



**Doctoral School
of Management
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THESIS SYNOPSIS

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**The Impact of Patent Protection on
Environmental and General Innovations**

Ph.D. thesis

Supervisor:

Dr. Gyula Zilahy
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Department of Environmental Economics and Technology

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I. BACKGROUND AND PRELIMINARY OBSERVATIONS

Patents similar to the ones we have today were created in the 18th century, first in England in 1718. Later, patent systems were established in almost all countries. The TRIPS Convention¹ in 1995 ensured that patent protection exists in case of all WTO member states (Hall and Harhoff, 2012). The philosophy behind setting up patents and other types of intellectual property protection was based on the belief that monopoly is able to stimulate innovation. Until the last decades this belief was widely accepted. From the middle of the 20th century more and more researchers have warned that further empirical studies are needed to assess the effects of the patent protection on innovative activity and on social utility. Research activity of this topic has accelerated in the last decades, and based on numerous empirical studies there is a serious question about the social utility of patents in their current form.

Patent is an exclusive intellectual property right enabled for a technological solution, invention. The invention is new, if it has not become public anywhere in the world, and there is an inventive step which is not obvious for an expert of the specific topic. Patent protection is valid up to twenty years started from the day when the patent application was filed and solely in the countries where the protection was granted. According to the theory of disclosure, in return for the exclusive rights, within 18 months after the patent application, its complete text has to be published. (Hungarian Intellectual Property Office, 2014, p.1. and Pakucs and Papanek, 2006, p. 162-166.).

The importance of the patents in the economy is apparent by the fact that a significant part of modern technological innovations is patented. According to researchers, in developed countries the ratio of patented technological innovations in the complete economy can be around 20-50% (Cohen et al., 2000, Arundel and Kabla, 1998, Kleinknecht and van der Panne, 2009). According to Bendzsel (2006) the past period proved that managing intellectual property should become a core competence of successful enterprises. By now the overwhelming part of the companies' intangible assets is built up by the elements of intellectual property (Osman, 2012). The legal right of patent protection can contribute to the value creation of companies. Compared to the value of the innovation the value of the patent

¹ Trade-related Aspects of Intellectual Property Rights

protection is typically between 40-60% depending heavily on the industry of application (Arora et al., 2008 and Jensen et al., 2009).

The traditional motivation of patenting is the protection of own innovations from imitation, but in the past decades the use of the patent system from strategic consideration has become widespread. According to Blind et al. (2006) the traditional motivation to patent is still the most important, but there are strong strategic motivations such as offensive and defensive blockade and the improvement in bargaining position. Offensive blockade is when firms patent in order to prevent their competitors to use innovations in the application areas relevant for the firm, even though they may not be interested in utilizing those patents. In case of defensive blockade, firms patent in order to prevent their own technological room to manoeuvre being reduced by others. There are several phenomena rooted in the strategic application of patents which are considered as negative from the point of the society by most researchers. There are organisations gathering a significant patent portfolio, but trying to gain benefits from suing market actors instead of their actual utilization. The slightly ironic name of these in literature and media is 'patent trolls'. When the patenting of numerous substituting and complimentary innovations is possible, some firms also patent them in order to protect their patented central innovation. Doing this excessively, firms can build up 'patent fences'. The so-called 'patent thickets' are forums for trading complimentary technologies. According to Cohen et al. (2000), patents in these cases function as a kind of currency. The extended patent portfolios are also used for scaring off potential new entrants, should they not possess the right quantity and quality of patents. There are also several strategic motivations which are likely to be useful for society, for example increasing reputation, fostering venture capital investments and motivation of employees by patent based incentives. According to Galasso and Schankerman (2010) even the patent thickets can have positive effects for the society by supporting the quick agreement of the companies during litigation and accelerating technological development. The total social effect of the above described strategic use of patents is not necessarily positive. It is a general view that such utilization of the patent system decreases competition, increases the cost of new firms' entering the market and affects especially smaller companies in a negative way.

