Doctoral School of Management and Business Administration

THESIS SYNOPSIS

Anna Zsófia Széchy

Environmental innovations in the Hungarian manufacturing sector

Ph.D. dissertation

Supervisor:

Dr. Gyula Zilahy
associate professor

Budapest, 2011

Department of Environmental Economics and Technology

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Table of contents

I. Background

The environmental problems the World is facing today, with their growing severity and increasingly global nature, are often called the most serious challenge that humanity has to face in the coming years. Although the reality of this crisis is now seldom called into question, many believe there is no cause for serious concern, since scientific advancement and human resourcefulness will, as they so often have in the past, provide the solutions in good time. Others are less optimistic, and believe that sustainability can only be achieved through serious sacrifices in our lifestyle, perhaps even a profound transformation of today's entire socio-economic structures. At the same time, there is widespread agreement that – whether sufficient on its own, or only an element of the solution – the development of environmentally benign technologies must play an important role in overcoming the environmental challenge.

We therefore need to find solutions which enable the reduction of the environmental burden associated with economic activity. However, it is of course not enough to invent these solutions, they must also become widely used by economic actors. In a profit oriented economic system, it is clear that this process cannot rely solely on the environmental consciousness of market players. Other drivers are also necessary, be it the cost savings associated with improved efficiency, or external pressure from the authorities or other actors. It is therefore vital to understand what motivates companies to develop or adopt environmentally friendly solutions, as well as to identify the barriers to this process.

In my dissertation I examine the environmental innovation activity of Hungarian manufacturing firms. There are, of course, many different types of environmental innovations – they may be related to the company's processes, products, or organisational issues[1]; they may address various environmental effects; they may be end-of-pipe or cleaner production-type solutions; they may be new only to the company, or to the entire market. These different types of innovations may have different motivations, and different resources and capabilities may be required for their implementation.

[1] The dissertation only deals with technological innovations, organisational innovations are not included in the scope of the research.

The literature – starting from various theoretical standpoints – identifies several factors which may influence corporate environmental innovation behaviour. The environmental economics approach emphasizes the importance of legislation, evolutionary economics focuses on environmental factors, while the resource-based view concentrates on the role of firm-internal characteristics. The environmental strategy literature also provides important insights by showing how the environmental behaviour of firms is shaped by the decision makers' perceptions and their interpretations of the risks and opportunities related to environmental issues.

However, past research has typically focused on a particular group of determinants or a particular type of innovation, comparative studies are rare. The aim of the thesis is therefore to study the determinants of the different types of environmental innovations, taking into account the characteristics of the firm as well as its environment. The innovation activity of companies may also differ significantly across industries and in companies of different sizes. The analysis of these effects is also an important goal of the work.

