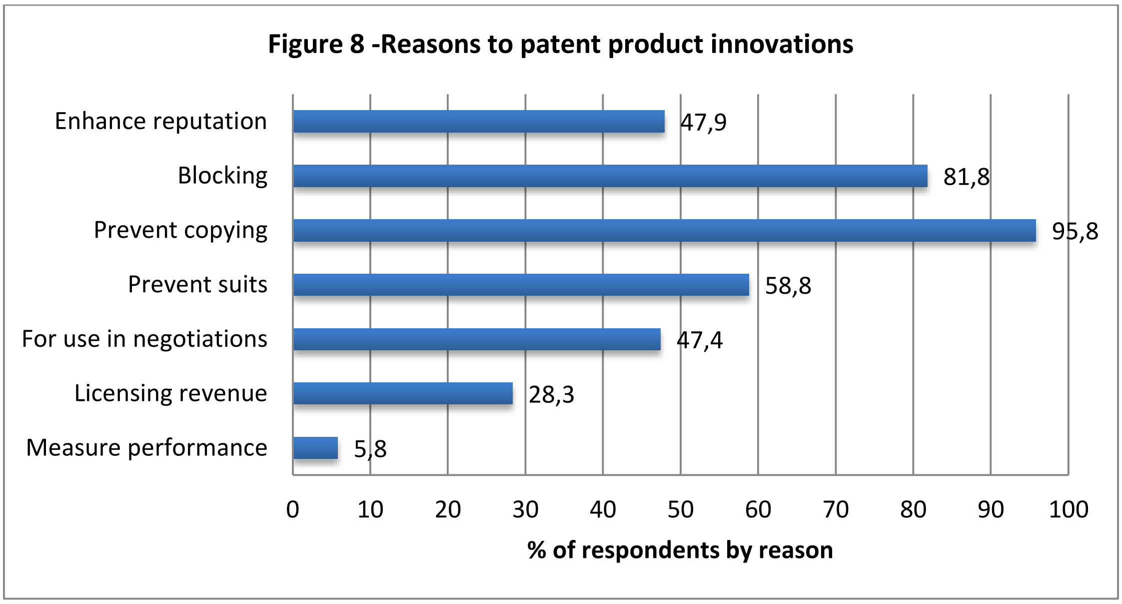


Source: Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.

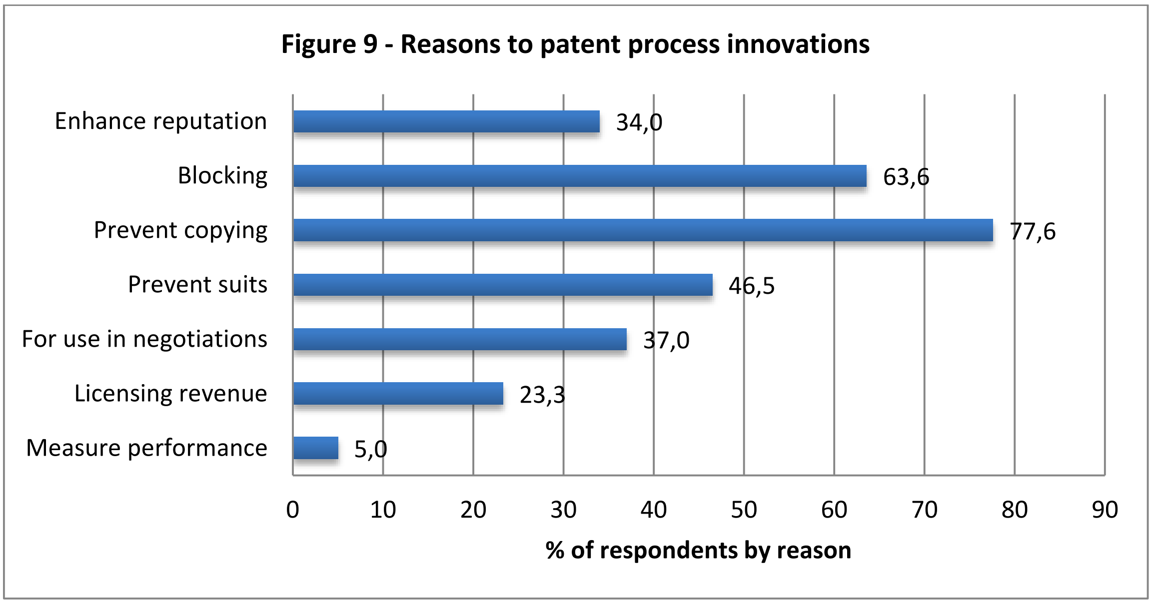


Source: Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.

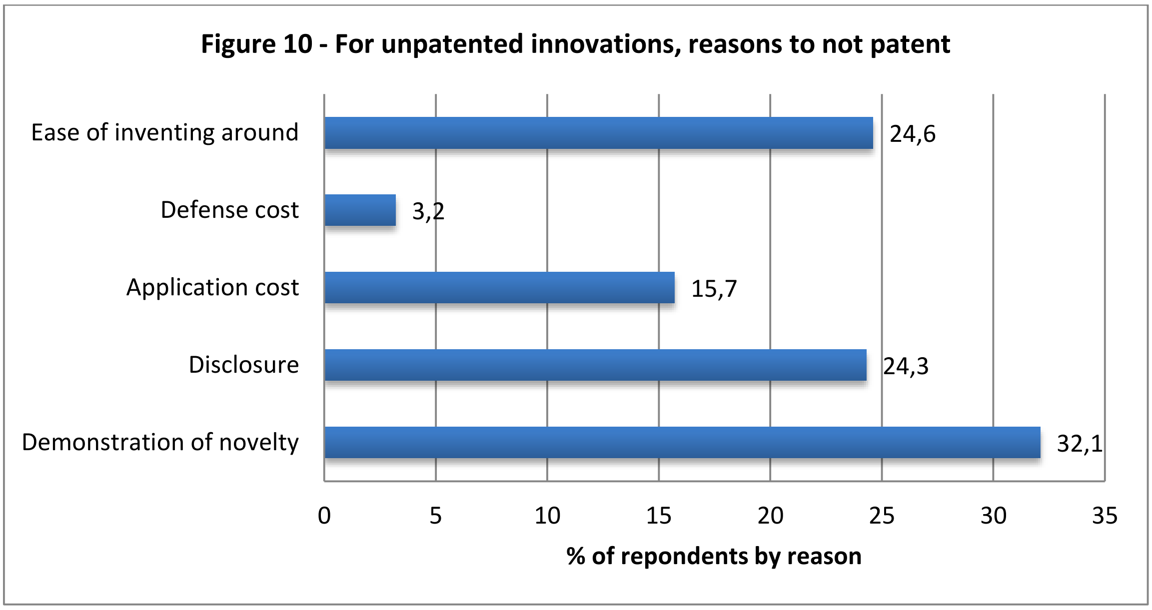
Companies refer the criteria of novelty in the patent application and the ease to invent around, as the most important reasons not to patent. On the other hand, the main reasons listed by companies to patent an innovation, either in product innovations as in process innovations are to prevent copying, to block potential competitors and to be protected against possible suits.



Source: Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.



Source: Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.



Source: Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.

To evaluate the strength of patent protection I used the Ginarte and Park Index (GPI, henceforth), an index of patent rights, initially calculated for 110 countries between 1960-1990, but meanwhile updated to 124 countries and until 2005. This index considers five components of the laws: duration of protection, extent of coverage, membership in international patent agreements, provisions for loss of protection, and enforcement measures. Each of these components was assigned a value of one if present and 0 if absent, with the score being the sum of these values as a percentage of the maximum value. So, the minimum possible national score was 0 and the maximum was 5.

As this index only includes values until 2005, I used the Intellectual Property Rights Index (IPRI, henceforth) to have data until 2010. The IPRI came to replace the GPI, however the measurements of the two indices are not the same.

For this study I only computed the values throughout 1980-2010, since it is our time sample analysis.

As regards the IPRI, it includes three categories: Legal and Political Environment, Physical Property Rights and Intellectual Property Rights, but for the purpose of this study I only presented the values for the Intellectual Property Rights that comprises the protection of intellectual property rights, patent protection and copyright policy. Unfortunately it does not make any differentiation between them. The overall grading scale of the IPRI ranges from 0 to 10, with 10 representing the strongest level of property rights protection and 0 reflecting the non-existence of secure property rights in a country.

I decided not to converge the value of IPRI to the scale of the GPI, since these are two different measures and cannot be directly comparable.

Since GPI did not present the average value for Europe, I computed it by calculating the arithmetical mean of all European countries listed in Ginarte and Park (1997).

Table 7 - Patents Rights Index

Region	1980	1985	1990	1995	2000	2005	2010[5]
Europe	3.12	3.18	3.21	3.87	4.25	4.33	7.46
Portugal	1.98	1.98	1.98	3.35	4.01	4.38	7.00
U.S.A.	4.19	4.52	4.52	4.88	4.88	4.88	8.50

Source: Ginarte and Park (1997) and Park (2008)

4. Results' analysis

In this section I will analyze in detail the data of the previous section.

Over the years, patent regimes have gone through important changes, especially in the past two decades. The major changes were done in strengthening patent rights, mainly, conferring more exclusive rights to patent holders, and expanding the coverage and easing enforcement of patent applications. For example, in Portugal until 1995, the duration of patent protection was only 15 years and in the United States was 17 years, while the European Convention had already implemented the period of 20 years to the duration of the patent protection.

[5] Data collected from Intellectual Property Rights Index 2012 Report, regards the section of Intellectual Property Rights, the data is not divided by intellectual properties categories, therefore its include all types of intellectual property (patents, copyrights, trademarks, mask works and trade secrets.

The United States and Japan were the first to reinforce the duration of patent protection in pharmaceutical industry, followed by Europe in 1992. Nowadays, there is a supplementary protection certificate that extends the duration of the patent protection, in Europe. This certificate only comes into force after the corresponding general patent expires. It normally has a maximum lifetime of 5 years, can be extended to 5,5 years in cases related to human medical products which data from clinical trials conducted in accordance with an agreed Pediatric Investigation Plan have been submitted.

In Portugal, before joining the European Union (EU), patent rights did not have very strong protection. For instance, only after joining the EU, Portugal introduced the patent for products, before only the processes of the invention were patentable. Also, only after the adhesion to the EU, Portugal implemented by decree the possibility to “reverse the burden of proof”. This measure was already been discussed in the Parliament in 1980 but due to the pressure of the big economic groups did not passed.

Furthermore, this strengthening of patent protection did not only give higher protection to the patent holders, the field covered by patents was also expand, as in the case of the United States that, in 1989, took a more liberal approach regarding the software industry and business methods, which became patentable for the first time.

In Europe, software and business methods are still not protected through patent, due to the fact that they do not meet the “obviousness” criteria. However, Europe continues to strength patent protection, in April 2004 was approved a Directive by the European Parliament and the European Council to ease the enforcement of intellectual property rights.

Now, if we look to the data in Section 3 it is possible to see that the number of patent applications at the EPO and at the United States Patent and Trade Office (USPTO) is increasing between 1990-2011, more than 45% and almost 200%, respectively. Although the Portuguese Institute of Industrial Property (INPI) recorded an increase of more than 95% in patent fillings between 1980-1990, but after 1991 the number of patent applications decreased significantly. This can be explained by the Portuguese adhesion to the EU, which required that Portugal joined the EPO until 1992, therefore, after 1992 the patent applications in Portugal increased, but they were registered at the EPO and not at the INPI.

