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DRIVERS AND DRAWBACKS OF ENVIRONMENTAL INNOVATION – EMPIRICAL ANALYSIS OF THE HUNGARIAN CHEMICAL SECTOR

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ABSTRACT

The empirical study is based on 70 structured interviews with representatives of Hungarian chemical companies carried out by the Budapest Corvinus University in April-May 2010. The 70 companies reported 104 environmental innovations in the last three years. In the cases of 102 innovations, they reported also the degree of innovativeness. Smaller companies (especially microcompanies) have fewer financial resources to realise environmental innovations. Yet this is only true on a 61-72% significance level in cases where small companies had access to external financial sources. About three-quarters of all environmental innovations are adaptations of existing technology. Novel innovations, although fewer in number, seem to have a bigger influence on environmental improvement than adaptations. Considering that these novel innovations can then be adapted by other companies, they have outstanding significance. I analysed the relationship between the novelty of innovations and the financial position of the company producing them. I found that there is a difference between the return on investment in novel innovations and adaptations favouring the former. Companies in the worst financial position find it hard to accomplish novel innovations, very few of them pursue these instead of adaptations. Companies with average or above average financial position (64-70% in our sample) are able to achieve novel innovations.
Keywords: Environment, innovation, chemistry

INTRODUCTION

The effect of mankind on the environment can be described by the following formula (*Ehrlich*, 1968): I=P*A*T, where P means population, A means affluence (calculated with the income per capita), T means technology, which is emission generated in connection with producing goods, services and the consumption of these. In order to be sustainable, we have to decrease our environmental load, to which one way is to decrease the T factor. Reducing T factor is possible with environmental innovation, under which I understand the following in this paper:

Environmental innovation is a technical innovation, through which the environmental load by unit of good/service can be reduced. Environmental advance can actually be the specific aim of the innovation, or just a side-effect.

According to *Iles* (2008) the extent to which green chemistry can change industrial production is uncertain but potentially vast. Many older chemical processes have not been updated with environmental impacts in mind (*Jenck et al.,*

2004). Thousands of chemicals used in everyday products have not been evaluated for their health risks, if any (*Wilson*, 2006). The pharmaceutical industry is notoriously wasteful because of its use of numerous manufacturing steps and batch operations. Generally, companies did not consider energy consumption when developing new processes and products.

THEORETICAL BACKGROUND

Measuring environmental innovation

Innovation activity can hardly be measured, as there is no functional relationship between the input and output of an innovation. Environmental innovation is even harder to be measured, as one innovation usually targets more fields, and environment can be only one of these, or just an unintentional side-effect.

According to *OECD* (2009) there are several ways to measure environmental innovation. The most common ways in the literature are tracking R&D spending, patent data, empirical study and case studies. There are several advantages and drawbacks of each method.

Barriers to environmental innovation

According to the Community Innovation Survey (CIS) in 2006 (*Széchy*, 2011) in Hungary the biggest barrier to environmental innovation are the financial matters (lack of internal financial resources, high cost of innovation, and lack of external financial resources). Bigger companies tend to feel fewer barriers than SMEs.

These findings are in line with other studies. *Johnstone et al.* (2006) found that a facility's business performance have a positive and significant impact on the decision to engage in general R&D. Facilities which report positive profitability over the last three years are more likely to engage in R&D than those who report that "revenue approximately covers costs" (the reference), while those reporting a loss are less likely to report that they have invested in general R&D. Both variables are significant at the 5% level. Thus, financial performance matters a great deal in explaining a facility's innovative behaviour, and this is in line with the general finding that R&D investments are often self-financed.

Taking medium-sized facilities (with 100-499 employees) as the reference for facility size, smaller facilities (with 50-99 employees) are less likely to engage in R&D while larger facilities (more than 500 employees) are more likely to do so. However, those two coefficients are not statistically significant.

Contrary, *Rothenberg et al.,* (2007) finds that in the US printing industry munificence (the 'richness' or 'leanness' of the business firm's environment with respect to resources available to the firm) of the company has no impact of the adoption of environmental innovations. This finding is contrary to the assumption that firms would cut down their non essential – environmental – expenditures in order to deal better with economic uncertainty. There are several explanations for this. First, perhaps investments in environmental technologies are not considered to be 'non-essential expenditures' for many firms. Second, it may be that in highly

dynamic environments, the firms that survive are more capable, both in general and in terms of environmental management.

Rehfeld et al. (2007) finds that regarding innovations in general, size has a significant positive effect on environmental product innovations, albeit the significance level is rather high in the binary logit model.