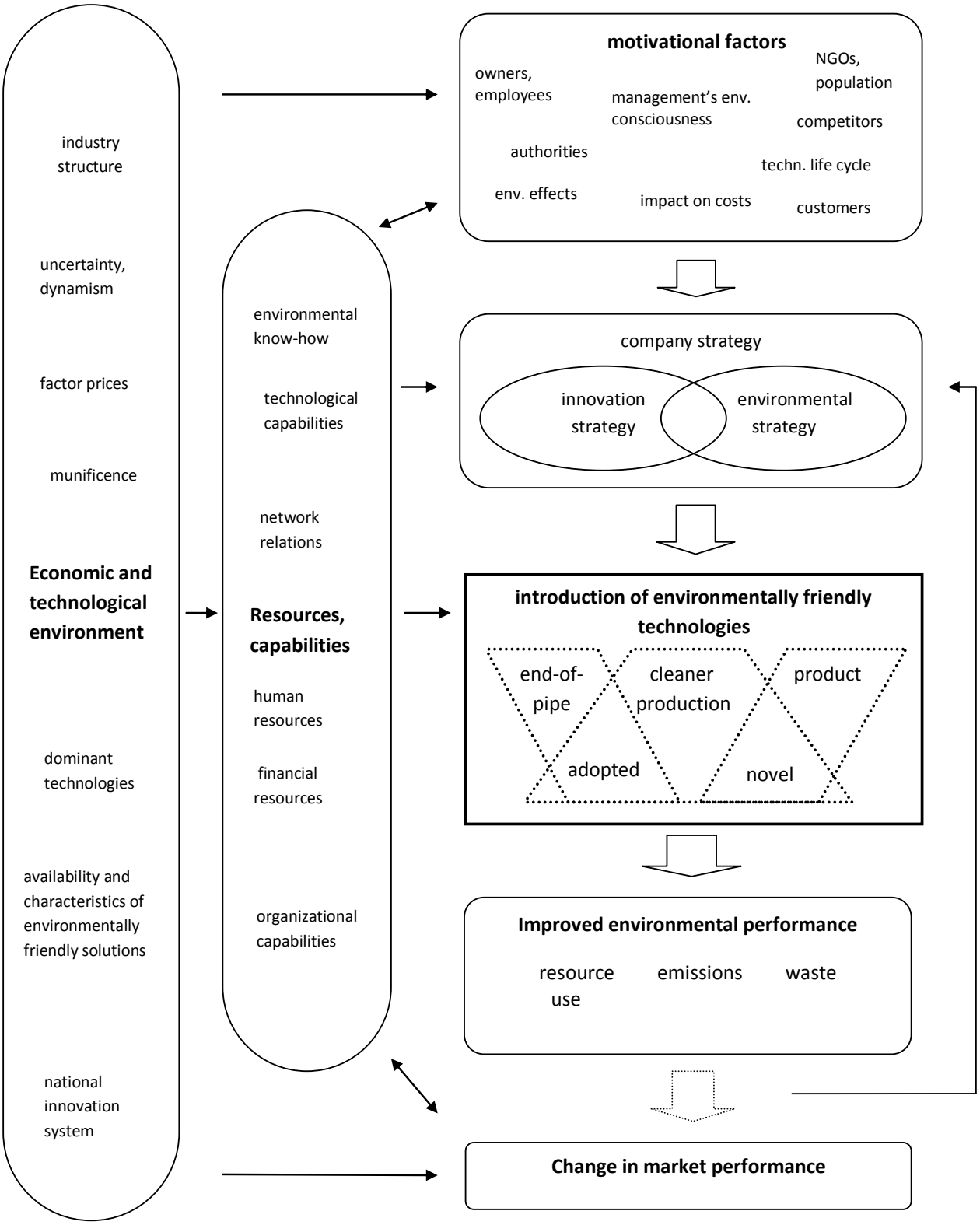
II. Research model and methods

The most important lesson from the literature review is that the factors influencing corporate environmental innovation behaviour are many and diverse, and thus, by focusing on one or few factors (such as the impact of environmental regulations or customer demand for green products), we cannot obtain satisfactory explanations for corporate environmental innovation behaviour. The other main lesson is that it is useful to separately analyse different types of environmental innovations, as their determinants as well as their results may be different. Therefore in my research model (Figure 1.), I have differentiated between end-of-pipe, cleaner production and product innovations, as well as novel and adopted innovations.

The determinants are divided into three main groups: the first is that of factors which influence companies' motivation to engage in environmental innovation. Examples include the expectations of various stakeholders or the cost-saving potential associated with environmentally friendly solutions – at the same time, it is important to stress that these do not necessarily have a positive effect on the intention to innovate (such as the costs associated with introducing a new technology or previous investments made by the company).

The second important group of determinants is the resources and capabilities of the organisation (including financial as well as human resources, know-how, external relations, etc.) The factors included in the third group, the characteristics of the economic and technological environment do not directly influence innovation activity, but through the two former group of factors. The characteristics of the national innovation system, for example, may determine how easy companies can find innovation partners or gain access to public financing, which can motivate environmental investments. The general economic climate has an impact on the financial situation of the company, the available pool of environmentally friendly technologies determines the costs saving potential linked to their introduction, etc.

Figure 1. Research model



Regarding environmental innovations and their determinants, I have made the following hypotheses:

H1: Significant differences exist in the intensity of the environmental innovation activity of individual companies; these are caused by differences in motivational factors, firm resources and capabilities, as well as variations in the economic and technological environment.

H2: Companies which are more innovative on a general level are also more active in the field of environmental innovations.

H3: The influence of factors affecting both general and environmental innovation activity is different in these two areas.

H4:

a) The determinants of the different types of environmental innovation (end-of-pipe, cleaner production, product) are different. End-of-pipe innovations are mainly motivated by regulatory compliance, cleaner production innovations by cost savings, and product innovations by customer demands.

b) The determinants of novel and adopted innovations are different.

c) The majority of end-of-pipe innovations are adopted technologies, while the majority of product innovations are novel solutions. Novel and adopted technologies both form a significant share of cleaner production innovations.

