CORVINUS UNIVERSITY OF BUDAPEST

ENVIRONMENTAL INNOVATIONS IN THE HUNGARIAN MANUFACTURING SECTOR

PH.D. THESIS

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Introduction

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.

Innovation as a competitiveness factor has increasingly been in the focus of researchers and policy makers over the past years (let it be sufficient to mention the Lisbon Strategy of the European Union whose original goal was to make the EU the most dynamic knowledge based economy of the World). Accordingly, surveys examining the innovation activity of the company sector are regularly undertaken in the EU as well as in Hungary in which recently the environmental dimension of innovation has also appeared.

There has, however, been no study expressly focusing on environmental innovations and containing in-depth analysis of the different types of environmental innovations in Hungary. This would be all the more important because the available data shows that Hungary is significantly lagging behind many other European countries in terms of innovation performance. Hungarian innovation policy is making increasingly conscious efforts to bridge this gap – it would therefore be definitely useful to know how these efforts can be directed at the same time to improve the quality of the environment.

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 to organisational issues; 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.

The literature, starting from various theoretical foundations, identifies several factors which may influence corporate environmental innovation activity. The environmental economics approach focuses on regulations, evolutionary economics emphasises the role of external factors, while the resource-based view deals with firm internal factors. The environmental strategy literature also provides valuable insights showing that companies' environmental behaviour is strongly shaped by the decision makers' attitudes, i.e. how they perceive the threats 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.

The research is based on the results of a questionnaire survey with the participation of nearly 300 companies of different sizes and geographical locations from the field of the chemical, food, machines, vehicles and electronics industries. The questionnaire, which was compiled with the help of industry experts, examines the intensity of the firms' environmental innovation activity, as well as its possible determinants and barriers. It adopts a novel approach compared to previous research in that innovation activity is not only examined in general but also through specific innovation examples, providing detailed information on the nature, motivations and results of these innovations and is therefore suitable for differential analysis. The questionnaire was implemented via face to face interviews and contains several open-ended questions enriching the research with some qualitative elements. The results of the survey were analysed with statistical methods: frequency analyses, crosstabulations and correlations. The structure of the variables related to the determinants of innovation was examined via cluster analysis and their overall effect was captured in a binomial logit model.

Differentiating between the types of environmental innovation in the analysis has clearly proven to be justified, as the research has shown significant differences in their motivations as well as their environmental effects related to both type and degree of novelty of the innovations. Firm size is an important but not exclusive determinant of environmental innovation, and the differences between the size categories are also present not only in the prevalence but also the nature of innovations – as was the case between the different industries.

The structure of the dissertation is as follows: in the theoretical section I first briefly examine the role played by technological innovations in overcoming global environmental problems. This is followed by outlining the concept of innovation and the main questions of innovation research.

After general innovation theory, I move on to theories related to environmental innovations and present an overview of the theoretical literature as well as previous empirical studies identifying the factors which have been found to influence corporate environmental activity. The next section presents the results of innovation surveys from the EU and Hungary, followed by the main characteristics of domestic innovation policy. The theoretical section concludes with the descriptions of the results from previous European and Hungarian studies on environmental innovation.

The literature review is followed by presentation of the research model, hypotheses and methodology. Discussion of the research results begins with the general characteristics of the sample and the environmental innovation activity of the companies. This is followed by the analysis of the determinants: firm resources and capabilities, stakeholder pressure, perceptions about the economic effects of environmental innovations and the companies' environmental effects; and the regression model examining the combined effect of the above factors. The analysis continues with the motivations and environmental effects of the specific innovations, and finally, the barriers to environmental innovation. The dissertation concludes with the examination of the hypotheses and a summary of the results.

1. Theoretical background

1.1 The role of technological development in solving environmental problems

In this dissertation forms of practical implementation of environmental innovation and its influencing factors are discussed. It is clear that better understanding of the supporting and hindering factors is absolutely necessary if we wish to enhance the efforts of companies in this respect. At the same time, the choice of this topic inherently suggests that environmental innovation activities of companies are considered to be a positive process which contributes to the solution of the environmental problems of mankind. As mentioned in the introduction, there are rather different views concerning the role of technological development in overcoming the environmental challenge. It is not the goal to of this dissertation to analyse these contradictions in depth, but I still think it necessary to mention briefly the wider context surrounding the issue of environmental innovation.