Chen (2008) compared green core competence, green product innovation performance, green process innovation performance, and green images of Taiwanese large enterprises with those of Taiwanese small and medium enterprises (SMEs) in the information and electronics industry. The study showed that green core competence, green product innovation performance, green process innovation performance, and green images of SMEs were all significantly less than those of large enterprises in the information and electronics industry in Taiwan.

Profitability of radical and incremental environmental innovation

Achilladelis et al. (1990) show that there is a strong correlation between originality and market success of individual innovations, and that a radical innovation may ultimately prove to be more profitable for a company than an incremental innovation despite the high risks associated with its development. They have analysed the most important driving forces for radical innovation in the chemical industry in the period 1950–1980. It turns out that the key factors were 'in-house expertise' and 'market demand', followed by 'science and technology advances' and 'raw materials' (availability or scarcity of feedstocks). 'Competition' came fifth and was followed by 'governmental legislation' and 'societal needs'.

Eder (2003) performed an expert inquiry on the chemical industry. He has found that as a general tendency, there is quite a strong correlation between the ecological and economic potential of the investigated innovation options. Only few exceptions to this rule can be found for some technologies that are economically very promising, but do not have a very big ecological potential (new drugs, new polymers; to a lesser extent information technology and new pesticides). Deviations from the rule are even less important in the other half of the matrix, where just closing/interlinking of material flows and recycling as well as use of innocuous reagents seem somewhat better ecologically than economically.

Differences between cleaner production type and end-of-pipe technologies

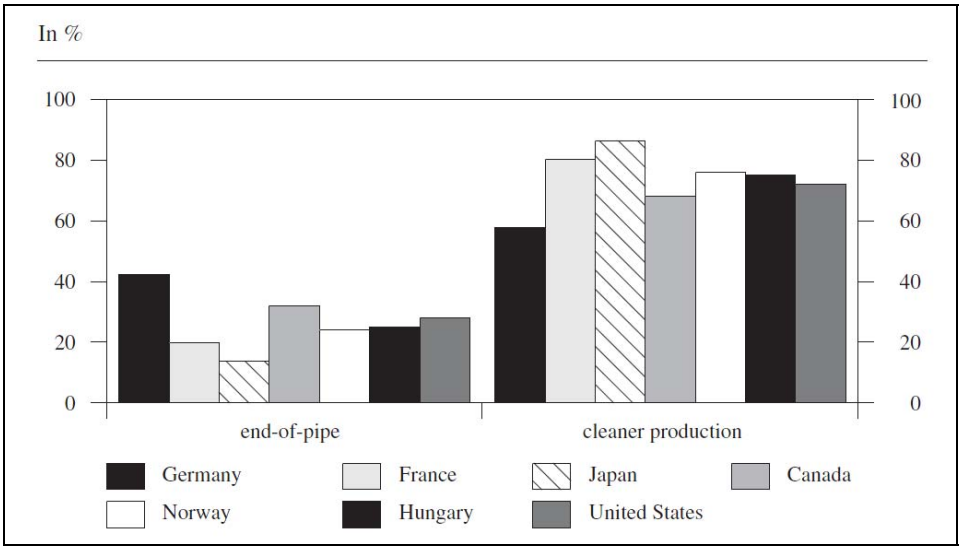
According to *del Río González* (2009) and *Csutora et al.* (2004), cleaner production technologies are frequently regarded as being superior to end-of pipe technologies for both environmental and economic reasons (see *Skea*, 1995; *Kemp*, 1997*; Murphy and Gouldson*, 2000; *Johnstone and Labonne*, 2006 and *Frondel et al.*, 2007, among others).

Frondel et al. (2007) found that cleaner production technologies are frequently more advantageous than end-of-pipe technologies for both environmental and economic reasons, but technology choices are often influenced by the specific environmental problem and the regulatory framework stipulating a certain technology standard that can only be reached with end-of-pipe measures. Apart from the flexibility of regulation, the choice between these two technology options

also hinges on their cost-effectiveness for meeting the required standards. They find that firms appear to predominantly invest in cleaner production technologies (*Figure 1*).