Several researchers find that in case of only about 30% of the innovations would not be realized in the absence of the patent system necessary, with great variance between industries. In case of several industries the patent system hardly fulfils its original function, while in case of several other industries the majority of the patents would not have been

invented in the lack of patent protection. Textile industry can be a good example for the former, while pharmaceutical industry for the latter. Despite this, in the majority of the industries the use of patents is widespread because the advantages provided by patent protection exceed the costs of patenting (Mansfield, 1986, Brouwer and Kleinknecht, 1999, Blind et al., 2006, de Rassenfosse, 2010).

There are several researchers who advise the gradual abolishment of the patent system based on the above, like for example Boldrin and Levine (2009). In their meta-analysis they argue that the strengthening of the patent system has not been accompanied with the increase in the global innovation activity, only with regional realignment in a couple of cases. Mazzoleni and Nelson (1998) point out that most studies hardly focus on the numerous advantages of patent system. The studies are almost exclusively based on the examination of existing firms, among them the larger ones. However, the patent system can significantly help the new actors entering the market, the smaller firms or the institutions operating in a non-corporate framework (e.g. universities). However, taking all these aspects into consideration, Mazzoleni and Nelson do not think that the further strengthening of patent system would have an economic advantage on a global level. Bessen and Meurer (2008) describe that the assessment of social impacts of the patent system is extremely difficult and the studies trying to quantify this did not lead to reliable results. A reason for this is that studies in literature are mostly based on large sample representative surveys and due to the significant difference in innovations and the widespread indirect effects, it is difficult to reach general conclusions.

The critics in the both scientific literature and the media along with the increasing dissatisfaction of companies has been partly echoed. The reform of patent system was initiated in more countries. In the USA, patent system was reformed in 2011 incorporating several measures advised by researchers. In Europe improvement is expected from the introduction of the Unified European Patent System and Court which would unite the currently fragmented patent institution system, significantly improving its transparency and decreasing its costs. The implementation of the system seems realistic in 2015. However according to researchers more radical reforms are necessary (for example Bessen and Meurer, 2008, Boldrin and Levine, 2009, Krakovsky, 2012).

II. METHODOLOGY

It is clear from the literature review that the most important and current question of the research of patents is whether the existence of the patent system enhances innovation and ultimately social utility. Regarding this topic, a number of studies try to analyze, what reforms of the patent system could support the positive effects and hinder the negative ones. There are only few studies that are able to give at least a partial answer to these questions. The main reasons for this are the huge variance between the specific innovations, and the sometimes large-scale externality effects which are difficult to assess. So, the studies which are usually based on large scale representative surveys fail to give universal findings.

The effect of the patent system on environmental innovations is a much less researched topic. Still, this field is worth studying as environmental innovations have several unique attributes which could alter the patent system's effect on them. The main reasons for this are the double-externality effect, the different attitude of the companies towards these kinds of innovations and the greater need for their efficient diffusion.

Two main goals of my research are to contribute to a more thorough understanding of the advantages and disadvantages of the patent system for innovative companies, and to study the diversity of these effects in the special case of environmental innovations. In the latter case I also apply an approach different from most studies, as I study environmental innovations not only in the environmental sector, but in all industries in Hungary. Results from the study of the case of Hungary are also relevant for other EU countries.

Based on the literature review and the above, I have formulated the following hypotheses:

H1. The realization of patented environmental innovations depends more on the existence of the patent system than in the case of non-environmental innovations.

H2. The main motivations of patent protection and the importance of these are similar in Hungary and in the European Union, namely: commercial exploitation, protection from imitation, blocking, pure defense (ensuring that the use of a company's own technology is not hindered others), setting of technical standards, improving reputation, licensing.

H3/A. The patent premium (the added value to the innovation by patent protection) makes up a significant part of the patent value.

H3/B. The value of the patents increases with the size (revenue, employee number) of the innovator.