The nature of the worldwide environmental challenge is well described by the so called „Ehrlich formula”. According to the formula, global environmental impact can be decomposed into the product of three factors, namely population, per capita consumption (GDP) and the environmental impact per unit of GDP (which depends primarily on technology). (Ehrlich-Holdren 1971) Thus, if we intend to reduce the global environmental impact, this can theoretically be achieved by reducing one or more of the three above factors.

Since the purposeful reduction of the population or that of the per capita consumption would require fundamental rearrangement of the present social and economic system, these ideas – although representatives of ecological economics argue the necessity of such measures quite convincingly (e.g. Hueseman 2003) – are unpopular among business and political decision makers alike. Since economic growth is a main priority in market economy based consumer societies, presently there are no realistic signs of its being challenged at the political level. (This situation is well illustrated by the fate of the concept of sustainable development. Here, the re-interpretation of a concept originally centring on the ecological limits of the carrying capacity of the Earth has take place in such a manner that next to the ecological aspect, the social and economic dimensions also appeared, and presently, the discussion is often about sustainable – i.e. continuous – economic growth (Welford 1997, Kiss 2008)).

In as much as an intervention into demographic processes and consumption is rejected, it is only the technological factor – that is, environmental efficiency – which remains the sole way out of the environmental crisis. In principle, increasing environmental efficiency by better utilization of the natural resources makes it possible to reduce the environmental impact without decreasing the level of material welfare. Accordingly, the long term environmental strategy of most countries is based on improving environmental efficiency. The notion of "decoupling", referring to the separation of economic growth and environmental impact has become a central idea. Terms such as "dematerialisation" or "decarbonisation" of the GDP are also referring to this separation.

Influential studies e.g.: "Factor Four" by Ernst Ulrich von Weizsäcker (Weizsäcker et al. 1998) discuss the immense possibilities connected to the improvement of environmental efficiency. Great popularity was achieved by the paradigm of "ecological modernisation" which offers an appealing vision of the future; assuming that environmentally friendly trends in technological development and the system-wide application of eco-innovations will bring about the solution of environmental problems and simultaneously give new impetus to economic development (Jänicke 2008, Pataki 2009). This was the spirit in which e.g.: the 2020 strategy of the EU or the "Green Growth" strategy of OECD (OECD 2010) was conceived. The basis of the ecological modernisation theory is the so called "Porter-hypothesis" (Porter – van der Linde 1995), according to which environmental protection is not, as traditionally assumed, simply a cost-increasing factor; rather, because it stimulates more efficient operation, it eventually results in increased competitiveness for companies or even national economies. Thus, in this approach, stimulating environmental innovation and the removal of hurdles from its path is a principal political task (Coenen – Díaz Lopez 2010).

Critics of the ecological modernisation theory emphasize that there are several problems hindering the technology based solution of environmental problems. One of these is the vested interests opposing the widespread application of environmental friendly technologies (e.g.: the fossil fuels lobby). Another aspect is that not all environmental problems have a technological solution, for example urbanisation or the loss of biodiversity. Jänicke (2008) and Pataki (2009) point out that because the ideas of ecological modernisation do not touch the foundations of the business mindset and do not deal with ethical or power aspects, this is considerably reducing their potential contribution to environmental sustainability.

However, the most serious criticism is related to the so called “rebound effect”, and fundamentally questions the environmental potential of increased efficiency. The essence of the rebound-effect is, that due to increased efficiency, the given product or service will become cheaper and thus, demand for it will rise, and the increased consumption will undermine the environmental advantage. The magnitude of the rebound effect depends on several factors (e.g. price elasticity of the demand). In extreme cases it may even happen that the use of the given resource will actually increase in absolute terms – but in all cases it is true that the environmental benefit expected from the improved efficiency will not be realised to a full extent (Jänicke, 2008).