Figure 1

Choice of environmental technologies in 7 OECD countries



Source: *Frondel et al.,* 2007

METHODS

The empirical study is based on structured interviews with representatives of Hungarian chemical companies, carried out by the Budapest Corvinus University in April-May 2010. This research was part of an international study, within the EU Act Clean project, which focuses on environmental innovation. Chemical professionals were involved in planning the interviews, in order to ensure the relevancy of the interview questions. The objects of the study were the Hungarian chemical companies, with the exception of the pharmaceutical sector. (We didn't deal with the pharmaceutical sector due to the large discrepancy between them and the rest of the sector.) There are about 700 companies registered in the chemical sector, and by taking out that are active mainly in the pharmaceutical sector, having only commercial or no activity, we came to a list of about 350 companies. We had the opportunity to interview 70 of them personally. Interviews were carried out by students of the Budapest Corvinus University, who were preliminary trained. The 70 companies reported 104 environmental innovations in the last three years. In case of 102 innovations, they reported also the innovativeness.

The advantages of the empirical study are that we could directly observe realized innovations, and gather a lot of data about them, and also about the backgrounds and effects.

We tried to deal with the disadvantages of the empirical survey in the following ways:

- *low answer rate:* we contacted the companies through the Hungarian Chemical Industry Association (MAVESZ), so we got data from 20% of the companies.
- *low quality of data:* through the personal contact we had the opportunity to have the companies answer a lot more question (and more thoroughly), than they would have in case of a postal survey.
- *subjective element:* The companies named the specific examples of innovations, and we could judge them. Of course the subjective element regarding other questions still remains.
- *interviewee's proper information* about the company and the questions: due to the personal contact we could control that the interviewee is in position to answer the questions and the interviewer could give exact information regarding the survey questions.

In our sample, the variables are mostly qualitative, quasi-rank and rank level. I applied the $\chi 2$ test of independency using contingency tables. The drawback of this method is that the number and the limit of categories influence the results, so in most of the cases I've done the analysis with multiple versions. As a general rule, with the sample size of about 100, 6-12 categories can be created.

Examples

Examples of environmental innovations are:

- Delivering the barrels back to the supplier for burning and reusing.
- Cleaning the pipes with a cheaper and more environmentally friendly material, instead of dissolvent
- Using less mineral-oil in the end-products
- Collecting the waste selectively
- Monitoring the contamination of ground water
- Sewage treatment facility
- Using heat exchanger in the technology

From this list it is clear (and is underlined by lot of interviewees) that the main driver of innovation is not always the environment, but the reducing of costs and upgrading technology.

Most of the examples can be grouped into 4 categories:

- Upgrading technology
- Recycling
- Filtering
- Green(er) products

Hypothesis

Hypothesis 1:
Companies in better financial position have realized more novel innovations.
Based on the literature I assume that financial matters represent a significant barrier to novel environmental innovations.

Hypothesis 2:
Small and medium sized companies had less financing to realize environmental innovations, than big ones.

Hypothesis 3:
Novel innovations had better profitability and environmental performance than adaptations.

There is very limited literature on this specific issue. There seems to be a common view that in this respect radical innovations are better than incremental ones, and cleaner production type technologies are better than end-of-pipe technologies. Novel innovations tend to be more the cleaner production type.

Hypothesis 4:
Companies with more efficient and modern equipment wee able to realize more novel environmental innovations.

RESULTS

I analysed the relationship between novelty of innovations and the internal financial position of the company. There is a difference on a 98-99.9% significance level between the 3 categories, as can be seen on *Figure 2*. There is a difference between the two kinds of adoption on a 98% level, but difference between novel innovation and adaptation of mature technology on an 88% significance level. Companies with average financial position are making novel innovations and adapting mature rather than new technology[1]. The reasons behind this have to be further analysed.

In case of relation of external financial position and novelty of environmental innovation, I came to similar conclusion, there is difference on a 99.6% significance level. In this case there is no significant difference between the adopters of mature and new technology (difference on a 14% significance level) (*Figure 3*).

According to the results, companies in the worst financial position (both own or external financing) are finding it hard to accomplish novel innovations, very few of them had chosen these against adaptations. Companies with average or good financial position (61% in the case of external and 76% in the case of internal financing) are able to gather enough financing to achieve novel innovations. We can reject Hypothesis 1, however we can confirm, that it is true taking only companies in bad and average financial position. We can assume, that companies in good financial position would be able to realize more novel innovations, but there are other factors affecting their decisions.

[1] Interviewees could judge financial position, modernity and efficiency of the company on a scale of six. The three categories of the analysis were created from these, by merging categories 1-2, 3-4 and 5-6.