H4/A. In case of the patented innovations, the effective lifetime of the innovation is shorter than the patent protection period granted by law.

H4/B. In case of patented innovations, the effective lifetime of the innovation is shorter than the theoretical lifetime.

H5. Hungarian innovators with patent applications find the reform of the patent system necessary, in line with the vast majority of researchers.

According to Griliches (1990) there is lack of appropriate data to measure innovations and their effects, as innovative activity is hard to measure, its effects are difficult to assess and there is no function-like relationship between the inventive input and output. There are several methods in the literature for the study of innovations, macro-level innovation indices, company-level empirical research with surveys or other methods or innovation-level empirical research collecting detailed information to assess the diffusion and effects of innovations. In case of environmental innovations, gathering relevant data from macro-level statistics is difficult, as this type of innovation is often realized as a part of or only as a by-product of innovations focusing on other fields. Company-level surveys or similar methods can serve as a suitable tool for the research of environmental innovations. This type of research is most appropriate when dealing with well defined and researched topics. Major disadvantages of these types of studies are the subjectivity and relatively high costs. Bias can arise when we try to aggregate the answers of people with different backgrounds and knowledge about the topic and the specific question². Only during a thorough study of a specific innovation brings the researcher close enough to experience the complex nature of innovative activity, and is able to make relevant conclusions. This can be achieved by interviews which are most appropriate when dealing with less researched and less common areas, and is useful for experimental studies. The disadvantage of this method is that it is difficult to come to representative industry or macro-level conclusions. Based on the above benefits and drawbacks of the different methods, the optimal method to test my hypotheses is to gather detailed data about specific innovations. According to my knowledge only one such research was done in Hungary, as part of the PatVal II survey. Such a detailed research can

² Similar to the research of Némethné Pál (2010) where companies interpreted the term “innovation” differently.

complement the existing patent literature, and might influence the patent system to better enhance environmental innovations.

To test the hypotheses, a sample of companies which have invented environmental innovations and are also active in patenting is needed. There are three ways to create such a sample:

- Large scale representative study targeting numerous companies, and identifying relevant companies. The disadvantage of this study is the relatively high proportional cost of gathering data from relevant companies. I participated in the research of Széchy (2012), who examined the environmental innovation activities of nearly 300 firms from the several industries in 2010-2011. Due to the very low rate of patented innovations the survey, this source was not suitable for testing the hypotheses.
- It is possible to identify companies with patents regarding environmental innovations. Although patents at the Hungarian Intellectual Property Office are not classified according to environmental performance there are ways to gather information from the detailed description of the patents. In one of my previous studies I identified about 700 patents protecting environmental innovations, with an application time between 1990 and 2006 (Szűcs, 2011). According to this study it is rather easy to decide which patented innovation can be regarded as environmental innovation. Most patent descriptions summarize the advantages of the innovation, explicitly stating lowered material usage, lowered energy requirement, less hazardous waste, or more environmental friendly product or process. The major disadvantage of this method is that most recent patent applications have to be excluded from the study as the patent approval time is recently 3-4 years and 5-7 years in some specific industries (for example pharmaceuticals)³. With thorough selection, the sample can be representative of the patenting activity in Hungary, not taking the most recent 4-7 years into account. All of the patents at HIPO can be studied and the approved patents of environmental innovations can be sorted out to have a sample. These can be compared to the patent applications of Hungarian

³ My previous study (Szűcs, 2011) used patents with application dates between 1990 and 2006, and which were later granted. Studying granted patents served as a measure of value, and was useful for filtering numerous patent applications with marginal value, as well as redundant ones. A method similar to this is suggested to be used in this research too.

applicants at European Patent Office, to have a more robust sample likely to contain the most valuable patents of environmental innovations. The explanatory power of the research can be further increased with a patent citation based measure, widely regarded as a good proxy of patent value (for example Trajtenberg, 1990). The time lag however significantly decreases the relevance of the study, and it is more difficult to acquire detailed information about more prior inventions. The other major disadvantage of this method is that the sampling can just partly be automatized and high costs arise in case of manual sampling.