H5: The different types of environmental innovation (end-of-pipe, cleaner production, product; novel, adopted) improve environmental performance by different degrees.

As it is impossible to rely on statistical information to analyze most of the factors found in the research model, I have opted for the survey method, involving companies from the chemical, food, electronic, machine and vehicle industries[2]. The choice of these sectors is partly justified by their economic importance (together they provide more than 2/3 of the total value added in the Hungarian manufacturing industry), and also, I was aiming to compose a sample

[2] The implementation of the survey was funded by the TÁMOP-4.2.1/B-09/1/KMR-2010-0005 project.

that is heterogeneous regarding innovation intensity as well as the type and severity of the environmental effects involved.

To assist the composition and professional quality of the questionnaire, I conducted preliminary interviews with experts from the industries surveyed. An important feature of the questionnaire is that it not only contains basic questions regarding the level of environmental innovation activity, but also elicits information on specific eco-innovations carried out by the companies during the past 3 years. This allows the differential analysis of the various types of environmental innovations (end-of-pipe/ cleaner production/ product; new/adopted). The questionnaire was completed via face-to-face interviews (conducted by students of the Corvinus University of Budapest after thorough training) and contains several open ended questions, enriching the research with some qualitative elements.

The survey was carried out first in the chemical industry in Spring 2010, followed by the other industries in Summer 2011. Lessons from the chemical industry survey were analyzed and led to the addition of a few further questions, however, modifications undermining comparability did not prove necessary. The questionnaire consists of three main sections: after a section on general company information followed the questions regarding environmental innovation behaviour (at first in general, then about the specific innovations), and finally, a section on the determinants.

For the sampling procedure, the main aim was to obtain a sample suitable for comparing the different industries and company sizes (that is, obtaining sufficient amount of data from each industry and size group). Therefore we attempted to reach approximately the same number of companies from all industries, meaning that the chemicals and vehicles sectors, whose actual proportion within the manufacturing industry is much smaller, are overrepresented in the sample, as are medium and large companies (although micro and small enterprises still form the clear majority). Altogether the interviewers contacted 1126 companies, of whom 297 were willing to answer the questions, resulting in a participation rate of 26,4%.

Analysis of the data was carried out by statistical methods, such as frequency analysis, crosstabs and correlations, and the overall effect the determinants was captured using a binomial logit model. The latter method was chosen because it fits the nature of the survey data (categorical variables, lack of normal distribution). The independent variables (the

determinants of environmental innovation activity) are used to create a regression function which is suitable for predicting the group membership (in this case the presence or absence of environmental innovations) of the companies in the sample. The analysis of the answers to the open ended questions also provided useful insights for interpreting the statistical results.

III. Results

1. Identification of the determinants of environmental innovation activity

In the literature review I have identified several factors which can be linked to environmental innovation activity. Of these factors, I have examined in detail the role of perceptions about the companies' environmental effects, the economic effects of environmental innovations, pressure from various stakeholders, the adequateness of available resources and capabilities; as well as the effects of firm size and industry.

The analysis has shown that all the above factors are connected to the intensity of environmental innovation activity, however the connection is usually not very strong, meaning that none of the determinants examined are decisive on their own. The combined effect of the determinants was examined through binomial logistic regression analysis. The resulting model, containing the change in the firm's annual earnings, the perceived availability of financial and human resources, pressure from owners to improve environmental performance and the perceived magnitude of certain environmental effects (product-related effects, air pollution and the creation of hazardous waste) has medium explanatory power regarding the presence or absence of environmental innovations. Inclusion of firm size in the model has shown that size, though important, is not a substitute for the above factors, all of which (except air pollution) remained significant in the model. This means that they also affect environmental innovation activity on their own, not only through firm size.

2. Mapping actual environmental innovations in the Hungarian manufacturing industry

The research goes beyond the widespread approach which only takes into account the presence or absence (or perhaps number) of innovations. The analysis of specific innovations has proven to be a rich source of information as to what types of technologies are the most common, what are the reasons behind their introduction and their effects. The results show that the majority of environmental innovations introduced in the Hungarian manufacturing industry affect firms' processes, and most of them are preventive by nature. Regarding the degree of novelty of the innovations, about 20% were reportedly novel innovations developed by the firm, the others were adopted technologies.