Because of the above problems it is increasingly suggested that for a real solution, it is necessary to go beyond technological improvements concerning individual products or manufacturing processes and reforms of entire socio-technological systems (e.g.: mobility or food supply) are required (Coenen – Díaz López 2010, Smith et al. 2010). These solutions would obviously affect our entire way of life – although the focus is still on increasing environmental efficiency but for example besides more sustainable production, the “green growth” strategy of the OECD is already discussing making also consumption more sustainable (OECD 2010). Jänicke (2008) also argues that achieving ecological sustainability cannot be accomplished without structural changes (that is changes in the structure of supply and demand). At the same time he maintains that improvements in environmental efficiency represent at least as big an environmental potential as strategies based on lifestyle changes.

Interesting thoughts are put forward in this respect by Femia et al. (2001) who suggest that the problem is too narrowly presented by the Ehrlich-formula, since the ultimate goal of human activity is not to produce material goods, but human well being. Between human well being and environmental impact there are several factors which offer possibilities for intervention: reduction of the environmental impact per unit of production is only one of these. According to the authors, decoupling of well being and environmental impact can also be accomplished by reducing the amount of products per unit of services (after all it is not the products themselves which people need but the functions or services offered by them, e.g. it would not be necessary for each person to individually possess a given product in order to be able to use it). A further possibility is to try to increase well being while at reducing the quantity of services (e.g. by increasing leisure time or by enhancing human relations).

Thus, increasing environmental efficiency by technological innovation and transforming the structure and intensity of consumption are not mutually exclusive alternatives; on the contrary, they can complement each other in solving environmental problems. The magnitude of the environmental challenge necessitates full utilisation of all possibilities (Jänicke 2008, Femia et al. 2001). The author of this dissertation agrees that the quest for sustainable development cannot be limited to technological innovations – nevertheless, these are an important element of the reduction of environmental impact, thus the study of their drivers and the ways to enhance them remains an important task.

1.2 Innovation theory

In order to study environmental innovation it is necessary to identify the main concepts, theories and research trends concerning innovation itself. This is the topic of the next sub-chapters.

1.2.1 The concept of innovation

The economic significance of innovation was first emphasized by Joseph Schumpeter in the first decades of the XX. century. At the time, mainstream economic thinking was focusing on the description of the equilibrium states of the economy, technology was considered as an exogenous factor. Schumpeter, however, saw the economy as a system undergoing continuous change because of technological development, where companies compete through innovation activities just as through prices (Schumpeter, 1980). Schumpeter defines innovation as a novel combination of the production factors and distinguishes five main types:

- Opening up of a new market
- Production of a new product or product quality
- Introduction of a new production process
- Opening up of a new raw material procuration source
- Carrying out the new organisation of an industry

Schumpeter emphasizes the difference between the concept of invention and innovation: a central element of innovation is namely the successful application while this does not always happen in case of each invention. At the same time, innovation is not necessarily based on a new scientific or technological discovery.

In connection to the concept of innovation, representatives of the management sciences emphasize the idea of novel ways of satisfying consumer demands. According to Peter F. Drucker's influential book, innovation means “changing value and satisfaction obtained from resources by the consumer” (Drucker 1985, p.31). Similarly this approach is applied by Attila Chikán in his textbook on business economics, where innovation is simply defined as “satisfaction of consumer demands at a new, higher level” (Chikán 2005 p.215)

Although innovation can be defined in many ways, currently researchers and policymakers predominantly apply the concepts of the so-called Oslo Manual, elaborated jointly by OECD and EUROSTAT. The Manual was first published in 1992 in order to provide a uniform conceptual and methodological framework for the study of innovation. While in the first edition the problem has been approached from the point of view of production, in the third edition published in 2005 the concept of innovation is already extended to include the service sector and organizational as well as marketing innovations.

> **„An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.” (OECD 2005, p.46)**

This dissertation deals with (environmental) product and process innovations – together called *technological innovations*. According to the definition of the Oslo Manual, “a product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.” (OECD 2005 p.48). Process innovation is defined as “the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software." (OECD 2005 p.48) Distinguishing between product and process innovation is not always unambiguous. What is a product innovation from the point of view of a certain company may play a role in the renewal of processes at another point in the value chain (Dodgson et al. 2008).