Figure 2

Relation of internal financial position and novelty of environmental innovation

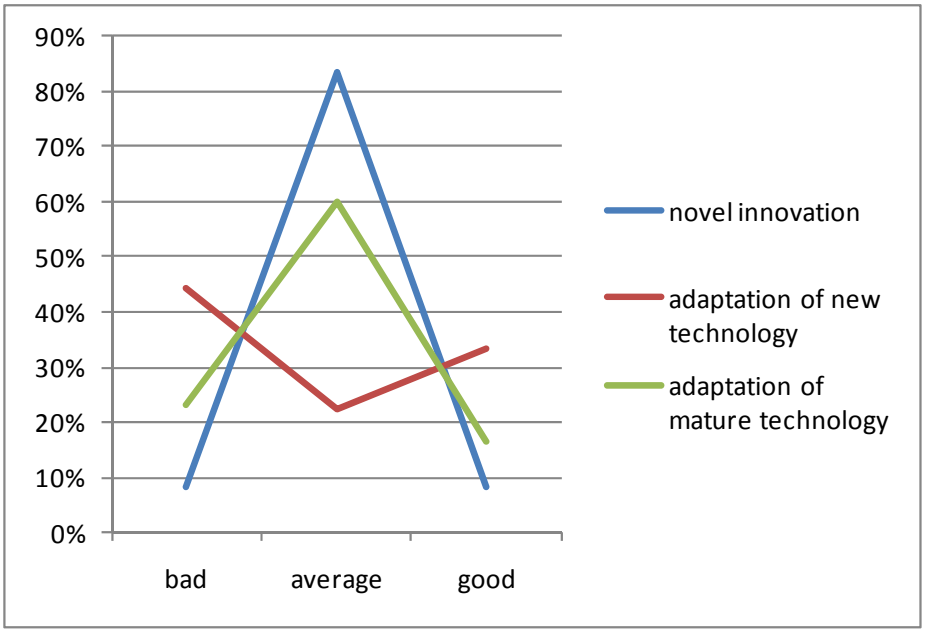
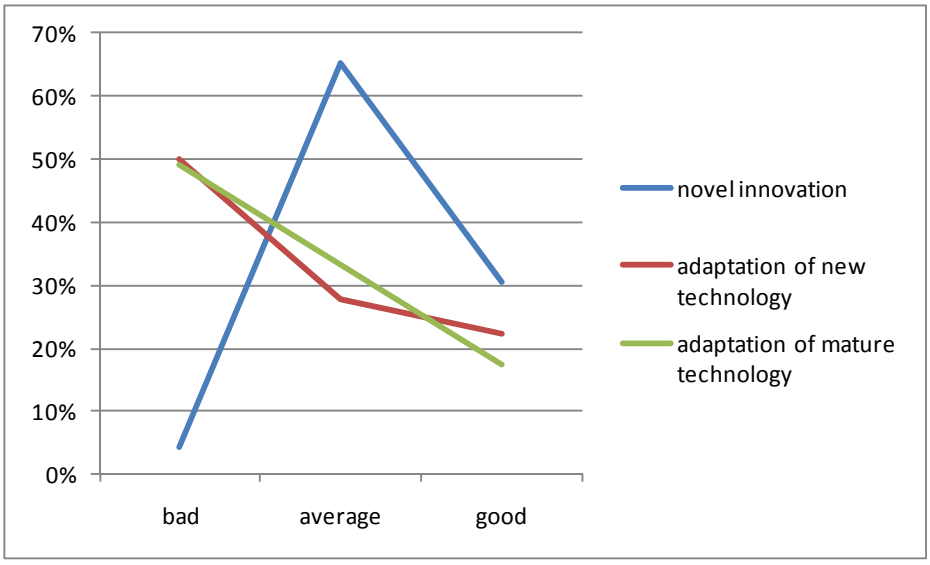


Figure 3

Relation of external financial position and novelty of environmental innovation



Smaller companies (especially the micro size companies) are having less financial resources from inside the company to realise environmental innovations than bigger ones, on an 84-95% significance level, which is a probable result (*Figure 4*).

If we leave out micro size companies, there is no significant (28-60%) difference between small-medium and big companies. Size of the company is measured by the number of employees. Micro size companies are firms with less than 10 employees, small companies are between 10-49 employees, medium companies are between 50-250 employees and big companies are over 250 employees in this research. In the sample there are only 4 pieces of big companies.

On the other hand this is only true on a 61-72% significance level, in case of access to external financial sources (*Figure 5*). Even less significant when leaving out micro companies (28-59%).