As to the specific areas, innovations increasing energy efficiency were the most common as well as general modernization investments which improved environmental performance in several aspects. Measures related to recycling waste and reducing air or water pollution were also carried out in large numbers. Regarding the use of harmful substances, the substitution of organic solvents and lead-based solders were common.

Contrary to the everyday use of the term, environmental innovations are defined in the literature as innovations which *result in* a decrease environmental impact. This approach substantially widened the scope of innovations covered by the research since only 1/3 of them were motivated by explicit environmental considerations (although improvements introduced because of regulatory compliance or the protection of workers' health were also directly aimed at decreasing environmental effects, all these together only make up less than half of the innovations covered in the survey). The most common motivation (cited by respondents for more than half of the innovations) was cost reduction, with market considerations also appearing often. In this light, it is not surprising that the factors included in the regression analysis were only partially able to explain the presence or absence of environmental innovations, as this is clearly heavily influenced by the opportunities provided by accessible technologies for reducing operational costs.

3. Comparison of the various types of environmental innovation

Differentiating between the types of environmental innovation in the analysis has clearly proven to be justified, as the research has shown their typical motivations to be different. The vast majority of cleaner production-type innovations are motivated by the aim to reduce costs, while product innovations are typically driven by prospective market advantages. For end-of-pipe technologies, regulatory compliance as well as explicit environmental considerations are important and several measures were taken in order to protect employees' health.

I have also found a significant relationship between the types of innovations and their degree of novelty. Novel innovations are most common among product innovations, while end-of-pipe innovations are typically adopted technologies, with the introduction of solutions already widespread on market being the most common. Similarly, novel innovations are most often driven by market considerations, while the tools of regulatory compliance and protecting workers' health are usually adopted innovations. The situation among cleaner production type innovations is interesting, as companies appear to prefer existing technologies when aiming at

cost reductions, while environmental considerations appear more often in relation to novel technologies.

Although according to the definition, innovations introduced for various reasons all qualify as environmental innovations, the underlying motivations are not irrelevant for the outcome. Examination of the environmental effects of the innovations shows – although in this regard the picture provided by the survey is somewhat fuzzy – that those innovations which are motivated by explicit environmental considerations were able to reduce firms' environmental impacts across almost all dimensions more than innovations implemented for other reasons. Exceptions are energy and raw material use efficiency, where cost reduction aims lead to the greatest improvements. The data also indicate that novel and adopted innovations also differ in effectiveness, as respondents indicated greater improvements in environmental performance related to the former (for all three basic types of environmental innovation).

4. In-depth analysis of the role of firm size in environmental innovation activity

Previous research on environmental innovations has typically concentrated on large firms with a few studies explicitly focusing on smaller companies, but studies comparing firms of different sizes are extremely rare (especially when it comes to micro-enterprises). One of the main lessons from the comparison is that the higher environmental innovation performance of large companies cannot be explained solely by their advantages in terms resources and capabilities. In addition to the better availability of resources, pressure from all stakeholders as well as the severity of environmental impacts also increases parallel to firm size. Therefore it is not simply the case that smaller companies lack the necessary time or money to invest in environmentally friendly technologies, rather, they are also less motivated to do so. It is probably due to this fact that – as the results show – small firms are lagging behind their large counterparts in the field of environmental innovation more than in their overall innovation performance.

It has also turned out that firm size not only affects the number, but also the type of environmental innovations significantly. Among the smallest firms, innovations related to improving environmental efficiency are comparatively rare, which is probably explained by the large capital demand of such measures. At the same time, micro-enterprises are the most market oriented and exhibit a relatively large number of innovations motivated by customer demands. (Surprisingly, the smallest and the largest companies share certain similarities,

namely a higher share of product innovations and novel innovations.) By contrast, the environmental innovation activity of small and medium-size enterprises is clearly focused on cleaner production-type solutions improving environmental efficiency and decreasing costs, and usually involves the adoption of technologies already available on the market.

Large companies reported a significantly higher share of innovations motivated (also) by protecting the environment. This indicates that smaller companies are less able to afford investments without direct economic benefits (as is also shown by the shorter payback time found among the innovations introduced by smaller companies). At the same time, it should be noted that environmental protection was most often cited by large companies in conjunction with other motivations. What is clear is that taking environmental considerations into account is more embedded in the thinking and vocabulary of larger firms.