According to the definition of the Oslo Manual, everything is considered as innovation that is *new to the given company*, thus innovation includes both internally developed and adopted solutions. Based on the degree of novelty, the Manual distinguishes innovations new to the company, to the market, or to the World. Thus, it should be stressed that innovation is not equal to research and development (R&D). Related to R&D, the OECD and EUROSTAT have also published a document, the so-called Frascati Manual. Here, the following definition is given for R&D: "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications." (OECD 2002, p. 30)

The main types of R&D are basic research, applied research and experimental development. In spite of the clear differences, it is a frequent problem that the concepts of innovation and R&D are confused even by experts (Némethné 2010a).

1.2.2. Basic trends in innovation research

Following the work of Schumpeter, the study of innovation from the perspective of the social sciences started to gain real importance only in the 1960s. The study of innovation is possible from the viewpoint of several scientific fields: while economics approaches investigate mainly the resources spent on innovation and the impacts of innovation; the process itself, which takes place within organizational structures and where learning has a central role, is studied by organization theories, sociology and management science (Fagerberg 2006).

In economic science, the school based on the concepts of Schumpeter is called innovation economics or *evolutionary economics*, since development of the economy is understood similarly to biological evolution. Here, the source of the changes is the appearance of innovations, the success of which depends on how far they meet the challenges of the external environment. Within the field of management science, evolutionary economics is related to the *resource based view of the firm*. According to the latter, resources and capabilities of the firm decide how successfully it can adapt to its environment, that is, to gain competitive advantage (Wernerfelt, 1984). Three basic questions can be identified throughout the literature dealing with innovation: the first is how to distinguish between radical and incremental innovation, the second concerns the source of innovation, and the third is how far the process of innovation can be institutionalized (Tzeng, 2009).

The division of innovation into *incremental and radical* changes goes back to the 1970s. Radical innovations contain a significant degree of novelty and lead to deep rearrangements in the companies' processes or markets; while incremental changes mean slight changes, continuous improvement of the technology within the existing structures (Freeman, 1982). Incremental innovations are based on perfecting the existing knowledge thus usually strengthening the position of established market players; while radical innovations (which are much less common) usually – but of course not always – undermine the position of established players (Utterback, 1996). Schumpeter himself looked upon innovation as "creative destruction" thus he stressed the importance of radical innovation; but from the point of view of the development of the economy the sum of incremental changes also has great significance (Fagerberg, 2006).

Later representatives of evolutionary economics interpreted the radical-incremental dimension of innovation connected to the concept of so called technological regimes. *Technological regimes or paradigms* are formed due to pressure from the selection environment when a certain technology – due to economies of scale, learning curves, transaction costs, correspondence to the environment, etc. – achieves a dominant position which excludes the spread of alternative solutions. After that, incremental developments within the given technological regime usually follow, until significant changes in the selection environment result in radical innovations again, changing the technological regime (Dosi, 1982).

The next basic question is related to the *source of innovation*. For a long time, models describing the process of innovation were so called *linear models* which interpreted innovation as subsequent chains of separate activities (Dodgson et al., 2008). In this approach, the main steps of innovation are basic research, applied research, invention, market testing and diffusion. Thus, in the world of linear models the basic question is the direction of the process: is it the development of new technologies which generates innovation ("technology push"), or is it the market demand which sooner or later creates the solutions enabling its satisfaction ("market pull")? The following are listed as possible sources of innovation by Drucker (1993):

- unexpected events
- incongruity (between reality as it is and as it is assumed to be or "ought to be")
- the needs of processes
- changes in industry or market structure
- demographic changes
- changes in perception, moods and meanings
- appearance of new knowledge (scientific and non-scientific).

It can be seen that both market and technological factors can be found in the list and any of these can be a source of innovation. At present, the linear concept of innovation is generally dismissed in the literature and innovation processes are usually explained by the combination of the two models.

Innovation is increasingly considered as a complex interaction between market- and technological factors where conscious strategic processes within the company, organizational solutions supporting innovation, and networks play an important role (Figure 1) (Dodgson et al., 2008).

Figure 1: Strategic integrated model of the innovation process

source: Dodgson et al. 2008 p 63.