As regards the origin of patents applications it is important to notice, that the number of domestic patent fillings at the INPI increased substantially, as the number of patent applications decreased, from 1992. This supports the theory that, although the number of patent applications at the INPI recorded a sudden decrease, this not means that the patent applications in Portugal have decreased. The total number of patent applications in Portugal increased but after 1992, these applications are filled at the EPO and not at the INPI.

In figure 2 we can notice a slightly increase of non resident patent fillings at the EPO and at the USPTO, which may be explained by the desire of foreign patent holders increase the extent of their patent application, and also, to protect their market in other countries, blocking domestic innovators to use their innovation.

Relative to the field of patent applications, analyzing the data is possible to see that the most chosen field by patent applicants varies across the three economies and in the case of Europe and United States of America also differs across time.

In Europe, throughout 1980-1996, the technological fields that exhibited more applications, according to WIPO's qualification were measurement and civil engineering, after 1996 the technological field which registered more patent fillings was transportation.

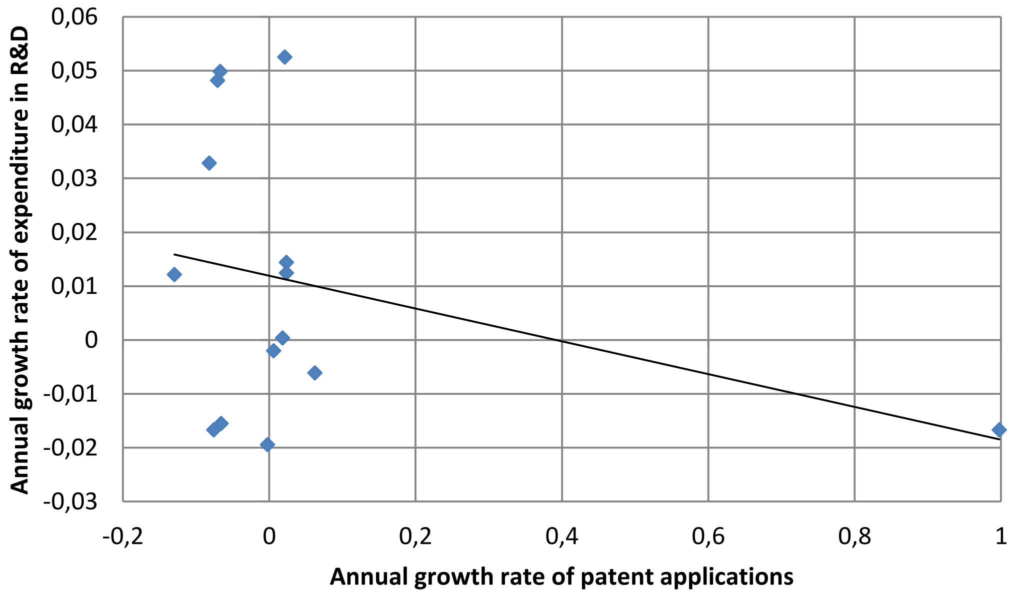
In Portugal, between 1980-1994, the fields which have registered more patent applications were pharmaceuticals and organic fine chemistry. After that period, we can see an increase in the patent applications for civil engineering, although pharmaceuticals, medical technology and organic fine chemistry also registered a high number of fillings.

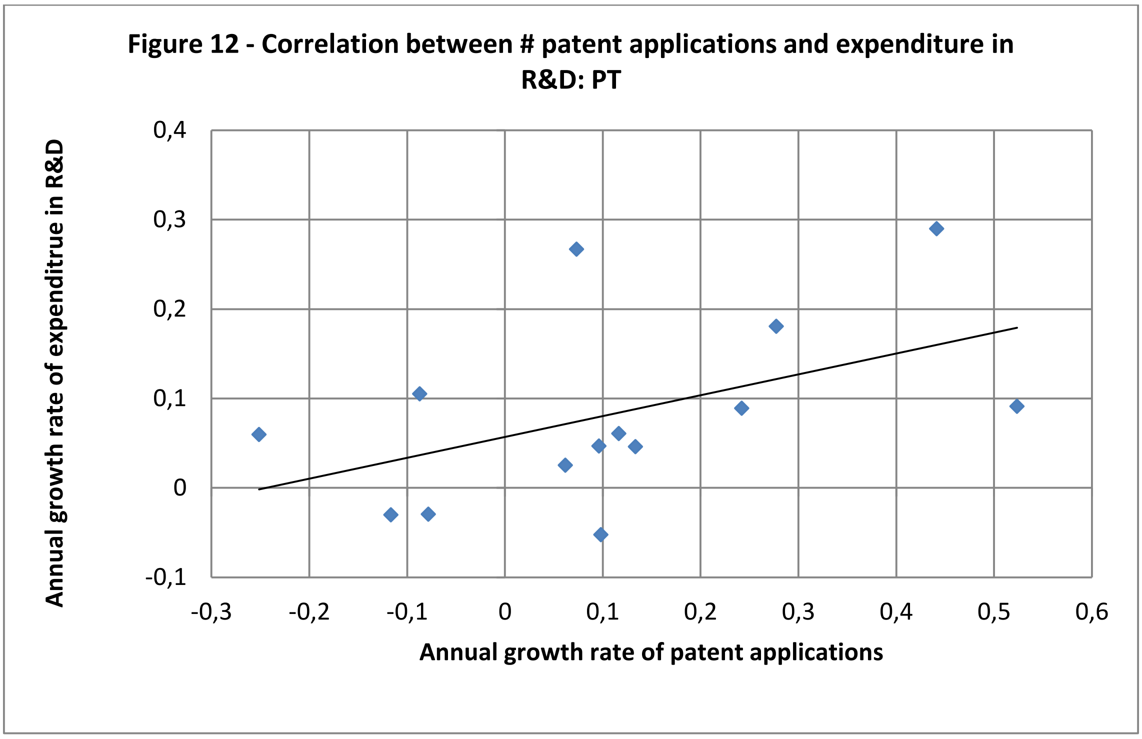
In the U.S.A, throughout 1980-2011, medical technology was one of the fields that registered the largest number of patent applications, the other two technological fields which noticed more fillings were electrical machinery, apparatus and energy and organic fine industry. After 1995, the number of patent applications in computer technology increased significantly, making it, between 1996-2011, the field with more applications.

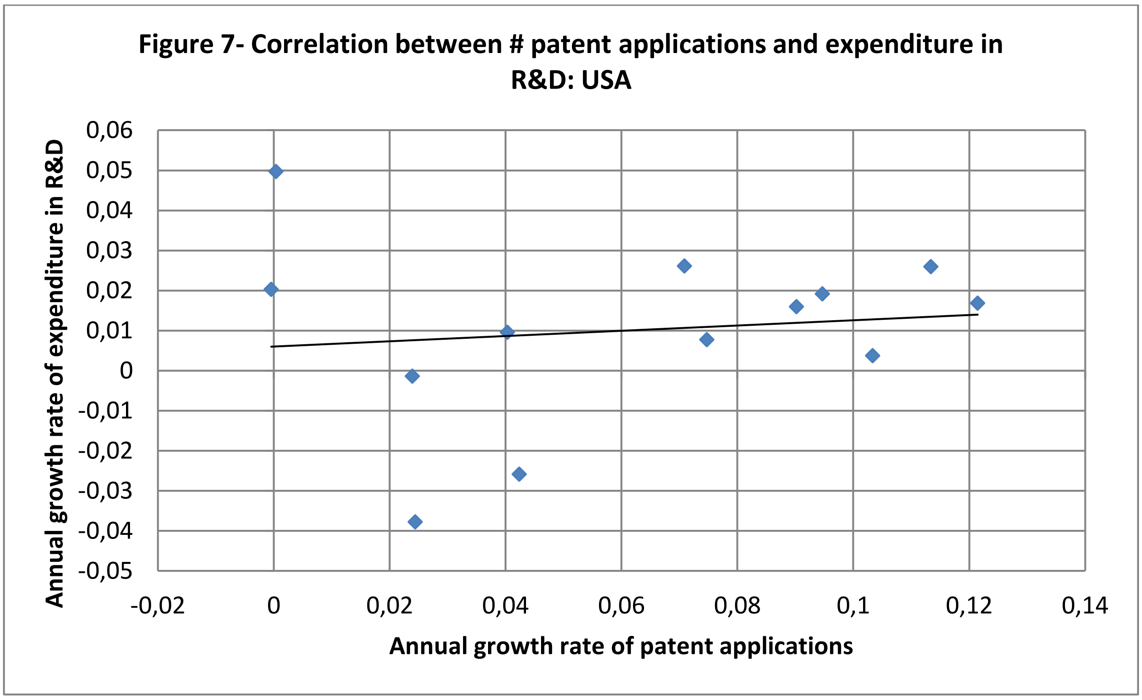
To understand better the relation between the number of patent applications and the value of the expenditures in R&D, as a percentage of GDP, I used the ordinary least squares (OLS) method to construct the regression line describing this relation. Figures 11, 12 and 13 show the linear regressions for Europe, Portugal and the U.S.A..

The results demonstrate that the model does not fit the data, for all the economies and this can be explain because this relation is not synchronic. The investment in R&D occurs years before the fillings for patent, since the creation and development of a new invention take time.

Figure 11 - Correlation between # patent applications and expenditure in R&D: EUR







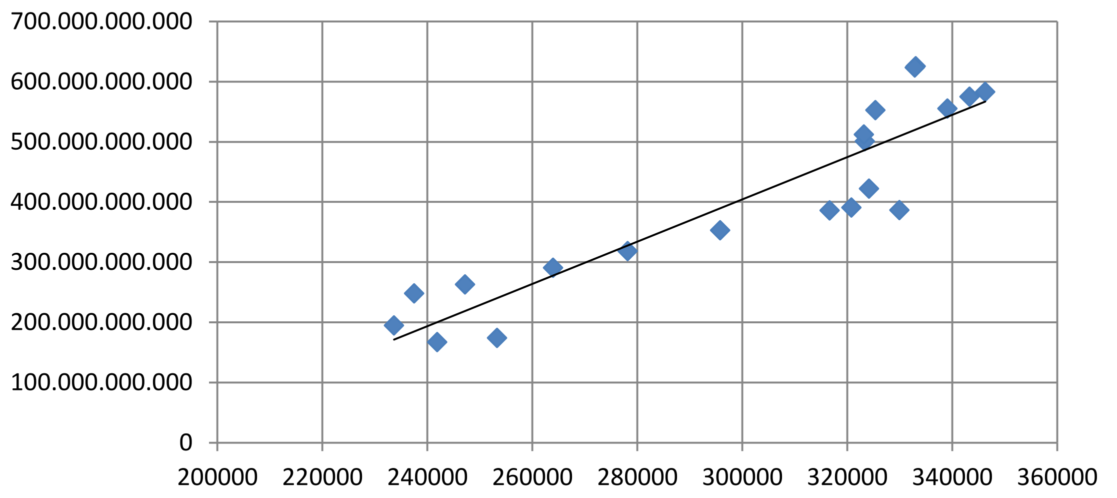
With respect to the scientific and technical journals published there is a positive relation between the number of patent applications and the number of articles published. Over the years the number of articles published increased exponentially in all economies. An explanation for this can be the development of new methods of communication and the ease of diffusion of that communication, as for example, internet, the applications for smartphones, just to mention a few.