5. Identification of industry characteristics

The chemical industry, being the most environmentally sensitive sector, was the only one in the survey where respondents reported significant environmental effects other than energy and raw materials use. Pressure from the authorities and, occasionally, NGOs and the local population as well as the importance of protecting workers' health are felt most strongly here. The chemicals sector is the one where environmental protection equipment has been in use for the longest time, and a relatively large part of the innovations are also end-of-pipe technologies. The availability of human and financial resources for environmental innovation is also seen as most adequate by the chemical companies. At the same time, it is interesting that increased attention from European policymakers as well as the general public directed at the environmental and health risks of chemical products does not so far appear to affect the activity Hungarian firms. The proportion of product innovations found in the chemical industry was below the sample average, and none of the companies reported any specific steps taken in relation to the REACH regulation.

After the chemical industry, electronics is the sector where companies are the most active in the field of environmental innovation, but the nature of this activity is quite different. Electronics firms reported an exceptionally high number of product innovations, most of them involving a decrease in the energy consumption of the product. The role of customer demands and market incentives is very strong. This is probably due to the fact that the industry is characterized by rapid technological development and short product cycles making

developments affecting environmental features also more frequent. Of the industries examined, the effects of the recent economic crisis were least felt in the electronics sector, and it is probably due to the relatively favourable overall situation of the industry that the availability of various resources necessary for environmental innovation was also rated above average by the respondents from electronics companies.

According to the results of the survey, the least environmentally innovative sectors are the machine and the food industry. Here we can mainly find cleaner production innovations aimed at reducing costs and product innovations are very rare. The role of market incentives is the weakest in these two industries, and the mentioning of environmental considerations is also the least common.

6. Identification of the barriers to environmental innovation

The improvement of the companies' financial situation was cited most often by respondents as the necessary precondition for increasing environmental innovation activity. At the same time, 15% stated that there was no need for the company to introduce environmental innovations because they "do not pollute the environment". Regarding the severity of their various environmental effects, it was also striking that the vast majority of companies, including the larger ones, perceives these to be negligible (with the exception of energy and raw material use and waste generation). It appears therefore that many think distinctly about "classic" environmental pollution (i.e. the release of harmful, toxic substances into the environment) which is only a concern if regulatory limits are exceeded, and resource use issues, which however, are mainly seen as cost, rather than environmental problems.

7. Recommendations to promote the diffusion of environmentally friendly technologies

The results of the dissertation point out several possibilities to promote the diffusion of environmentally friendly technologies. Motivating micro-enterprises is the most difficult, but because of their important role in the economy (as well as their overall environmental impact), this group should not be neglected. The most important task here is to promote cleaner production innovations to improve environmental efficiency. Results of the research show that public support and grants related to environmentally benign technologies currently do not reach the smallest companies. From the sample, it was mainly medium and small enterprises which were able to benefit from such funds, however it can also be seen that large

companies are the ones most consciously and actively searching for these opportunities. Many respondents from small companies expressed their frustration at the difficult conditions of grant applications – therefore it would definitely appear worthwhile to improve the accessibility of such funds for smaller firms as they are the ones most in need of support.

The research has also shown that environmental incentives from end consumers and the civil society are very weak in Hungary today (although some large companies have experienced pressure from the latter group). However it is also clear that regulations are not able to effectively promote environmental innovations in all areas. In this light, it is worth considering suggestions from the literature which advocate indirect forms of state intervention by strengthening consumers and the civil society. I believe such measures could also be effective in Hungary (e.g. promoting product innovations in the food industry by improving the efficiency of information supply about the products' composition).

The important role of internal stakeholders found in the sample, the greater environmental effects of innovations motivated by environmental protection, as well as certain statements from the respondents show that the personal motivation of company decision makers is an indispensable driver for the introduction of the environmental innovations. Therefore, next to regulations and financial support, the importance of shaping the consciousness of business actors as well as the population as a whole (e.g. promoting positive examples, education for environmental consciousness) is not to be underestimated.

8. Suggestions for further research

Insofar as environmental innovation activity is largely determined by the range of accessible technologies and their effects on firms' costs, it would be useful to examine how consciously and through what channels companies gather information about innovation opportunities. We also know little about how corporate investment cycles and broader technological constraints influenced the innovation decisions. In order to incorporate these effects, it would be worthwhile to also examine the environmental innovation activity of Hungarian firms with qualitative methods.

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