On average, 39% of companies are lacking proper external financing for environmental innovations. In the case of micro companies it is 54%, which is a non-significant difference.

The results show, that smaller (especially micro) companies have significantly less financing from internal sources, but it is partly compensated by the access to external financial resources. Not only should the big companies be able to gather proper financing for innovations. We can accept Hypothesis 2 only on a significance level of 61-72%.

Figure 4

Access to internal financing for environmental innovations

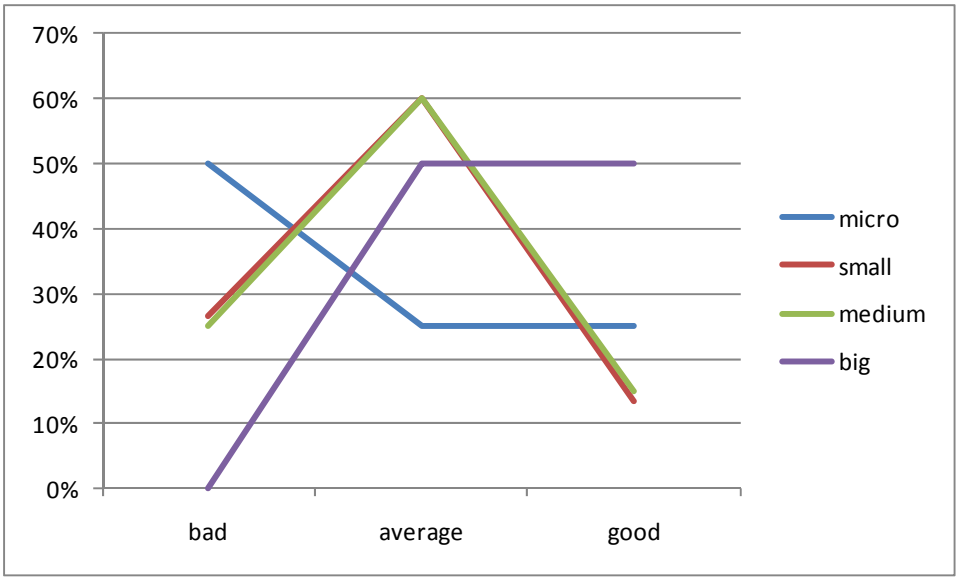
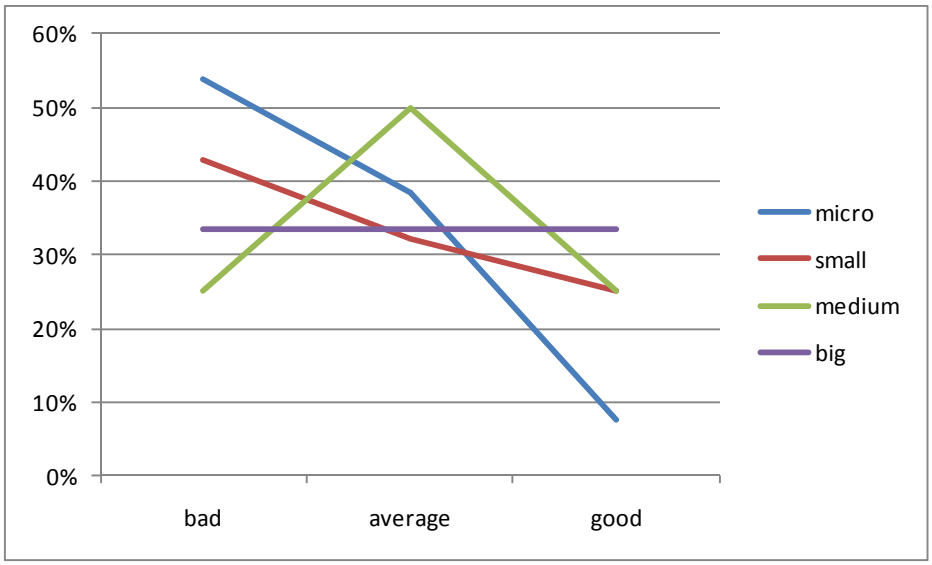


Figure 5

Access to external financing for environmental innovations



About three-quarter of all environmental innovations are adaptations of an existing technology. Novel innovations, although lower in number, seem to have bigger influence on environmental improvement than adaptations, and taking into account that these can be adapted by other companies, shows the real significance of them (*Figure 6*).