- The third way to gather a sample with companies active in environmental innovations and also patenting is to directly search for such companies using publications of awards, contests, newspaper, web, university or literature search. The study of an award or contest is an appreciated method in the literature. One of the most cited studies with similar sample is from Moser (2007), who examined more than 7000 innovations of four British and American world fairs between 1851 and 1915, where the significance of individual innovations was examined by a professional committee. Although the time-period studied is long past and the economy is substantially different, she was able to come to several valuable conclusions. The main advantage is that it contains independent measures about the value of the innovations which can be rather useful in interpreting results. It contains both patented and unpatented innovations, making a comparison possible. Detailed data can be gathered this way, but the method biases towards bigger companies and more valuable innovations, and is less likely to be representative.

After the thorough analysis of the advantages and disadvantages of the methods, the third method was selected as most appropriate for the research. I use the Hungarian Innovation Grand Prize, awarded each year since 1992 by the Hungarian Association for Innovation. The evaluation aspects of the prize are the achieved extra economic result or extra yearly income due to the innovation and other technological, economic advantages, originality, novelty, social utility and the elaboration quality of an application (Hungarian Association for Innovation, 2014). A jury consisting of scientists and business professionals evaluates each innovation and decides about the prize. The sample consists of the companies, which applied for the Hungarian Innovation Grand Prize between 2002 and 2013 and which also applied for patent protection. Research done on this sample stands out of the bulk of patent research using representative random samples. Regarding the earlier innovations it is quite difficult to

gather relevant data from interviews about activities performed more than 10 years ago (invention and patent application usually precedes the utilization of the innovation and the application for the prize with 1-5 years). Going further back in time, it is even more difficult to find people with relevant knowledge. The changes also in the patent system and in the economy make the study of older innovations less relevant.

The jury recognised 420 applications for the Innovation Grand Prize as innovation, between 2002 and 2013, from these 90 were identified as having at least one related patent application.

As opposed to my previous study (Szűcs, 2011) I have decided to study patent applications instead of granted patents. The reasons for this are that the population is relatively small and the ratio of the low value or redundant patent applications is low due to the selection method of the Innovation Grand Prize. According to Gambardella et al. (2010) the major advantages of studying patent applications are that applications already serve as strategic instruments, companies license the application already (do not wait until the granting of the patent) and that through this method studying recent patent applications is more appropriate. Furthermore, there is a better recall among respondents, and the conclusions are more up-to-date. Next to the advantages noted by Gambardella et al (2010), studying patent applications in the research can be considered a better method because of the 12 years long period. During a study of granted patents innovations from the most recent years has to be excluded. There are disadvantages of studying applications. According to Gambardella et al. (2010), these are that granted patents are likely to be commercialised more frequently than similar non-granted (pending) applications, some of the applications will be refused or withdrawn and that focusing on applications increases heterogeneity in the sample. In case of my research commercialisation of innovations with only patent applications is not a major problem, as most of the innovations in the sample are utilized. Innovations with later rejected or withdrawn patents can have smaller value and other different characteristics which can decrease the strength of the conclusions. However many Hungarian patent applications are withdrawn because the innovation seems to be valuable and the applicant decides to file an EPO application instead. Taking all the above into account, I study patent applications in my research.

The testing of my hypotheses, taking into account the attributes of the population, was achieved by structured personal and telephone interviews with respondents from the innovator companies with relevant knowledge about the innovation. The survey was