Concerning the value of the exports for high technological products, I also decided to use the OLS to compute the linear regression between the number of patent applications and the exports for high technological products.

In this case, the results seem to point out to a positive relation between the number of patent applications and the high technology exports, with the exception for Portugal. This exception can have the same explanation as above, since Portugal joined the EPO, in 1992, the number of patent applications at the INPI decrease significantly, due to non residents innovators are now using the EPO to register their applications for a patent in Portugal.

But these results are biased. As before, the relation between the number of patent applications and the value of exports for high technological products is not synchronic. Between the application for a patent and the export of the innovation can take years.

Figure 14 - Correlation between the number of patent applications and the high technology exports: EUR



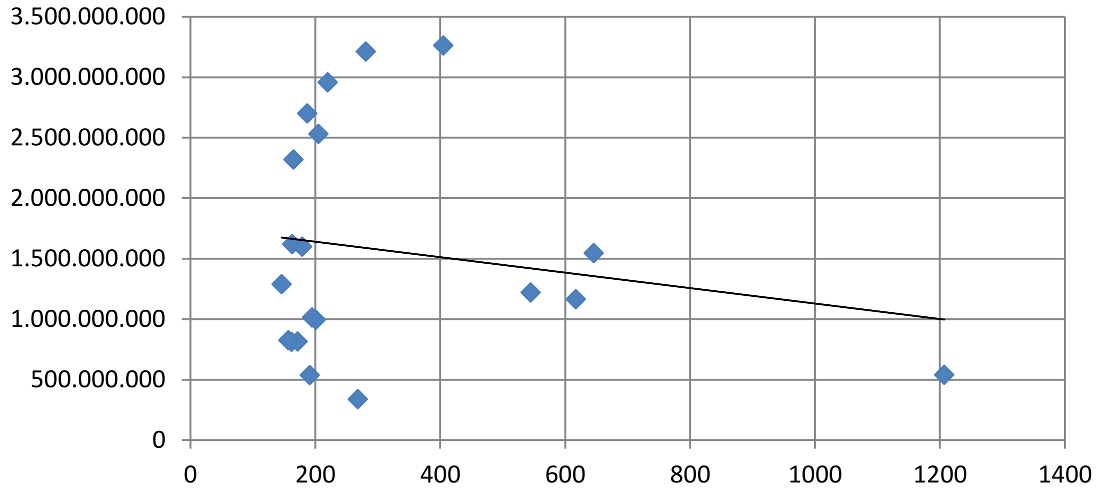


Figure 15 - Correlation between the number of patent applications and the high technology exports: PT

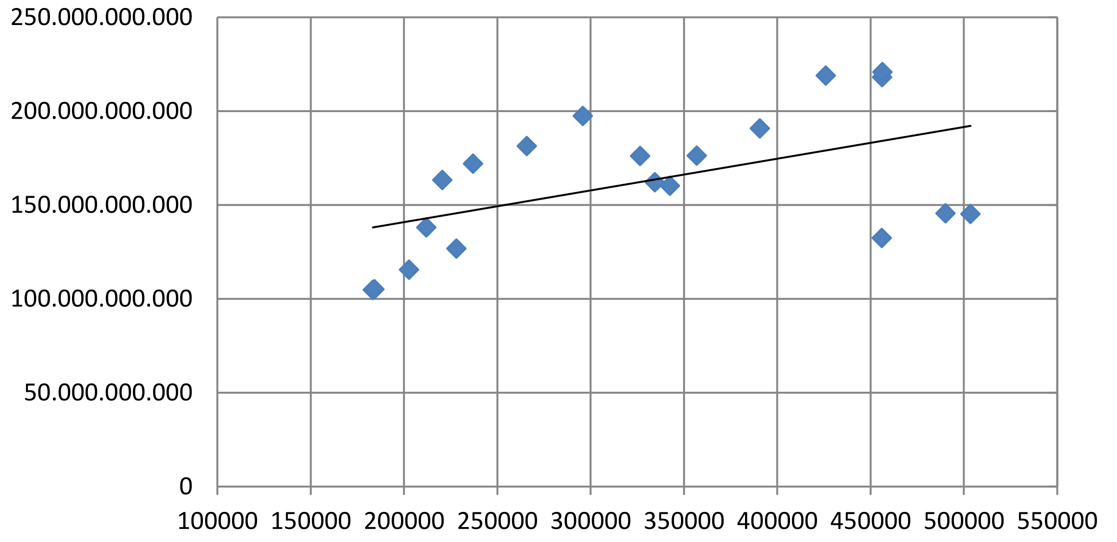


Figure 16 - Correlation between the number of patent applications and the high technology exports: USA

Comparing now the data collected from Cohen, Nelson and Walsh's (2000) with the data that I collected from the United States, I found some interesting and matching results.

As was showed in Section 3 both in product innovations as in process innovations the most effective methods of appropriation are secrecy, lead time advantage and complementary manufacturing. Patents only appeared in fourth place out of five as the best mechanisms to appropriate the profits of innovations, used by companies, with 34.8% for product innovations and 23.3% for process innovations.

Looking to these data by industry, and compare it with our sample for U.S. in 1994, is important to highlight that regarding product innovation the industry that highly rated patents as an effective mechanism of appropriation was the medical equipment industry, followed by drugs (54.70% and 50%, respectively). Now, observing the number of patent applications by industry in the U.S. during 1994 it is easy to see that the largest number of patent fillings were exactly in medical equipment[6]. The same happens to process innovations, which leads me to conclude that, actually, the most effective method to appropriate the profit of an innovation in pharmaceuticals is through patenting.

Although these surveys do not provide data for small firms, analyzing the data for the large firm subsample, it seems to support Mazzoleni and Nelson's (1998) work, which assumes that small firms and new entrants have more reasons to patent than the large companies, since large firms have other mechanisms to appropriate the return of their innovations. Here, it is important to proceed with careful since there are sectors where small firms and new entrants cannot compete with the large firms, due to the high value of the investments in R&D.

As regards the reasons for the use of patent protection by companies, these surveys also support the majority of the previous literature, as the most important being the prevention of copying by other companies, to appropriate some market power by blocking some potential competitors and, finally, to prevent some possible suits. Therefore, companies do not use patents as a mean of promoting innovation, but exactly the opposite, since one of the main reasons to patent is to exclude some potential innovators of the market. By blocking potential competitors, patents are preventing new entrants to improve previous innovations.

In contrast, the main reasons why companies decide not to use patent protection for their innovations, are the difficulty to fulfill the "novelty" criteria, this happens, because a several number of innovations are just improvements of previous

[6] See appendix IV – table VII

inventions. Other reason is the risk associated to the disclosure of the information – when a company applies for a patent it must disclosure information regarding the process and the method of the new invention, although, as was already explained, not all applications for a patent are conceded with a grant, since they need to pass the tests conducted by the patent offices, therefore there is a risk associated to this disclosure. Finally, since the companies need to reveal the innovation when filed for a patent, the other companies can easily invent around.

Now, considering the patent rights index presented at table 6, it is possible to observe the increase in the strength of patent rights over time, which supports most of the previous literature concerning patent protection.

Comparing them with the number of patent applications, I can observe that there are different trends for the different countries. For example, in the case of Europe between 1980-1995 we assisted to a reduction in the number of patent fillings, but the index of patent rights is increasing through that period, after 1995 we can observe an increase of patent applications and also in patent rights index. This increase in the patent applications after 1995 can be related with the increase of the patent rights index since, the effect of this index is not immediate, the policies taken need time to act and to show some results.

Portugal, indeed, exhibited an increase of almost 100% throughout 1980-1990, and the level of patent rights index did not present any variation, although we have seen an attempt to increase the level of patent protection in 1980, with the discussion for the approval of the "reverse of burden of the proof" in the Portuguese Parliament. In addition, after 1990 until 2010 the level of patent applications registered a decrease of 85% and the patent rights index, on the other hand, raised more than 250%. Yet, we cannot forget that this reduction in the number of patent applications is not real, since the patent applications in Portugal increased over the years in analysis, but after 1992, the majority of applications for patents were filled at the EPO, thus they do not count for the INPI data.

Regarding the U.S., there is a positive correlation between patent rights index and the number of patents filed at the USPTO. Although the increase in the number of patent applications more than triples the increase of patent rights index (370% and 103%, respectively.

5. Main conclusions and limitations of the study

This work supports the majority of theoretical conclusions regarding the relationship between stronger patent protection and the level of innovation, presenting a positive effect between the two. On one hand, the level of patent protection is increasing over the years, this increase not only respects to a higher protection of the patent holders, giving them more exclusive rights, but also in the expansion of the coverage of patent protection and the ease to enforcement patent applications. On the other hand, the number of patent applications follows this increase in the level of patent protection, with the exception for Portugal, but this, as was already explained, is due to Portugal joined the EPO in 1992, and the majority of the innovations are filed at the EPO and not at the INPI.

Regarding the relation between expenditures in R&D and the number of patent application, the model does not fit the data, and here it is important to not forget that the investment in R&D by the company is done years before the company applies for a patent. This happens because the development of the invention takes time and, therefore these two variables are not directly comparable. The same happens to the exports for high technological products, although in this case the data seem to fit the model.

As concerns to the fields of patent applications, the data showed some interesting results. There are some variations across different industries and across different periods of time. For example, in the United States we noted a change in the percentage of computers technology’s patent applications across time. But does this mean that, between 1980 and 1994, the industry of medical technology was more innovative than the computer technology one and that, after 1995, computer technology become more innovative than medical technology? The answer to this question is not linear. The explanation for this increase in patent applications for computer technology is simply due to the exponential development of this industry.

The data used from Cohen, Nelson and Walsh's (2000) surveys, allow to demonstrate the firms' perspective, regarding the use of patents for protection of their innovations.

Patent protection is especially important for small companies and new entrants that do not have other means to protect their innovations nor the resources to commercialize the innovation; so their only objective is to earn the profits through licensing. Although in cases where the investment in R&D is too high, small companies and new entrants cannot compete with the larger companies.

The data also showed that, for large companies, the use of a patent is not always their first choice of mechanism to protect the profits of their innovations, but this does not mean that they do not use patent protection completely. They can use different methods of appropriation in the different stages of the innovation process. For example, the companies can use secrecy and lead-time advantages in the first stages of the invention, while in the final stages of the development of the innovation, they use patent protection, in order to protect it from copy by rivals.

Certainly, when other methods of appropriation are used, the diffusion of information required by the patent application does not exist, which reduces the amount of knowledge available to the public. Thus, methods as trade secrets and lead-time advantages are not expected to raise the diffusion of technology considerably.

Nevertheless, these results are not entirely conclusive; there are some significant limitations to this study that need to be taken into consideration.

First, the number of patent applications provides an imperfect measure of innovative output, since not all innovations are patented. As we could see above, companies, in particularly the larger ones, have other methods to collect the profits of their innovations.

Second, not all patent filed have the approval of the patent offices and are conceded with a grant. And not all granted patents last until the patent protection ends, some proved to be solely redundant invention, and others are only used to block rivals to enter the market.

In addition, the relation between innovation and patent protection is not direct, since it takes some years after the policies are implemented for us to see some results in the level of innovation.