The third basic question is *to what extent it is possible to formalize and institutionalize innovation processes*. In the earlier works of Schumpeter, the central role was played by the entrepreneur, whose personal abilities were important in recognizing the opportunities offered by the novelties and to overcome the resistance of others. In his later works however, he stressed the significance of the organized innovation activities of large companies. Although innovations – especially radical ones – are inevitably accompanied by a significant risk of failure, market success and long-term survival of the companies is unthinkable without conscious innovation activities. As Drucker (1985, p.95) puts it: “innovation is real work that can and should be managed like any other corporate function”.

Thus for the management of innovation decisions and processes, a conscious *innovation strategy* is necessary. The most important feature of this strategy is that it must be able to handle a high degree of uncertainty. This means that the instruments of strategic analysis can only be applied to a limited degree, and instead, searching and being able to react to unexpected situations becomes the key to success. According to Dodgson et al. (2008) innovation strategy should manage three basic elements:

- innovation resources
    - financial
    - human
    - technical
    - marketing
    - organizational
    - network
- innovation capabilities
    - searching (identification and evaluation of opportunities and threats from the side of industry and technology)
    - decision (choosing between future options based on results of the search, on the existing resources and on the opportunities for value creation)
    - configuring (coordination of innovation efforts)
    - deployment (implementation of domestically developed or externally procured novelties within give time and budget constraints, establishment and protection of the value originating from innovation)
    - learning (increase of the innovation activity by experimentation and gathering experience)
- innovation processes
    - formation and functioning of supporting networks and communities
    - technological cooperation
    - research and development
    - creation of new products, services and activities
    - achievement of economic benefits by utilization (or selling) of innovations

Categorization of the innovation strategies is usually based on whether the firm adopts a “leading” role or it is merely acting as a follower. A possible division according to Dodgson et al. (2008) is the following (it should be noted that the below types are ideal types, in real life the strategy of companies does not entirely correspond to one or the other type):

1. Proactive innovation strategy: the company is striving to be a vanguard in innovation, is conducting intensive R&D (also including basic research), is also engaging in radical innovations of great risk
2. Active innovation strategy: the company is not the first to innovate, but is trying to follow quickly, its R&D is focused mainly on applied research, it is striving after incremental innovations of medium risk
3. Reactive innovation strategy: the company is cautious, adopting novelties quite late, engaging exclusively in incremental innovations of low risk, acquiring the necessary knowledge from external sources
4. Passive innovation strategy: there is no formalized innovation activity, incremental novelties are introduced under the pressure of customers, no risks are taken.

Iványi and Hoffer (2010) distinguish between leader-, follower- and adopter innovation strategy types, which categorization does not necessary apply for the whole company. According to the authors it may happen that the different divisions or product lines of the company follow different strategies depending on their market potential.

It can also be seen from the above categorization that a significant proportion of innovations are not based on the own developments of the companies but on the adaptation of novelties developed by others. A certain innovation may only accomplish deep changes in the market if a significant proportion of the market participants are adopting it – this process is called the *diffusion of innovation* (Bronwyn 2006). It is generally accepted that the diffusion of innovations follows an S-curve in time – which means it is slow initially, then accelerates significantly and finally – with the saturation of potential adopters – it will flatten out again (Fagerberg 2006, Dodgson et al. 2008).

In his seminal work on the diffusion of innovation, Everett Rogers explains the spread of novelties (be it technological innovation or any new ideas or habits) mainly by social factors, and by the characteristics of the given innovation (Rogers 1962). Potential adopters are divided by Rogers into 5 groups (innovators, early adopters, early majority, late majority and laggards). He is assuming that individuals or organizations which are younger, show a greater acceptance toward risk, have more financial resources and wider relational networks are more likely to fall into the first categories. Factors influencing the diffusion of a given innovation are the following:

- relative advantage (compared to earlier solutions)
- compatibility (with the earlier practice of the potential adopter or with social norms)
- complexity
- trialability
- observability (to what extent the innovation is visible to others)

It can be seen that the flow of information (accessibility of innovation information) plays a central role in Rogers' model. *Information-based models* of diffusion are often called "epidemic" models, since information connected to the innovation and thus innovation itself is spreading among potential adopters like an epidemic. As a certain solution is applied by more and more adopters, more knowledge and experience is gained and the given solution is introduced by others more easily. Naturally, this is true only if the content of the information is positive in nature – thus it is a basic assumption in Rogers' model that innovation is always an advantageous thing (Dodgson et al. 2008).