conducted with the help of students of the Corvinus University of Budapest after thorough training. The survey questionnaire contained several open ended questions, enriching the research with qualitative elements. The research was conducted between April and July 2014. Interviews were made with 43% of the population, which meant a sample size of 39. Although the population contains relatively few elements, this is in line with the languid Hungarian patenting activity, which is a structural weakness of the Hungarian economy according to Dutta (2012). According to Bessen (2008) among others, the value distribution of patents is strongly skewed, the most valuable decile giving the 70-90% of the value of all patents. Between 2002 and 2013 there were about 2500 patent applications from institutional applicants (mainly companies). The 2500 patent applications are likely to relate to significantly less innovations, as a lot of valuable innovations are protected by more patents. It is important to note that although most patent applications regarding the Innovation Prize have been applied for at the HIPO, but not all. On the other hand in case of several innovations there were more patent applications. Eventually, the population contains at least 3.6 % of Hungarian innovations with patent application, and a high ratio of the really valuable ones. It is also important to note, that most of the innovations in the population are utilized. These patents or applications have the biggest social and environmental effects. Most unutilized and marginal value patents have low social and environmental benefits, and the social costs related to the temporary monopoly can be bearable. The population can be regarded as representative of the Hungarian patenting activity, but is biased towards utilized and more valuable innovations. To be able to form generalizable conclusions, I based the structure of the interviews on a large scale representative study, the PatVal II with more than 22,000 patent applications between 2003 and 2005 in 20 European countries, in the USA and Japan. Several questions from this study were implemented in my survey questionnaire. Results of the PatVal II study include data from thousands of European patents, including Hungarian ones. The researchers had a representative sample of 335 patent applications at the EPO with Hungarian inventors. From these they were able to acquire 50 fully and 23 partially filled in questionnaires. Using exactly the same questions it is possible to make comparisons with that study. If the results are in line with the results of the PatVal II or PatVal II Hungary, it makes the conclusions more robust.

Analysis of the data was carried out by statistical methods, frequency analysis, crosstabs, correlations, independence tests and regression. The answers to the open questions provided valuable information in interpreting the results.

III. RESULTS OF THE THESIS

Two main goals of the research are the contribution to the more thorough understanding of the advantages and disadvantages of the patent system for innovative companies, and the study of the diversity of these effects in the special case of environmental innovations. In the latter case the selected approach is different from most studies, environmental innovations are not only studied in the environmental sector, but in all industries.

In the literature review several topics and research questions were identified mostly through the review and structuring of the past and current studies. Specific research topics were selected through the synthesis of the main goals of the research and the literature. The research questions selected for in depth analysis related to the difference between environmental and general patents with respect to the realization of the innovations in the absence of the patent system, the main motivations behind patenting, the value of patents with respect to the patent premium, the effect of company size on patent value, the theoretical and normal lifetime of patented innovations and the innovators' opinions about the possible patent reforms.

The relation between environmental innovations and the patent system

Respondents regarded 64% of the studied innovations as environmental innovations, which is a relatively high proportion. Taking into account that companies from the environmental technology & services represent only 8% of the studied innovations, this shows that it is extremely important to focus on environmental innovations in other sectors too. Most of these are cleaner production type innovations and are originated from various sectors. This type of environmental innovations share most attributes of non-environmental innovations from the same company or industry. The study has a broader view of the environmental innovation than most studies, as there was no criterion for the environmental innovations to be the aim of the innovation. This is a more holistic approach, as there were numerous innovations in the sample where environmental improvement was only a positive side effect not the main goal of the innovation. Environmental innovations originated from the environmental sector were mainly end-of-pipe technologies as opposed to the dominance of cleaner production type innovations in other industries. The latter type of environmental innovation depends heavily on the specific characteristics of the industry of innovation but is

not significantly different from the general innovations in most of the studied aspects. The studied environmental innovations depend less on the existence of the patent system, than non-environmental innovations, however, this can mainly be attributed to industrial effects. Taken apart from the pharmaceutical industry, there is no difference between environmental and general patents in this respect. This result is very important because of several reasons. An effective patent system fostering high value innovations in the whole economy can also be able to support environmental innovations. It also seems that the phenomena of double externality do not significantly influences the patenting activity of companies belonging to various sectors, who mostly realize cleaner production type of environmental innovations.