Another limitation of this study is that it does not take into account the costs of the patent system, not only in the optic of the firms but also in the economy, in general. Regarding the firms we need to take into account the risk's cost of the disclosure of the information since there is no guarantee that the innovation will be conceded with a patent grant, also for the invention to be protected is necessary that the company pays the fees to the patent office.

As concerns to the costs of the patent system for the economy, it is easy to see that it is not cheap to sustain a patent system, for the countries. The costs of implementation the patent office, the costs of hire specialists, the analysis and the tests that must be done to verify if an innovation can be granted with a patent grant also have a cost, the costs of the appeals, just to mention some. Therefore, for less developed countries the costs of a patent system can overlap its benefits, but in some cases, these costs are a necessary condition to attract foreign investment to the country.

Further, although this thesis demonstrates a positive relation between stronger patent protection and the level of innovation, I cannot prove that without a patent system the level of innovation would decrease, since I do not have data for the case of an economy with no patent system.

With respect to the surveys used to demonstrate the firm's perspective, they were only conducted in the United States during a short period of time, therefore they possibly do not translate the European reality, especially if we take into account that the American patent system is different from the European one, and not directly compared.

Finally, none of the data used in this study was generated by me, but was instead collected from third-party sources such as the World Bank, the World Intellectual Property Organization and research papers. While this allows the study to refrain from any potential bias, it limits the ability to reconstruct any missing data. For example, regarding the analysis of the expenditure in R&D, as a percentage of GDP, the lack of data does not allow to do a 'fair' comparison, since the data collected just back from 1996. Also, the missing data concerning the number of patents in force does not allow us to analyze the ratio between the number of patent applications and the number of patents that last until the end of the patent protection (20 years). Such an analysis would be essential in order to conduct an accurate re-evaluation of the patent system.

It is also important to interpret these data with caution, since the EPO includes 38 member states, including countries such as Turkey.

I further believe it would be important to analyze the different industries in the patent system and the duration of the patent protection for each of them, since it is not clear that the "one size fits all" principle of the current patent system is the most suitable to attain its fundamental goal: the promotion of innovation. Is it reasonable to assume that the pharmaceutical industry and the audio-visual technology industry share the same characteristics? Or that the industry for medical instruments and the semiconductors' industry are guided by the same purpose? It is hard for me to believe so. And I am not only considering the existing differences in the technology and economic cycles of each industry. It is also important not to forget that in the case of the pharmaceuticals the effective duration of the patent grant is much lesser when compared with the other industries, since it is necessary, in addition to the approval of the patent office, the approval of the national health authorities.

Moreover, the other methods of intellectual property protection were missed in this study, it would be interesting to do a similar analysis for each of them individually, but also for all of them to understand if, this positive effect registered in patents and innovation, also is registered if we count all the different types of intellectual property.

6. References

Acemoglu, Daron and Ufuk Akcigit (2011), "Intellectual property rights policy, competition and innovation*", Journal of the European Economic Association*, Vol. 10, No. 1, pages 1-42.

Amable, Bruno, Lilas Demmou and Ivan Ledezma (2010), "Product market regulation, innovation, and distance to frontier", *Industrial and Corporate Change*, Oxford University Press, Vol. 19, No.1, pages 117-159.

Anton, James J. and Dennis A. Yao (2004), "Little patents and big secrets: managing intellectual property", *The RAND Journal of Economics*, Wiley, Vol. 35, No.1, pages 1-22.

Arora, Ashish, Marco Ceccagnoli and Wesley M. Cohen (2003), "R&D and the patent premium", *NBER Working Papers*, National Bureau of Economic Research, No. 9431.

Arrow, Kenneth (1962), "Economic welfare and the allocation of resources for invention", *NBER Chapters*, in: The Rate and Direction of Inventive Activity: Economic and Social Factors, pages 609-626 National Bureau of Economic Research, Inc.

Arundel, Anthony (2000), "Patents – the Viagra of innovation policy?", Internal Report to the Expert Group, MERIT 2000.

Arundel, Anthony (2001), "Patents in the knowledge-based economy", *Beleidstudies Technology Economies*, Vol. 37, pages 67-88.

Baker, Scott, Pak Yee Lee and Claudio Mezzetti (2011), "Intellectual property disclosure as threat", *International Journal of Economic Theory*, The International Society for Economic Theory, Vol. 7(1), pages 21-38,03.

Baldwin, J. R., P. Hanel and D. Sabourin (2000), "Determinants of innovative activity in Canadian manufacturing firms: The role of intellectual property rights", Statistics Canada Working Paper No. 122.

Barzel, Yoram (1968), "Optimal timing of innovations", *Review Economics and Statistics*, Vol.50.

BERR (2008), "Regulation and innovation: evidence and policy implications", *Economics paper No.4*.

Besen, Stanley M. and Leo J. Raskind (1991), "An introduction to the law and economics of intellectual property", *The Journal of Economic Perspectives*, Vol. 5, No. 1, pages 3-27.

Bessen, James and Eric Maskin (2000), "Sequential innovation, patents and imitation", Departments of Economics, MIT working paper No. 00-01.

Boldrin, Michele and David K. Levine (2009), "Market size and intellectual property protection*", International Economic Review*, Department of Economics, University of Pennsylvania and Osaka University Institute of Social and Economic Research Association, Vol.50, No.3, pages 855-881.

Boldrin, Michele and David K. Levine (2013),"The case against patents", Journal of Economic Perspectives, American Economic Association, Vol. 27, No. 1, pages 3-22.

Breitwieser, Anja and Neil Foster (2012), "Intellectual property rights, innovation and technology transfer: a survey", *MPRA Paper*, University Library of Munich, No. 36094.

Chen, Y. and T. Puttitanum (2005), "Intellectual property rights and innovation in developing countries", Journal of Development Economics, Vol.78, pages 474-493.

Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", *NBER Working Papers*, National Bureau of Economic Research, No. 7552.

Denicolo, Vincenzo (2007), "Do patents over-compensate innovators?", *Economic Policy*, Vol. 22, pages 679-729.

Falk, M. (2006), "What drives business R&D intensity across OECD countries?", *Applied Economics*, Vol. 38, pages 533-547.

Fisher, William W. (2001), "Intellectual property and innovation: Theoretical, empirical, and historical perspectives*", Industrial Property, Innovation, and the Knowledge-based Economy*, Beleidsstudies Technologie Economie, Vol. 37.

Gallini, Nancy (1992), "Patent policy and costly imitation", *RAND Journal of Economics*, Vol. 23, No.1, pages 52-63.

Gallini, Nancy and Suzanne Scotchmer (2002), "Intellectual property: when is it the best incentive system?", *Law and Economics*, EconWPA.

Hall, Bronwyn H. (2003), "Business method patents, innovation, and policy", NBER Working Papers, National Bureau of Economic Research, No. 9717.

Hall, Bronwyn H. and Christian Helmers (2010), "The role of patent protection in (clean/green) technology transfer*", NBER Working Papers*, National Bureau of Economic Research, No. 16323.

Horowitz, Andrew W. and Edwin L. C. Lai (1996), "Patent length and the rate of innovation", *International Economic Review*, Vol. 37, pages 785-801.

Horstmann, Ignatius J., Glenn M. Macdonald and Alan Slivinski (1985), "Patents as information transfer mechanisms: To patent or (maybe) not patent", *Journal of Political Economy*, University of Chicago Press, Vol. 93, No. 5, pages 837-858.

Hovenkamp, Herbert J. (2011), "Antitrust and Innovation: Where we are and where we should be going", *Antitrust Law Journal*, Vol. 77.

Hovenkamp, Herbert J. and Chrisitina Bohannan (2010), "IP and antitrust: Reformation and Harm", *Boston College Review*, Vol. 51.

Jain, Subhash C. (1996), "Problems in international protection of intellectual property rights", *Journal of International Marketing*, American Marketing Association, Vol. 4, No. 1, pages 9-32.

Kamien, Morton I. and Nancy L. Schwartz (1974), "Patent length and R&D rivalry", *American Economic Review*, Vol. 64, pages 183-187.

Kanwar, S. and R. Evenson (2003), "Does intellectual property protection spur technological change?", Oxford Economic Papers, Vol. 55, pages 235-264.

Klemperer, Paul (1990), "How broad should the scope of patent protection be?", *RAND Journal of Economics*, Vol. 21, pages 113-130.

Kortum, Samuel and Josh Lerner (1998), "Stronger protection or technological revolution: What is behind the recent surge in patenting?", *Carnegie-Rochester Conference Series on Public Policy* 48.

Krasteva, Silvana (2012), "Imperfect patent protection and innovation", Department of Economics Texas A&M University.

Lederman, D. and W. F. Manoley (2003), "R&D and development", World Bank Policy Research Working Paper No. 3024.

Lerner, Josh (2002), "Patent protection and innovation over 150 years", *NBER Working Papers*, National Bureau of Economic Research, No. 2002.

Lerner, Josh (2009), "The empirical impact of intellectual property rights on innovation: puzzles and clues", *The American Economic Review*, American Economic Association, Vol. 99, No.2, pages 343-348.

Levin, R. C., A. K. Klevorick, R. R. Nelson and S.G. Winter (1987), "Appropriating the returns from industrial research and development", *Brookings Papers on Economic Activity*, Vol. 3, pages 783-831.

Mansfield, Edwin. "Intellectual property, technology and economic growth", in *Intellectual Property Rights in Science, Technology, and Economic Performance*, edited by F.W. Rushing and C. G. Brown, 17-30. Boulder, CO: Westview Press, 1990.

Mansfield, Edwin (1986), "Patents and innovation: an empirical study, *Management Science*, No. 32, pages 173-181.

Mansfield, Edwin, Mark Schwartz and Samuel Wagner (1981), "Imitations costs and patents: An empirical study", *Economic Journal* No. 91.

Maskus, Keith E. (1998), "The international regulation of intellectual property", *Journal Weltwirtschaftliches*, Vol. 134, pages 186-208.

Maurer, Stephen M. and Suzanne Scotchmer (2002), "The independent invention defense in intellectual property", *Economica* 535.

Mazzoleni, R. and R. R. Nelson (1998), "Economic theories about the benefits and costs of patents", *Journal of Economic Issues*, Vol. 32, No. 4, pages 1031-1052.

Merger R. P. and R. R. Nelson (1990), "On the complex economics of patent scope*", Columbia Law Review*, Vol. 90, No. 4, pages 839-916.

Moser, Petra (2005), "How do patent laws influence innovation? Evidence from nineteenth-century world's fairs", *The American Review*, American Economic Association, Vol. 95, No. 4.

Motta, Massimo (2004), *Competition Policy: Theory and Practice*, Cambridge University Press.

Nicholas, Tom (2003), "Why Schumpeter was right: innovation, market power and creative destruction in 1920s", *The Journal of Economic History*, Vol. 63, No.4, pages 1023-1058.

Nordhaus, William D. (1969), "Invention, growth and economic welfare: A theoretical treatment of technological change", Cambridge, MA: MIT Press

OECD (2004), *Patents and innovation: Trends and policy challenges*.

Pakes, Ariel (1985), "Patents, R&D, and the stock market rate of return", *Journal of Political Economy*, Vol. 93, pages 390-409.

Park, Walter G. (2008), "International Patent Protection", Research Policy, Elsevier, Vol. 37, No. 4, pages 761-766.

Park, Walter G. and J. Ginarte (1997), "Intellectual property rights and economic growth", *Contemporary Economic Policy*, Vol. 15, pages 51-61.