Rogers' model does not take into account the costs of innovation although that can be an important limiting factor of adoption. On the other hand, the other main branch of diffusion literature, the *economic models* are stressing the importance of those factors (costs, resources, abilities) which determine the adoption decisions of individual companies. Acceptance or rejection of a given innovation is namely the result of a cost-benefit analysis, which is also influenced by the fact that if the company binds itself to a given technology and a more advantageous solution emerges later, the switch to that technology may involve too high sacrifices. Thus, the decision is always about whether the company should introduce the given novelty at a given time or should the decision be postponed to a later date?

At the same time, the diffusion of innovation cannot be considered merely as the sum of individual decisions, since the behaviour of the individual actors is obviously influencing the others. There are certain variables which are endogenous from the point of view of the diffusion process, like the earlier mentioned phenomenon of increasing information – similarly the social acceptance, or the costs of the new technology as it is being perfected may also change. (The sunk costs of technology and the interactions between the market players lead us to the phenomenon of technological paradigms, outlined earlier.)

Finally, it is necessary to mention those diffusion models which study the decisions connected to the introduction of novelties on the basis of the *behavioural sciences*. The most influential model in this field is the “Theory of Reasoned Action” elaborated by Ajzen and Fishbein (1980), and its later version, the “Theory of Planned Behaviour”, by Ajzen (1985). According to the original version of the theory, the intention to act is influenced by two factors: the first one is the attitude towards the given behaviour (in this case innovation) which consists of what the actor believes about the consequences of the behaviour and how desirable those consequences are considered (e.g. the influence of the innovation on the costs or product quality). The second factor is the subjective norm covering the expectations of the players relevant for the actor (e.g. buyers, authorities) and the intention to meet those expectations.

Thus, the TRA is assuming that the intention to act is formed as a consequence of the above factors and this is directly linked to actual action. It is clear however, that actual action can be influenced by several limiting factors independent of the original intention and this was the reason why Ajzen later broadened the model to include the factors of perceived and actual behavioural control. The meaning of the former is to what extent the actor feels himself able to perform the given action – this affects the intention to act – while the actual control factor directly affects the actually realized (performed) action. Models derived from the theory of reasoned action and planned behaviour were mainly applied for studying the diffusion of novelties in information technology (e.g. Davis 1989), but they can be adapted for studies on other fields, e.g. environmental innovation (as will be shown later).

In recent years, an increased attention towards *networks and systems* can be observed in the innovation literature (Dodgson et al. 2008). Since the essence of innovation is the novel combination of thoughts, abilities and resources, it is quite obvious that the greater their available diversity, the more combinations are possible. Thus, the innovation performance of a company is greatly increased if it can get inspirations from its connections with the outside world, in addition to its own resources (Fagerberg 2006). Obviously, this is especially important for small companies, but nowadays innovation requires such complex knowledge that larger companies are also increasingly relying on external sources. In recent decades, a significant increase of innovation cooperations between companies can be observed, be it collaboration with competitors, buyers, suppliers, universities or research institutes. The forms of cooperation also vary widely from informal to contractual arrangements (Power-Grodal 2006).

According to Chesborough (2003) companies should turn from the “closed” approach of innovation (own R&D activities, strict protection of intellectual property rights) to “*open innovation*”, where the boundaries of internal and external activities become blurred and ideas, people and resources are moving freely across the limits of the organization. In this context, the main goal for the company is to gain as much knowledge as possible through its external relations and utilize that knowledge within the company in the most effective way (all this does not mean the complete cessation of own R&D

activities). The concept of open innovation gained great influence in business circles since its appearance but it also received significant criticism. According to Laursen and Salter (2006), openness beyond a certain level brings decreasing returns, since – besides making the protection of intellectual property more difficult – management of the many external partners increases the transaction costs and makes the innovation process more uncertain and slow. Thus, the authors recommend a combination of openness and internal innovation activities.