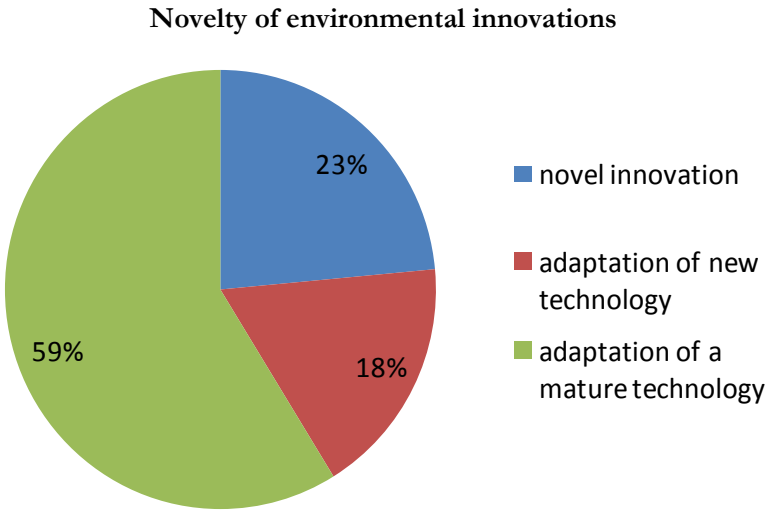
From the database I've created a variable called "environmental improvement". This variable is created by the aggregation of the 9 environmental categories in the interview (namely: energy efficiency, material efficiency, amount of waste material, toxicity of waste material, air pollution, water pollution, soil pollution, toxicity of products, toxicity of raw materials). I've found that on 94-99% significance level, the more novel an environmental innovation is, the bigger the environmental improvement is.

The effect of the novel innovations could even be multiplied, because novel innovations can be adopted by other companies. This underlines the importance of novel innovations, which are although lower in number, but cause bigger environmental improvement. Companies and policymakers should strive for increasing the proportion of novel innovations between environmental innovations.

I've found that there is a difference on a 90% significance level between the return on investment of novel innovations and adaptations, favouring the previous. There is no significant difference between the ROI of the adaptation of a new technology or the adaptation of a mature technology (difference on a 21% significance level).

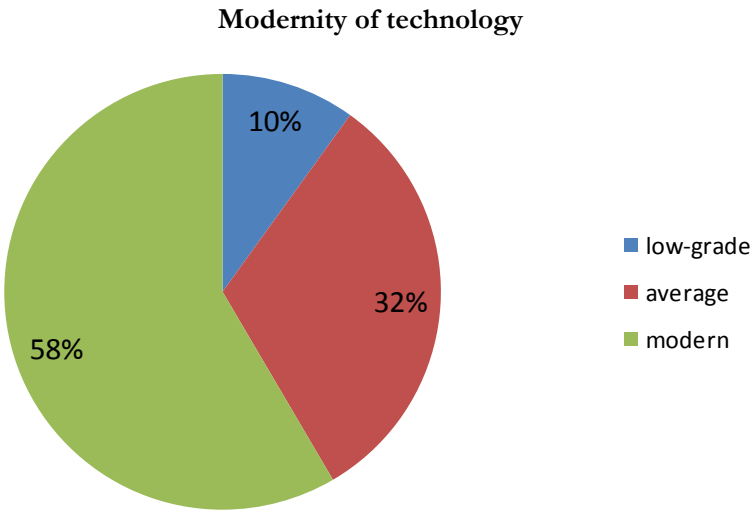
Novel innovations tend to be more the type of cleaner production than end-of-pipe technologies on a 93% significance level in this study, which is logical, because the company has better understanding of his own technology than the filtration technology. We can accept Hypothesis 3 on a 90% significance level.

Figure 6



As it can be seen on *Figure 7*, most of the companies have modern technology, only 10% have admitted to have low-grade technology.