Property Rights Alliance (2011), 2012 Report International Property Rights Index, a study conducted by Gaurav Tiwari.

Sakakibara, Mariko and Lee Branstetter (1999), "Do stronger patents induce more innovation? Evidence from the 1988 Japanese Patent Law Reforms", NBER Working Paper No. 7066.

Schankerman, M. and A. Pakes (1984), "Estimates of the value of patent rights in European countries during the post 1950 period", National Bureau of Economic Research Working Paper No. 1650.

Scherer, F. M., "Schumpeter and plausible capitalism", *Journal of Economic Literature*, Vol.1416, page 30.

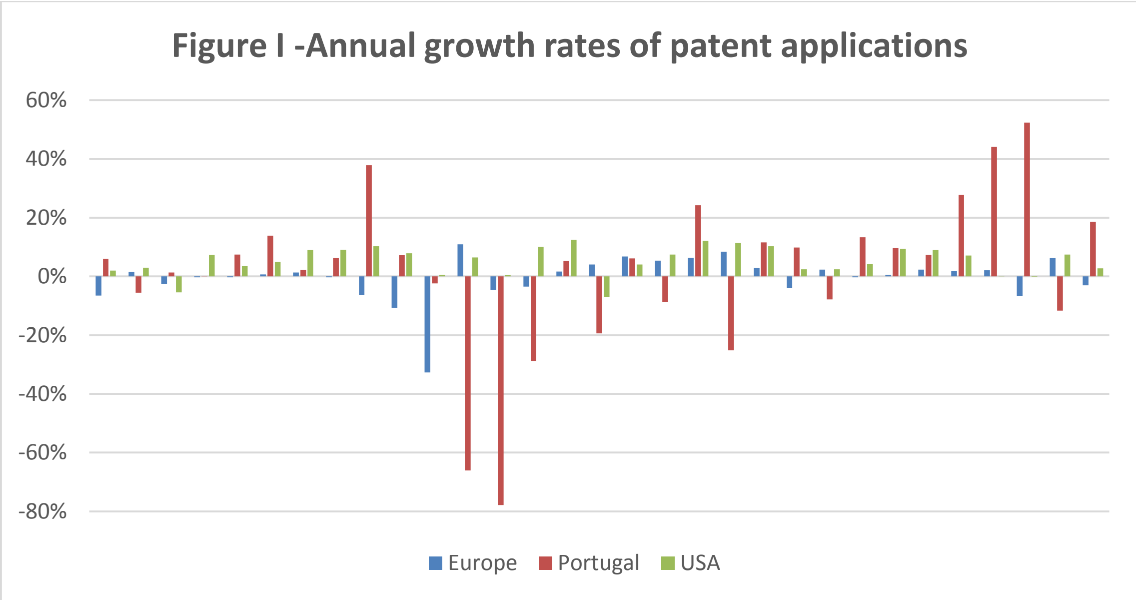
Schumpeter, J. (1943), *Capitalism, socialism and democracy*, London: Unwin University Books.

Shapiro, Carl and Richard Gilbert (1990), "Optimal Patent Length and Breadth", *The RAND Journal of Economics*, Wiley, Vol.21, No. 1, pages 106-112.

7. Appendices

In this section there is additional data that can be important to understand the relation between patent protection and innovation, and also to study the evolution of the patent system in Europe, Portugal and the United States of America.

Appendix I: Annual growth rates of patent applications



Appendix II: Tables of resident and non resident patent applications and grants

Table I – Total number of residente and non residente patente applications in Europe (1980-2011)								
Year	Total Patent application	Patent application resident	Patent application non resident	% of non resident patent application	Total patent grants	Patent grants resident	Patent grants non resident	% of non resident patent grants
1980	414756	279743	135013	32.55%	251059	147448	103611	41.27%
1981	366280	256928	109352	29.85%	228975	144362	84613	36.95%
1982	371218	270372	100846	27.17%	243333	139679	103654	42.60%
1983	370243	267494	102749	27.75%	220789	126053	94736	42.91%
1984	352076	265495	86581	24.59%	221016	120972	100044	45.27%
1985	361325	276554	84771	23.46%	202038	126266	75772	37.50%
1986	350692	278755	71937	20.51%	199322	129670	69652	34.94%
1987	351182	288307	62875	17.90%	191817	134194	57623	30.04%
1988	355367	285368	69999	19.70%	182603	132719	49884	27.32%
1989	313493	253060	60433	19.28%	179170	132575	46595	26.01%
1990	268951	210135	58816	21.87%	166962	127420	39542	23.68%
1991	208949	137277	71672	34.30%	98881	52706	46175	46.70%
1992	240442	163671	76771	31.93%	113226	62015	51211	45.23%
1993	227584	161394	66190	29.08%	121874	67769	54105	44.39%
1994	217146	151905	65241	30.04%	146177	85917	60260	41.22%
1995	208986	140780	68206	32.64%	141055	83371	57684	40.89%
1996	247154	162186	84968	34.38%	136035	85565	50470	37.10%
1997	254684	160410	94274	37.02%	145346	93891	51455	35.40%
1998	268959	170448	98511	36.63%	131644	81997	49647	37.71%
1999	295780	189771	106009	35.84%	126187	78066	48121	38.13%
2000	320733	203208	117525	36.64%	116434	73686	42748	36.71%
2001	320455	198586	121869	38.03%	123277	79797	43480	35.27%
2002	307139	188017	119122	38.78%	130970	84435	46535	35.53%
2003	314752	193351	121401	38.57%	158731	102181	56550	35.63%
2004	313693	196989	116704	37.20%	144258	89785	54473	37.76%
2005	316003	197443	118560	37.52%	141176	88083	53093	37.61%
2006	321701	203107	118594	36.86%	154900	96070	58830	37.98%
2007	338685	215923	122762	36.25%	145112	90512	54600	37.63%
2008	345874	220390	125484	36.28%	156884	99636	57248	36.49%
2009	323054	212873	110181	34.11%	164347	108083	56264	34.23%
2010	342822	221798	121024	35.30%	159684	103173	56511	35.39%
2011	332787	215220	117567	35.33%	151985	94012	57973	38.14%

Source: WIPO statistics database.

Table II – Total number of residente and non residente patente applications in Portugal (1980-2011)								
Year	Total Patent application	Patent application resident	Patent application non resident	% of non resident patent application	Total patent grants	Patent grants resident	Patent grants non resident	% of non resident patent grants
1980	1823	92	1731	94.95%	2295	95	2200	95.86%
1981	1933	90	1843	95.34%	1588	48	1540	96.98%
1982	1826	92	1734	94.96%	1213	9	1204	99.26%
1983	1851	91	1760	95.08%	1200	20	1180	98.33%
1984	1852	96	1756	94.82%	637	60	577	90.58%
1985	1991	85	1906	95.73%	960	42	918	95.63%
1986	2268	77	2191	96.60%	4037	202	3835	95.00%
1987	2319	61	2258	97.37%	1724	22	1702	98.72%
1988	2464	54	2410	97.81%	929	10	919	98.92%
1989	3397	86	3311	97.47%	1236	6	1230	99.51%
1990	3642	101	3541	97.23%	563	26	537	95.38%
1991	3555	102	3453	97.13%	453	15	438	96.69%
1992	1207	69	1138	94.28%	1253	19	1234	98.48%
1993	268	88	180	67.16%	1673	8	1665	99.52%
1994	191	103	88	46.07%	1371	50	1321	96.35%
1995	201	81	120	59.70%	960	22	938	97.71%
1996	162	86	76	46.91%	542	18	524	96.68%
1997	172	71	101	58.72%	643	27	616	95.80%
1998	157	96	61	38.85%	1801	54	1747	97.00%
1999	195	81	114	58.46%	983	82	901	91.66%
2000	146	81	65	44.52%	139	43	96	69.06%
2001	163	107	56	34.36%	194	44	150	77.32%
2002	179	130	49	27.37%	50		50	100.00%
2003	165	125	40	24.24%	221	88	133	60.18%
2004	187	123	64	34.22%	204	104	100	49.02%
2005	205	158	47	22.93%	231	145	86	37.23%
2006	220	184	36	16.36%	125	97	28	22.40%
2007	281	250	31	11.03%	187	145	42	22.46%
2008	405	381	24	5.93%	165	132	33	20.00%
2009	617	571	46	7.46%	146	125	21	14.38%
2010	545	499	46	8.44%	140	121	19	13.57%
2011	646	571	75	11.61%	145	96	49	33.79%

Source: WIPO statistics database.

Table III – Total number of residente and non residente patente applications in U.S.A. (1980-2011)									
Year	Total Patent application	Patent application resident	Patent application non resident	% of non resident patent application	Total patent grants	Patent grants resident	Patent grants non resident	% of non resident patent grants
1980	104329	62098	42231	40.48%	61827	37152	24675	39.91%
1981	106413	62404	44009	41.36%	65770	39225	26545	40.36%
1982	109625	63316	46309	42.24%	57889	33896	23993	41.45%
1983	103703	59391	44312	42.73%	56862	32872	23990	42.19%
1984	111284	61841	49443	44.43%	67201	38364	28837	42.91%
1985	115235	63673	51562	44.75%	71661	39554	32107	44.80%
1986	120916	65195	55721	46.08%	70860	38124	32736	46.20%
1987	131837	68315	63522	48.18%	82952	43518	39434	47.54%
1988	143836	75192	68644	47.72%	77924	40497	37427	48.03%
1989	158707	82370	76337	48.10%	95539	50185	45354	47.47%
1990	171163	90643	80520	47.04%	90366	47393	42973	47.55%
1991	172115	87955	84160	48.90%	96514	51184	45330	46.97%
1992	183347	92425	90922	49.59%	97443	52254	45189	46.37%
1993	184196	99955	84241	45.73%	98344	53236	45108	45.87%
1994	202755	107233	95522	47.11%	101676	56067	45609	44.86%
1995	228142	123962	104180	45.66%	101419	55739	45680	45.04%
1996	211946	106892	105054	49.57%	109646	61104	48542	44.27%
1997	220496	119214	101282	45.93%	111984	61707	50277	44.90%
1998	236979	134733	102246	43.15%	147520	80292	67228	45.57%
1999	265763	149251	116512	43.84%	153487	83907	69580	45.33%
2000	295895	164795	131100	44.31%	157496	85071	72425	45.99%
2001	326471	177513	148958	45.63%	166038	87606	78432	47.24%
2002	334445	184245	150200	44.91%	163518	86976	76542	46.81%
2003	342441	188941	153500	44.83%	169035	87901	81134	48.00%
2004	356943	189536	167407	46.90%	164291	84271	80020	48.71%
2005	390733	207867	182866	46.80%	143806	74637	69169	48.10%
2006	425966	221784	204182	47.93%	173770	89823	83947	48.31%
2007	456154	241347	214807	47.09%	157283	79527	77756	49.44%
2008	456321	231588	224733	49.25%	157772	77501	80271	50.88%
2009	456106	224912	231194	50.69%	167349	82382	84967	50.77%
2010	490226	241977	248249	50.64%	119614	107792	11822	9.88%
2011	503582	247750	255832	50.80%	224505	108626	115879	51.62%

Source: WIPO statistics database.