Motives to patent

The relatively low ratio of innovations dependent on patent protection is in line with the literature. Innovations that would not have been invented in the lack of patent protection are exaggeratedly typical to the pharmaceutical sector. This again emphasises that patent protection in the modern economy is not what it used to be several centuries ago. The patent protection nowadays is much more than just a way of protection from imitation for the companies. Innovators use the patent system in several other strategically advantageous ways helping the commercial exploitation of the innovation, blocking, ensuring that the use of the own technology is not hindered by third parties, setting of technical standard, improving reputation or licensing. These motivations are similar even with different background settings like the date and country of invention. This together with the studies presented in the literature show that these motivations can be considered robust.

Value of patents and patent premium

During the study regarding the value of patents, the explanatory power of the Hungarian Innovation Grand Prize was tested. The results show that although there is a significant connection, the explanatory power of the Grand Prize on patent value is rather weak. Great advantage of the study is that next to the assessment of the jury of the Grand Prize the companies have also assessed the value of their patents. As this is likely to be possible in only a limited number of future studies, special caution is needed when using the prize or award as a proxy for the value of the patent. Studying the patent premium, two markedly distinct categories of innovators was discovered. Innovators from the first group regarded

patent premium to be rather important in contrast with the innovators from the other group who were on the opposite opinion. This can partly explain why several researchers have found significantly different patent propensities in previous studies. Firm size was tested as a factor influencing patent value. Results show that there is no significant connection between the two on a 95% significance level, but in case of several variables like employee number or yearly sales filtering out spin-off companies, the relation came close to be significant, although with a projected weak explanatory power. The results show that patents of small companies can also be of great value.

Lifetime of innovations

In case of the lifetime of the innovations it was unexpected that neither the effective nor the theoretical (normal) lifetimes differ significantly from the patent protection time granted by law. This shows that the social costs arise regarding the delay in follow-on innovations and the deadweight loss during the whole patent protection time. It is important to note that in several cases a superior or imitated innovation reached the market during the lifetime of the innovation. Competition with these has decreased the market share of the innovation, but positive yields were still possible to achieve. This shows that although there are social costs regarding patenting until the lapse of the patent or even further, these costs decrease with time in case of several innovations. It is also important to note that only few respondents have answered that the lifetime of the innovation came to an end due to the lapse of the patent protection time. Although the average lifetime of the innovations in the sample is not significantly different from 20 years but this can rather be attributed to the average lifetime of the innovations than the lapse of patent protection. It was also unexpected that in case of almost two-thirds of the innovations the effective and normal lifetimes of the innovations did not differ. The main reasons for this can be that innovators are able to profit from the innovation until the end of the normal life cycle, although to a decreasing amount in several cases.

Opinions about the possible future reforms

Almost half of the respondents think that the patent system is useful for the companies, which shows that patents can yield significant advantages for innovators. Regarding the possible future reforms of the patent system, it can generally be said that the majority of the

respondents were against most reforms, especially more radical ones, like the gradual abolishment of the patent system, and there were several companies who were uncertain about the effects of such reforms. Only the setting up of a United European Patent System and Court was welcomed by most of the respondents. The critical view of respondents regarding the reforms can partly be traced back to the fact that they are active in patenting and the majority of them take advantage of the patent system, while social costs are not fully internalized.

Suggestions for further research

In light of the findings from the thesis it is also possible to make suggestions for further research. Next to the large scale representative studies, research with a more in depth view of the patenting of innovations can give invaluable insights into the characteristically different innovation processes of the companies. The studies based on other innovation prizes, fairs, etc. can provide us with a population of patented innovations with much more valuable information about patents than available in patent registers. These can serve as an excellent base for researching further aspects of the patenting process. The assessments of the effects of possible future reforms are also vital. As most of the researchers and an ever growing part of the companies regard future reforms as necessary, and given the great number of potential reforms, it is important to have relatively accurate preconceptions about the changes in the patent system.

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V. THE AUTHOR'S OWN PUBLICATIONS RELATED TO THE TOPIC

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