Figure 7



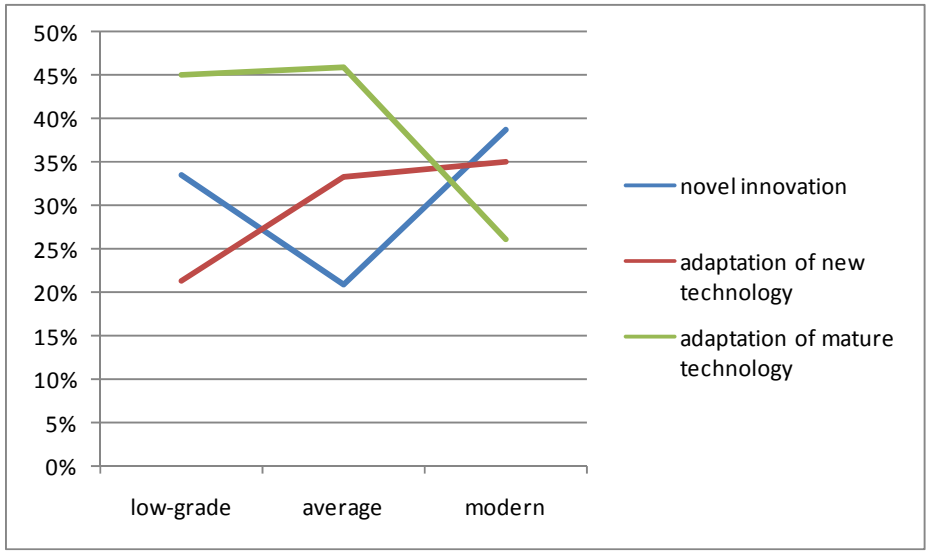
I analysed the relation between the modernity of a company's technology and the novelty of innovation, and found that there is only a weak relation, difference only on a 70% significance level (*Figure 8*).

With low-grade technology a firm can have any type of innovation (no lock-in of the technology), with average technology adaption is slightly more possible (and

tends to be mature technology), with modern technology you might not adapt as many mature technology.

Figure 8

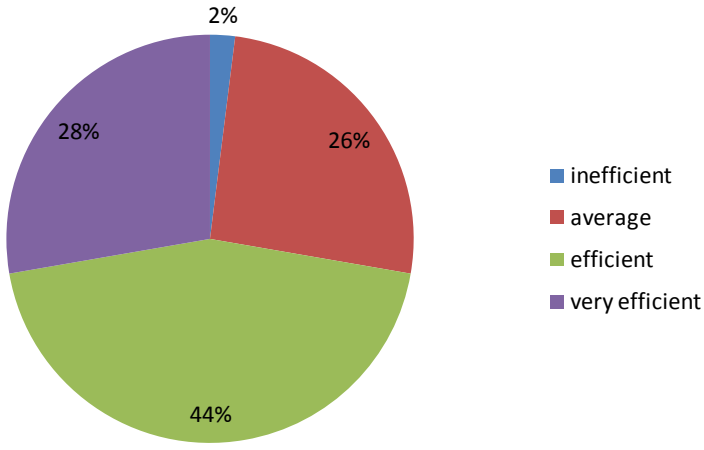
Relation of modernity of technology and novelty of environmental innovation



Only 2% of companies admitted to have inefficient technology, most of the companies have efficient technologies (*Figure 9*). It seems that inefficiency is more critical for surviving than low-grade technology.

Figure 9

Efficiency of technology

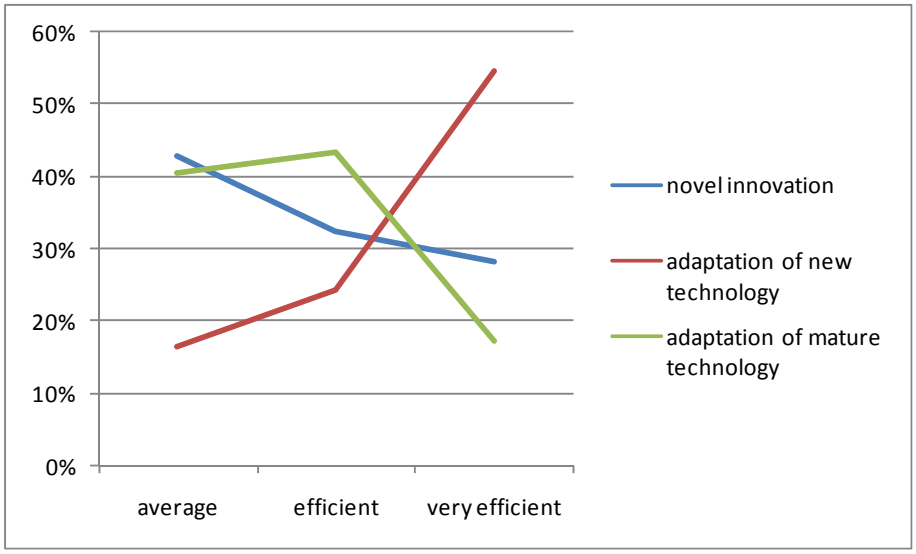


There is a relation between the efficiency of the technology and the novelty of environmental innovations on a 97% significance level (*Figure 10*).