Appendix III: Total of patent grants by technology

Table IV - Patent grants by technology in Europe (1980-2011)

Technology	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1 - Electrical machinery, apparatus, energy	13951	14670	14726	13369	12647	14521	13513	12302	11052	9997	9514	9784	9054	8131	8059	8609	7042	7738	6534	6187	5347	5587	6514	7300	7232	7197	7827	7434	7505	6784	7434	7164
2 - Audio-visual technology	4120	4216	4765	4243	4400	5715	5238	4564	3971	3991	3941	3853	3834	3403	4031	4006	3501	3629	3469	3377	2800	2950	3466	3779	3527	3426	3938	3391	3466	3193	3183	3224
3 - Telecommunications	2744	2781	3133	2696	2804	3669	3151	3041	2675	2506	2444	2387	2455	2508	2637	2755	2445	2822	2882	2876	2503	2720	3167	3979	4283	4310	4738	4052	3885	3169	3092	3121
4 - Digital communication	766	810	813	679	754	910	792	803	678	707	693	700	696	745	881	936	871	1000	1106	1151	1185	1311	1668	2390	2960	3727	4035	3923	3934	3744	3989	4524
5 - Basic communication processes	4445	4396	4508	3747	3484	4213	4167	3682	3301	3111	2782	2957	2555	1933	1744	1644	1448	1526	1421	1104	1004	1255	1302	1623	1465	1495	1655	1395	1419	1221	1212	1259
6 - Computer technology	4525	4506	4692	3781	3848	4526	4931	4801	4092	4011	3716	3928	3149	2702	2752	2815	2604	2880	2971	3040	2801	3318	3762	4900	4259	4558	4771	4337	4359	4073	4202	4622
7 - IT methods for management	31	31	36	33	41	55	50	33	40	42	35	46	40	34	45	53	53	89	96	127	134	177	259	333	325	366	301	291	295	242	235	253
8 - Semiconductors	1431	1255	1587	1601	1453	2078	1915	1698	1478	1591	1565	1430	1421	1653	1978	1971	1871	1850	1656	1482	1230	1517	1870	1871	1717	1963	2428	2495	2319	2124	2194	2474
9 - Optics	4006	3854	4705	4213	3919	5042	4555	3921	3256	3366	3195	3294	3154	3455	4020	3922	3399	3673	3306	2740	2261	2500	2933	3321	2982	2867	3258	2817	2822	2444	2348	2505
10 - Measurement	14010	16352	15072	14305	12783	15717	15678	14414	13772	13230	12814	14147	12648	9744	7510	7349	6048	6846	6045	4886	4588	4644	5783	6241	6358	7541	7434	7102	7208	7091	7168	6913
11 - Analysis of biological materials	809	979	905	944	950	1294	1213	1100	1136	1191	1133	1315	1370	1114	1016	921	920	978	956	890	794	721	992	1176	1202	1171	1322	1260	1361	1312	1318	1404
12 - Control	4040	4402	4304	3853	3540	4158	4189	3945	3506	3317	3032	3093	2797	2330	2219	2248	2038	2175	2153	1988	1746	1841	2081	2518	2548	2412	2702	2365	2396	2098	2125	2117
13 - Medical technology	3762	4266	4942	4580	4952	5861	5864	5191	5002	5478	5277	5959	5800	5564	4892	5271	5145	5949	5738	5498	4747	4283	5730	7816	7993	7823	7639	7166	7541	7984	7681	7771
14 - Organic fine chemistry	12493	11408	11413	11522	11988	12520	12348	9584	8204	7739	7044	6641	6201	6121	6478	7105	5681	5605	4967	4746	3954	4715	5172	6117	5581	4768	5015	4920	5125	4620	4629	4598
15 - Biotechnology	1587	1523	1708	1943	2174	2398	2475	2152	2058	2052	2256	2193	2277	2297	2386	2727	2102	2184	1882	1727	1459	1544	1841	2958	2978	3150	3282	2526	2736	2683	2922	2987
16 - Pharmaceuticals	4360	4285	4334	4769	5298	5406	6097	4739	4242	3982	3870	3869	4169	4542	4678	5507	4423	4703	4240	4134	3693	3995	5064	6084	5755	5525	5706	5753	6126	5842	5521	5474
17 - Macromolecular chemistry, polymers	6017	5271	5277	5027	4403	5784	5060	4153	3399	3302	3141	3115	3091	3051	3236	3282	3153	3324	2817	2666	1903	2085	2320	2735	2867	2483	2562	2089	2215	2072	2107	2273
18 - Food chemistry	2227	2323	2344	2109	2184	2665	2465	2212	1958	2034	2122	2220	2574	2266	1805	2261	1932	2269	1905	2019	1788	2002	1997	2949	2362	3045	2927	3085	3777	6096	5047	5216
19 - Basic materials chemistry	7590	7341	7675	7452	7345	8511	8069	6771	5669	5395	5219	5133	5102	4750	4592	4922	4106	4337	4137	3833	3096	3271	3712	4512	4348	3794	3801	3435	3287	3157	3306	3448
20 - Materials, metallurgy	9911	10998	10924	9504	8469	9878	9595	8484	7622	7075	6969	7576	7569	5878	5147	5486	4254	4713	4016	3420	3106	3201	3402	3913	3704	3570	3290	3807	4434	4003	3456	3659
21 - Surface technology, coating	3487	3485	3863	3601	3221	4104	3914	3468	2871	2913	2824	2884	2689	2570	2318	2519	2213	2317	2120	1890	1520	1703	1952	2244	2201	2004	2162	2039	1977	1950	2013	2110
22 - Micro-structural and nano-technology	1				1	2	2	1	2	2	2	2	3	5	4	19	15	24	17	26	21	27	42	50	84	109	148	191	215	266	304	390
23 - Chemical engineering	9349	10074	10557	9476	8485	10395	10085	8675	8047	8085	7920	8017	8022	6438	5527	6352	4995	5244	4739	4214	3386	3760	4188	4779	4476	4152	4145	3960	3932	3731	3633	3631
24 - Environmental technology	3177	3379	3630	3110	2938	3480	3306	3107	2883	2882	3076	3211	3211	2549	2447	2631	2354	2685	2431	2126	1731	1821	2188	2313	2249	2202	2358	2248	2199	1990	2236	2225
25 - Handling	10040	10092	10589	9284	9038	11754	11553	10620	9529	9516	8827	8548	7906	6387	5642	6004	5560	5941	5266	4623	3749	3963	4772	5652	5532	4983	5442	4852	5023	4491	4886	4723
26 - Machine tools	13645	15986	15478	13818	11640	15398	15314	13995	12266	11706	10986	10847	10583	8995	6210	6118	5210	5544	4875	4191	3657	3687	4616	5277	5002	5437	5316	4904	5181	4997	4476	4395
27 - Engines, pumps, turbines	6102	6618	7560	6959	6254	8170	8124	7521	6202	5795	5862	5351	5573	5032	4916	5055	4344	4600	4651	4133	3306	3587	4518	5565	5480	6079	6441	5497	5468	5083	5396	5312
28 - Textile and paper machines	7243	6759	7312	6876	6268	8498	7891	7044	5879	5537	5252	5067	4793	4411	4360	4559	4166	4563	3972	3602	2744	3065	3605	3946	3623	3186	3703	3276	3316	2927	2982	2933
29 - Other special machines	10536	12101	12896	12038	10673	13198	12536	11615	10932	11141	10506	10990	10657	8659	6898	7490	6322	7051	6491	5740	5001	5228	6147	7153	6953	6413	6431	6188	6390	5770	5511	5437
30 - Thermal processes and apparatus	5159	5785	6186	5570	5236	6245	6136	5399	4666	4751	4311	4025	3870	3154	2667	2940	2553	2720	2611	2432	2127	2298	2493	2712	2680	2566	3013	2369	2312	2273	2132	2147
31 - Mechanical elements	9372	10132	10572	9547	8977	12084	12072	10633	9076	9351	8836	8177	8126	7079	6220	6656	5427	5978	5722	5226	4695	4985	5683	6546	6754	6845	7502	6100	6187	5724	5809	5852
32 - Transport	8514	8347	8621	8858	8171	10236	10300	9516	8200	8311	8112	7627	7830	7061	7084	7933	6696	7784	7156	6525	6120	6458	7527	8600	9310	10539	11465	9931	10501	10151	10434	9530
33 - Furniture, games	3006	2954	3227	2999	2949	4108	3882	3399	3101	3300	3354	3386	3424	3119	3168	3364	3072	3140	3270	2892	2613	2638	2928	3604	3570	3424	3310	3153	3293	3143	3265	3011
34 - Other consumer goods	3418	3231	3830	3468	3480	4641	4461	4022	3514	3230	3260	3154	3240	2806	2878	3082	2854	3023	2854	2612	2284	2424	2733	3096	3010	2911	3042	2919	2846	2977	2892	3378
35 - Civil engineering	12387	14296	15491	13592	11934	13873	13792	11976	11374	11842	11869	12539	12156	9782	7499	8289	7799	8182	7567	6781	5913	6364	7056	8061	8105	8053	8164	7324	7688	7453	7273	6967

Source: WIPO statistics database.

Table V - Patent grant by technology in Portugal (1980-2011)

Technology	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1 - Electrical machinery, apparatus, energy	3	19	40	44	21	21	90	18	3	27	18	3	27	47	48	48	14	7	50	52	8	4	3	8	5	1	2	8	6	5	9	2
2 - Audio-visual technology		9	24	18	6	8	56	16	1	10	1	1	10	18	19	32	6	6	25	22	1	1		7	2			2	4		2	1
3 - Telecommunications	1	14	23	12	7	7	37	4		8	2	1	16	21	14	28	4	8	20	12	9	3	2	4	1			4	2	4	2	
4 - Digital communication		4	1	1		3	12	4		1			4	2	6	9	4	4	9	7	2	1	1	2	3		1	2	1		3	3
5 - Basic communication processes		3	10	6	4	2	20	4		3			4	5	2	10	2	2	5	7		1		1	1			2		1	1	
6 - Computer technology		6	9	6	4	1	17	9		2	1		5	8	10	15	3	1	11	8	1			3			1	4	4	2	7	2
7 - IT methods for management													2							1							1	2	2		1	
8 - Semiconductors		1	3	2	3	2	6		1	1			4	2		4		7	1					1				1	2	1		2
9 - Optics		2	4	6	4	6	35	5	1	4	3		5	11	9	11	4	3	14	7	2	2		2	4	1	2	4	1	4	2	3
10 - Measurement		12	17	21	10	9	45	9	4	14	1	7	18	35	23	34	10	2	20	13	6	4	2	5	10	3	2	7	12	5	10	8
11 - Analysis of biological materials	1	4	3	7		4	13	11	11	15	16	1	14	9	12	15	4	7	16	17	1	2			2			2	1	3	4	
12 - Control	1	8	8	6	11	2	22	5	1	4	1	1	7	10	10	9	3	2	14	17	3			4	4		1	6	3	2	8	3
13 - Medical technology	3	10	23	31	13	23	94	32	6	31	20	3	34	62	36	69	24	27	71	68	5	9	4	4	2	2	2	8	4	8	9	4
14 - Organic fine chemistry	37	164	225	254	104	190	690	389	298	285	234	32	241	113	196	300	90	128	186	244	15	16	6	8	9	1	4	4	7	9	6	7
15 - Biotechnology	4	16	32	32	11	32	114	77	82	83	92	9	75	47	59	96	30	63	91	99	1	8	6	7	6	1		5	3	3	4	3
16 - Pharmaceuticals	24	84	122	160	59	109	449	275	256	242	237	26	234	122	186	296	96	152	221	270	11	16	10	11	10	3		2	8	6	2	5
17 - Macromolecular chemistry, polymers	2	18	37	27	20	27	110	69	47	49	38	6	59	33	35	53	21	20	53	46	3	9	1	2	2			1	1	2	1	1
18 - Food chemistry	1	11	21	17	9	18	85	37	30	25	38	4	29	30	30	44	13	29	43	34	5	13	1	5	5	1	2	7	10	6	1	3
19 - Basic materials chemistry	12	65	95	98	47	90	279	145	93	93	83	12	65	41	63	79	37	41	56	96	5	10	8	4	2		2	6	9	2	2	4
20 - Materials, metallurgy	2	23	52	34	14	25	103	49	22	24	39	9	45	36	34	59	15	18	28	35	5	7	3	2	4	5		10	5	4	4	3
21 - Surface technology, coating	1	11	26	21	12	13	63	23	8	8	9	1	18	19	16	20	11	16	14	28	2	3		1	2	1	1	1		3	3	1
22 - Micro-structural and nano-technology																1													1	2	1	2
23 - Chemical engineering	2	34	46	35	22	29	96	48	23	30	31	4	42	63	43	48	20	27	43	38	7	7	4	4	11	3	1	4	6	5	3	7
24 - Environmental technology		7	14	17	10	10	35	15	7	10	4	1	16	35	16	24	8	5	14	23	2	4	3	4	6	2		11	7	1	5	1
25 - Handling	2	15	50	64	18	26	139	39	7	23	6	8	35	84	66	55	17	20	44	51	5	4	2	6	4	3	1	8	3	5	6	6
26 - Machine tools	2	9	21	34	15	15	75	21	8	10	8	4	29	38	30	38	12	9	32	32	12	7	1	3	1	3	1	12	3	5	3	4
27 - Engines, pumps, turbines	2	7	24	27	20	9	38	8		6	2	1	12	13	15	22	5	8	5	12	4	1	2	1	4	3	1	4	10	10	6	4
28 - Textile and paper machines	2	14	35	31	15	26	105	34	17	22	20	3	39	48	42	57	13	26	44	56	4	8		4	11	1	1	4	3	1	3	3
29 - Other special machines	1	32	57	53	51	44	199	60	16	36	23	13	55	109	83	71	25	37	58	63	10	9	2	3	13	4	4	14	7	7	5	5
30 - Thermal processes and apparatus	1	15	34	25	6	12	61	14	3	7	2	1	14	24	27	16	6	8	19	25	7	3	3	5	4		1	4	7	1	3	2
31 - Mechanical elements		13	43	20	21	11	76	28		11		3	18	54	33	41	11	9	32	28	4	3	1	3	8	2		5	2	5	2	4
32 - Transport	2	19	41	37	20	17	93	23		8	2	5	20	36	25	28	6	13	24	27	10	6	6	13	12	2	1	11	3	5	5	4
33 - Furniture, games	2	5	31	27	18	16	90	19	1	7	4		20	46	29	31	10	12	24	19	4	3	1	5	2	3	1	7	4	10	4	5
34 - Other consumer goods	1	11	23	14	16	20	75	16	3	14	12	4	17	28	31	29	9	5	17	20	4	6	1	1	2	1		5	9	3	2	
35 - Civil engineering	1	21	46	48	36	15	122	28		21	8	5	27	68	56	59	23	20	49	45	12	11	9	5	10	8	5	29	17	18	14	12
Total	**110**	**686**	**1240**	**1235**	**627**	**842**	**3544**	**1534**	**949**	**1134**	**955**	**168**	**1260**	**1317**	**1304**	**1751**	**556**	**742**	**1353**	**1522**	**170**	**181**	**82**	**138**	**162**	**54**	**38**	**206**	**167**	**148**	**143**	**114**

Source: WIPO Statistcs Database

Table VI - Patent grant by technology in USA (1980-2011)

Technology	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1 - Electrical machinery, apparatus, energy	3818	4111	4065	3874	4566	4661	4406	5585	4935	5647	5281	5417
2 - Audio-visual technology	1700	1729	1854	1983	2183	2673	2830	3822	3487	4330	3622	4186
3 - Telecommunications	983	995	1001	962	1142	1336	1383	1788	1734	2129	1981	2018
4 - Digital communication	185	216	242	233	292	366	418	503	471	636	545	616
5 - Basic communication processes	904	1022	1071	983	1146	1384	1395	1490	1314	1581	1440	1665
6 - Computer technology	957	1003	997	1085	1402	1441	1645	2123	2193	3070	2824	3040
7 - IT methods for management	26	21	29	24	24	37	34	46	51	77	70	71
8 - Semiconductors	858	898	866	970	1074	1300	1471	1822	1721	2252	2388	2966
9 - Optics	2515	2834	2385	2379	2779	2959	2976	3708	3845	4758	4762	5171
10 - Measurement	3254	3430	3117	2951	3694	3923	3932	4844	4276	5388	4903	5121
11 - Analysis of biological materials	289	345	303	246	318	286	314	414	415	551	454	464
12 - Control	1022	1094	999	931	1064	1225	1246	1493	1335	1760	1527	1584
13 - Medical technology	2026	2095	1838	1771	2201	2461	2862	3449	3200	4193	4159	4491
14 - Organic fine chemistry	3727	3972	3163	2808	3220	3382	3116	3210	3178	4014	4067	4128
15 - Biotechnology	496	575	542	511	583	574	616	864	834	1053	1061	1203
16 - Pharmaceuticals	900	972	914	834	1090	1058	1112	1347	1308	1851	1749	1887
17 - Macromolecular chemistry, polymers	2016	2347	1906	2062	2209	2382	1986	2206	2215	2652	2612	3060
18 - Food chemistry	668	724	641	670	656	830	689	803	983	1441	1077	1049
19 - Basic materials chemistry	2490	2801	2330	2519	2788	2751	2325	2502	2475	2953	2743	2997
20 - Materials, metallurgy	1879	1952	1657	1830	1909	1966	1925	1979	2003	2386	2166	2415
21 - Surface technology, coating	1114	1269	1106	1264	1392	1397	1326	1384	1276	1569	1634	1571
22 - Micro-structural and nano-technology	1			1	2	2	3	4	2	4	2	8
23 - Chemical engineering	2603	2712	2305	2192	2414	2537	2443	2650	2729	3225	3081	3108
24 - Environmental technology	968	1047	838	755	879	885	863	1009	994	1209	1179	1247
25 - Handling	2622	2576	2365	2239	2720	3114	3033	3363	3198	3828	3593	3861
26 - Machine tools	2522	2711	2257	2283	2808	3113	3220	3335	2966	3461	3216	3532
27 - Engines, pumps, turbines	2403	2489	2286	2548	3134	3081	2536	3160	2966	3227	3005	3180
28 - Textile and paper machines	1976	2167	1810	2075	2198	2502	2377	2521	2363	2828	2765	2911
29 - Other special machines	3349	3535	2974	2775	3307	3449	3312	3829	3818	4366	4271	4353
30 - Thermal processes and apparatus	1528	1794	1457	1473	1724	1608	1419	1452	1296	1457	1412	1368
31 - Mechanical elements	2752	2958	2448	2246	3031	3351	3355	3859	3321	4013	3686	3898
32 - Transport	2751	3003	2643	2452	3031	3034	3317	4239	4127	4850	4548	4774
33 - Furniture, games	2193	2004	1844	1551	1853	2126	2265	2591	2595	3334	3250	3484
34 - Other consumer goods	1850	1886	1581	1473	1720	2019	2038	2287	1996	2513	2544	2689
35 - Civil engineering	2656	2970	2429	2458	3158	2941	3152	3731	2951	3849	3472	3643
Total	62001	66257	58263	57411	67711	72154	71340	83412	78571	96455	91089	97176

Technology	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1 - Electrical machinery, apparatus, energy	5349	5213	5283	5462	6099	6342	8235	8876	9554	10066	10361	10405	10884	9303	11143	10302	10454	11382	14259	14116
2 - Audio-visual technology	4323	4526	4822	4996	5553	5610	7968	7782	8070	8426	8716	9240	9779	8264	10793	9532	9505	10060	12242	13150
3 - Telecommunications	2151	2395	2811	3075	3624	3254	5224	5788	5962	6118	6317	6536	7004	6453	9520	8167	8431	8979	11073	11790
4 - Digital communication	736	866	1096	1301	1636	1509	2513	2922	3365	3558	3937	4348	5329	5099	6496	5862	6598	7179	9178	9923
5 - Basic communication processes	1729	1534	1811	2006	2044	1983	2769	2852	3100	3361	3529	3637	3711	3359	4439	4390	4374	4446	5225	4866
6 - Computer technology	3381	4102	5062	5633	7143	7607	12088	12385	12159	13044	13071	13893	15059	14315	21832	20149	22214	25141	33739	35805
7 - IT methods for management	84	147	159	123	165	224	513	641	752	691	798	891	919	1161	1348	1312	1740	1977	3565	3608
8 - Semiconductors	3046	3350	4000	4120	4066	4555	6243	7760	9159	10789	11202	11338	11474	9989	10592	9832	9575	10677	14273	14272
9 - Optics	5108	5357	5384	5028	5704	5820	7870	7397	7501	7774	8068	8940	9438	8301	9440	8630	8923	9196	10791	10279
10 - Measurement	4983	4859	5210	5330	5585	5157	6499	6445	6887	7304	7972	8590	8433	7583	9030	8809	9155	9270	10776	10265
11 - Analysis of biological materials	594	671	621	612	727	876	1251	1152	1062	1205	1096	1079	1001	821	1065	1032	1050	1029	1462	1386
12 - Control	1576	1671	1726	1751	1897	1862	2519	2616	2733	2741	2719	2853	2986	2680	3639	3148	3327	3462	4447	4484
13 - Medical technology	4645	4730	5561	5492	5727	6039	8109	7876	8044	8175	8049	9082	7330	6094	6854	6144	5489	6263	10124	11221
14 - Organic fine chemistry	4252	4621	3845	4023	4017	4635	5067	5031	4732	4960	5299	4485	3684	3202	4166	3996	3913	4188	5263	5368
15 - Biotechnology	1521	1797	1590	1704	2307	3201	4541	4509	3876	4359	4019	3686	3292	2819	3278	3222	3002	3124	3995	4114
16 - Pharmaceuticals	1871	1892	1827	2066	2545	3356	3882	4231	3996	4421	4579	4246	3168	2835	3811	3410	3389	3656	5127	5085
17 - Macromolecular chemistry, polymers	3138	3265	3019	2610	2542	2470	2795	2764	2798	3044	3133	2952	2638	1922	2067	1747	1507	1648	2650	2599
18 - Food chemistry	1043	1151	1165	1117	1179	1163	1559	1736	1851	1826	2262	2015	2002	1438	1966	1862	1917	1813	2054	1918
19 - Basic materials chemistry	3004	2929	3008	2949	2949	2933	3500	3823	3546	3668	3544	3410	2975	2170	2405	2148	2022	2174	2983	3119
20 - Materials, metallurgy	2341	2327	2342	1959	1948	1885	2171	2336	2137	2415	2409	2329	2058	1607	1570	1413	1306	1519	2071	1971
21 - Surface technology, coating	1664	1683	1785	1835	1740	1765	2219	2445	2578	2738	2771	2756	2638	2096	2448	2491	2386	2561	4061	4519
22 - Micro-structural and nano-technology	7	14	20	35	46	51	64	76	103	133	171	247	300	262	218	151	120	103	109	79
23 - Chemical engineering	3375	3281	3189	3045	3061	3148	3667	3952	3702	3716	3605	3521	3123	2696	3074	2736	2837	2822	3837	4087
24 - Environmental technology	1368	1427	1357	1383	1401	1419	1774	1739	1719	1772	1698	1624	1503	1336	1449	1418	1504	1601	2105	1930
25 - Handling	3762	3579	3738	3539	3487	3324	4300	4527	4403	4419	4237	4099	3510	3140	3605	3128	3205	3322	4370	4407
26 - Machine tools	3389	3175	3099	2836	2987	3120	3850	4312	4514	4640	4179	4348	4077	3521	4359	3501	2891	2771	3645	4168
27 - Engines, pumps, turbines	3299	3205	2879	2691	2975	2874	3494	3426	4146	4884	4950	4996	4730	4265	4518	3801	3620	3437	4154	4247
28 - Textile and paper machines	3081	2889	2759	2906	3110	3104	3882	3920	4234	4455	4375	4159	4007	3227	3357	3025	3180	2949	3828	3800
29 - Other special machines	4486	4289	4278	4090	4064	4119	5078	5156	4952	5090	4979	5104	4560	3603	3890	3356	3083	3072	4621	4790
30 - Thermal processes and apparatus	1302	1394	1463	1272	1305	1226	1635	1734	1720	1835	1633	1578	1477	1437	1446	1157	968	968	1326	1280
31 - Mechanical elements	3752	3472	3493	3246	3571	3457	4360	4682	4887	4949	4979	4677	4305	3794	4254	3524	3287	3304	4341	4566
32 - Transport	4516	4568	4627	4547	5026	4688	6224	6381	7215	7799	7720	7364	6958	6389	6449	5756	5525	5343	6760	6414
33 - Furniture, games	3421	3169	3741	3637	3893	3800	4887	4895	4955	4650	4712	4770	4310	3597	4061	3629	3467	3521	5050	5083
34 - Other consumer goods	2531	2385	2572	2655	2746	2824	3607	3990	3727	3631	3403	3030	2961	2383	2755	2523	2412	2313	3156	3117
35 - Civil engineering	3361	3244	3234	3089	3387	3267	4012	4185	4411	4493	4455	4231	3952	3479	3849	3191	3120	3373	4745	4387
Total	98189	99177	102576	102163	110256	112667	148369	154342	158550	167149	168947	170459	165575	144640	175186	158494	159496	168643	221405	226213