Very efficient companies are more likely to adapt new technology. Companies with average efficiency are likely to adapt mature technology. Both types of companies are almost as much as capable of novel innovations.

Figure 10

Relation of efficiency of technology and novelty of environmental innovation



Modernity and efficiency of the technologies of the companies have moderate influence on the novelty of innovations. It rather affects the decision between the adoption of new or mature technologies. Companies with low grade and lower efficiency technology should be able to create novel innovations. Moreover, they might have more potential, as there is more room for improvement and less technology lock-in. We can reject Hypothesis 4.

Given these findings, it is important to note the limitations of this study. First, this study is limited to one industry (chemistry). There is relatively small number of firms, and the drawback of $\chi 2$ test of independency is that the number and the limit of categories influence the results (although in most of the cases I've done the analysis with multiple versions). Above these, this industry has special characteristics, therefore, it might not be possible to generalize some of its findings to other industries.

CONCLUSION

When asked about environmental innovations, companies usually admit, that they would need more money to spur innovation activity. In this paper it is proven, that

proper financing is indeed crucial for these types of innovations, but most of the companies are able to raise the funds needed. From environmental innovations, novel innovations have the best environmental effect, so I tried to analyse the boundary conditions of these. I found that most of the companies with average or good financial position are able to gather enough financing to achieve novel innovations. Companies in the worst financial position (both own or external financing) are finding it hard to accomplish novel innovations, very few of them had chosen these against adaptations. Companies with low grade and lower efficiency technology should also be able to create novel innovations. Moreover, they might have more potential, as there is more room for improvement and less technology lock-in. Taking into account that novel innovations have better return on investment than adaptations, there is further room for environmental improvement through the facilitation of novel environmental innovations.

REFERENCES

Achilladelis, B., Schwarzkopf, A., Cines, M. (1990): The dynamics of technological innovation: the case of the chemical industry. In: Res Policy, 19. 1-34. p.

Chen, Yu-San (2008): The Driver of Green Innovation and Green Image – Green Core Competence. In: Journal of Business Ethics, 81. 531–543. p.

Csutora, M., Kerekes, S. (2004): A környezetbarát vállalatirányítás eszközei. KJK-Kerszöv : Budapest

del Río González, P. (2009): The empirical analysis of the determinants for environmental technological change: A research agenda. In: Ecological Economics, 68. 861-878. p.

Eder, P. (2003): Expert inquiry on innovation options for cleaner production in the chemical industry. In: Journal of Cleaner Production, 11. 347-364. p.

Ehrlich, P. R. (1967): The Population Bomb. New York, Ballantine Books.

Frondel, M., Horbach, J., Rennings, K. (2007): End-of-Pipe or Cleaner Production? An Empirical Comparison of Environmental Innovation Decisions Across OECD Countries. In: Business Strategy and the Environment, 16. 8. 571-584. p.

Iles, A. (2008): Shifting To Green Chemistry: The Need for Innovations in Sustainability Marketing. In: Business Strategy and the Environment, 17. 524–535. p.

Jenck, J., Agterberg, F., Droescher M. (2004): Products and processes for a sustainable chemical industry. In: Green Chemistry, 6. 11. 544-556. p. in Iles 2008.

Johnstone, N., Labonne, J. (2006): Environmental policy, management and R&D. In: OECD Economic Studies, 42. 1. 169–203. p.

Kemp, R. (1997): Environmental Policy and Technical Change: a Comparison of the Technological Impact of Policy Instruments. Edward Elgar, Cheltenham. in del Río González 2009.

Murphy, J., Gouldson, A. (2000): Environmental policy and industrial innovation: integrating environmental and economy through ecological modernisation. In: Geoforum, 31. 33–44. p. in del Río González 2009.

OECD (2009): Indicators of innovation and transfer in environmentally sound technologies. ENV/EPOC/WPNEP/(2009)FINAL, Environment Directorate/Environment Policy Committee, Paris

Skea, J. (1995): Environmental technology. In: Folmer, H., Gabel, H.L., Opschoor, H.O. (eds.): Principles of Environmental and Resource Economics. Edward Elgar : Cheltenham in del Río González 2009.

Széchy, A. (2011): Környezeti Innovációk a Hazai Feldolgozóiparban. Ph.D. értekezés-tervezet

Wilson, M. (2006): Green Chemistry in California: a Framework for Leadership in Chemicals Policy and Innovation, report to the California State Legislature by the University of California at Berkeley. in Iles 2008.