Source: WIPO Statistcs Database

Appendix IV: Patenting activity by industry (1991-1993) – percent of R&D units applying for patents and percentage of product and process innovations

Table VII - Patenting activity by industry (1991-1993), percent of R&D units applying for patents and percent of product and process innovations

Industry	# firms	% applying	# firms2	Mean % product	# firms3	Mean % process
Food	87	52.87	78	14.64	74	15.21
Textiles	23	43.48	21	9.49	18	6.79
Paper	31	77.42	23	59.19	20	47.99
Printing/Publishing	12	41.67	12	44.37	12	19.96
Petroleum	15	73.33	12	37.74	10	62.28
Chemicals	64	68.75	50	68.90	44	61.49
Basic chemicals	35	77.14	26	51.28	23	26.38
Plastic resins	25	76.00	20	24.39	20	35.17
Drugs	49	73.47	35	95.50	29	41.85
Miscellaneous chemicals	29	72.41	21	57.74	16	15.75
Rubber/Plastic	34	64.71	29	39.80	26	20.09
Mineral products	18	38.89	16	79.25	17	53.76
Glass	6	50.00	6	5.83	4	2.16
Concrete, cement, lime	10	50.00	8	42.11	8	23.80
Metal, nec	7	71.43	5	2.97	4	37.38
Steel	11	54.55	7	4.46	7	2.68
Metal products	44	77.27	35	48.78	28	26.55
General purpose machinery, nec	74	74.32	60	45.50	49	27.65
Special purpose machinery, nec	63	92.06	47	38.51	38	9.84
Machine tools	11	72.73	9	29.07	8	3.38
Computers	25	80.00	19	38.82	16	26.10
Electrical equipment	21	61.90	18	59.16	17	18.65
Motor/Generator	22	40.91	21	29.20	17	3.14
Electronic components	26	46.15	23	34.15	20	8.46
Semiconductors and related equipment	17	64.71	14	48.51	12	20.60
Communication equipment	32	59.38	29	59.58	25	48.20
TV/Radio	8	62.50	7	60.93	6	0.00
Medical equipment	66	89.39	51	66.80	42	31.16
Precision instruments	33	69.70	27	40.01	24	23.04
Search/Navigational equipment	37	86.49	32	50.24	24	24.43
Car/Truck	9	88.89	8	48.63	5	19.62
Autoparts	31	77.42	26	53.13	19	16.12
Aerospace	49	77.55	42	50.81	37	35.66
Other manufacturing	85	64.71	72	37.05	62	17.22
Total	1109		909		781	

Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.

Appendix V: Effectiveness of appropriability mechanisms for product innovations

Table VIII - Effectiveness of appropriability mechanism for product innovations: Mean percentage of product innovations for which mechanism considered effective

Industry	# of firms	Secrecy	Patents	Other legal	Lead time	Complementary sales/service	Complementary manufacturing
Food	89	58.64	18.26	21.18	53.37	39.83	51.18
Textiles	23	63.70	20.00	25.87	58.26	55.22	58.26
Paper	31	55.00	36.94	26.45	47.10	40.00	39.84
Printing/Publishing	12	32.50	12.08	21.67	48.33	66.25	60.42
Petroleum	15	62.00	33.33	6.33	48.67	40.33	35.67
Chemicals	65	52.77	37.46	21.62	48.62	44.92	41.31
Basic chemicals	35	48.00	38.86	11.57	38.29	45.86	44.71
Plastic resins	27	55.93	32.96	18.15	38.33	44.63	46.11
Drugs	49	53.57	50.20	20.82	50.10	33.37	49.39
Miscellaneous chemicals	29	70.69	39.66	25.52	55.52	55.17	48.97
Rubber/Plastic	35	56.86	32.71	10.14	40.86	34.29	37.71
Mineral products	18	46.11	21.11	12.22	39.72	37.78	40.00
Glass	6	46.67	30.83	11.67	50.00	62.50	70.00
Concrete, cement, lime	10	45.00	30.00	17.50	38.00	45.50	40.00
Metal, nec	6	65.83	20.00	5.00	50.83	58.33	61.67
Steel	10	37.00	22.00	11.50	61.50	34.50	42.00
Metal products	44	43.07	39.43	18.18	48.18	37.05	40.11
General purpose machinery, nec	74	49.19	38.78	20.88	52.23	41.15	43.65
Special purpose machinery, nec	64	45.08	48.83	23.05	59.69	46.33	51.09
Machine tools	10	61.50	36.00	9.00	61.00	43.00	34.50
Computers	25	44.20	41.00	27.20	61.40	40.20	38.00
Electrical equipment	22	39.09	34.55	15.00	33.41	32.27	31.82
Motor/Generator	22	50.91	25.23	19.09	48.86	47.27	45.23
Electronic components	26	34.04	21.35	20.19	45.58	50.00	51.15
Semiconductors and related equipment	18	60.00	26.67	22.50	53.33	42.22	47.50
Communication equipment	34	47.21	25.74	20.15	65.69	42.06	41.18
TV/Radio	8	50.00	38.75	35.63	53.75	24.38	38.75
Medical equipment	67	50.97	54.70	29.03	58.06	52.31	49.25
Precision instruments	35	47.29	25.86	20.86	54.14	49.57	45.57
Search/Navigational equipment	38	48.95	28.68	24.08	46.84	32.89	40.53
Car/Truck	9	42.22	38.89	19.44	65.56	41.67	42.22
Autoparts	30	50.83	44.35	15.65	64.35	44.84	53.06
Aerospace	48	55.10	32.92	16.15	58.02	34.58	46.88
Other manufacturing	84	49.29	33.81	26.61	63.51	42.56	45.30
Total	1118						

Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.

Appendix VI: Effectiveness of appropriability mechanisms for process innovations

Table IX- Effectiveness of appropriability mechanism for product innovations: Mean percentage of process innovations for which mechanism considered effective

Industry	# of firms	Secrecy	Patents	Other legal	Lead time	Complementary sales/service	Complementary manufacturing
Food	89	55.84	16.4	15	41.91	29.78	46.52
Textiles	23	60.65	25.22	24.35	48.7	44.35	53.91
Paper	31	58.87	27.58	19.35	34.52	20.65	34.03
Printing/Publishing	12	20.45	8.64	10.91	33.64	50.91	63.64
Petroleum	15	57.33	36.67	6.33	32	27.67	31.33
Chemicals	65	53.65	20.4	12.86	27.14	28.41	42.3
Basic chemicals	35	58.43	29.71	11.71	25.71	26.71	40.14
Plastic resins	27	62.96	21.3	7.22	23.7	25.19	34.26
Drugs	49	68.13	36.15	16.04	35.52	25.21	44.17
Miscellaneous chemicals	29	76.25	27.32	15.71	33.93	40.36	54.46
Rubber/Plastic	35	59.14	19.86	11.43	35.86	23	37.43
Mineral products	18	48.89	23.33	11.11	28.61	27.5	46.94
Glass	6	56.33	30.83	18.33	31.67	42.5	50
Concrete, cement, lime	10	54	18.5	15.5	26.5	31.5	33.5
Metal, nec	6	65.83	31.67	12.5	66.67	46.67	50
Steel	10	41	15.5	11.5	42	25	42
Metal products	44	46.19	22.5	15.36	39.05	35.36	47.38
General purpose machinery, nec	74	37.54	23.62	16.3	34.86	28.33	40
Special purpose machinery, nec	64	41.83	28.57	16.03	44.92	35.48	41.27
Machine tools	10	48	18	9.5	43	34	39
Computers	25	42.5	30.25	16.75	9.75	23.5	35.5
Electrical equipment	22	31.59	19.09	6.82	19.09	11.82	18.86
Motor/Generator	22	42.62	22.14	17.86	44.52	31.67	39.29
Electronic components	26	46.54	15.19	15	42.69	42.31	55.77
Semiconductors and related equipment	18	57.5	23.33	8.33	47.78	32.22	42.5
Communication equipment	34	36.3	14.7	13.94	43.03	33.64	40.61
TV/Radio	8	47.5	18.75	18.75	38.75	32.5	46.88
Medical equipment	67	49.24	34.02	22.27	45.15	32.12	49.55
Precision instruments	35	43.55	16.77	15.81	35.48	32.74	40.81
Search/Navigational equipment	38	43.65	13.24	16.35	39.05	31.89	42.97
Car/Truck	9	34.44	21.67	17.22	34.44	26.67	41.11
Autoparts	30	56.45	24.35	15.16	50.16	36.94	55.97
Aerospace	48	49.26	21.38	13.3	42.23	28.4	44.89
Other manufacturing	84	51.65	23.42	20.76	44.56	31.39	38.29
Total	1118						

Source: Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2000), "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Papers, National Bureau of Economic Research, No. 7552.