Cohen and Levinthal (1990) introduced the concept of *absorptive capacity* to describe the capability of companies to integrate and utilize information from external sources. According to the authors, absorptive capacity depends on already existing knowledge which means that the company can best broaden its knowledge in the field to which it has turned initially. Establishing absorptive capacity in new areas requires conscious decision and serious investments. Thus, we again return to the problem of technological path-dependence and lock-in, and the dominance of incremental innovations.

Another important recognition accompanying the development of innovation theory was that beyond the networks between innovation actors, entire innovation systems in geographic areas or economic sectors are also of great importance. There are several interpretations of the concept of *(national) innovation systems*: in a broader sense "they include all parts of the economic structure and institutions which affect the process of learning or acquiring knowledge, further the process of research and utilization of research results. Thus, they include also the production, marketing and monetary systems." On the other hand, in a narrower sense "they include only those organizations and institutions which participate in the research process and in the utilization of new scientific results" (Iványi-Hoffer, p.27, 2010).

Thus, the system-oriented approach points to the fact that innovation achievements in a given country do not exclusively depend on the achievements of individual organizations and institutions but also on the synergy between them. Since innovation nowadays is looked upon as an important determinant of the competitiveness and development of national economies, comparison and evaluation of innovation systems is receiving considerable attention. Such evaluations and rankings are regularly published by the European Union and the OECD. Their conclusions are usually incorporated into the innovation policies of national governments. At the same time, Dodgson et al (2008) are warning that the results of such evaluations should be treated with great caution, since innovation has no unambiguous and reliable indicators, and evaluations based on several different indicators greatly depend on the weighting of the individual indicators.

1.2.3. The concept of environmental innovations

Environmental innovation (also named eco-innovation) does not have a generally accepted definition such as the one found in the Oslo Manual for innovation in general. Although the Manual includes a few examples when the novelty (innovation) is resulting in improvements in the environmental characteristics of a given product or process, explicit definition and criteria to distinguish environmental innovation are not given.

For the definition of environmental innovation two basic approaches may be applied: either those innovations are considered environmental which are *aimed at* the reduction of the environmental impact of the economic activity (e.g. Hemmelskamp 1996), or those which are *resulting in* the reduction of the environmental impact, independently from the original purpose of the innovation. In the literature, the latter approach is more common[1] (e.g. Rennings 2000, Bernauer et. al 2006, Kivimaa 2007, Kammerer 2009). This is logical, considering that if the reduction of the environmental burden via technological innovation is considered desirable, then the results and not the

[1] Not all authors make the definition of eco-innovation they apply explicit. It is of fundamental importance however that the meaning of environmental innovation should be exactly clarified for the persons providing answers or data in the studies.

aims are important, and therefore the motivation and circumstances of every innovation with positive results should be examined. However, statistical data about investments mostly contains information on investments which aim at environmental protection (the Hungarian Central Statistical Office also collects such data). On the other hand, the EUROSTAT innovation surveys apply the result-based approach.

Interpreting environmental innovation as the introduction of environmentally sound technologies will also lead to the result-based approach. The UN Agenda 21 defines environmentally sound technologies (ESTs) as technologies which "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes". Environmentally sound technologies in the context of pollution are "process and product technologies that generate low or no waste, for the prevention of pollution. They also cover "end-of-pipe" technologies for treatment of pollution after it has been generated." (UN 1992, chapter 34, item 1-2.) The EU's Environmental Technologies Action Plan (ETAP) formulates the same idea more concisely: "such technologies are all those where their use is less environmentally harmful than relevant alternatives" (European Commission 2004, page 2).

Therefore, if environmental innovation means the introduction of environmentally sound technologies, then **every innovation resulting in the reduction of the environmental impact related to the economic activity can be considered environmental innovation**. Environmental innovation can therefore be an investment that is implemented by an enterprise primarily to reduce costs, if it results in energy or raw material saving. I will hereafter use this definition (it should however be noted that the reduction of the environmental impact is not a definite criterion in every case, either – for instance in the case of new products where there is no benchmark (Hellström 2007)).

Although most authors fail to stress this, one can only speak of environmental innovation if it results in the reduction of environmental burden *per unit of production*. Thus, reductions of the produced quantity cannot be interpreted as environmental innovation; on the other hand, the company's environmental impact in the absolute sense may increase despite of environmental innovations if there is a sufficiently large increase in production. The World Business Council for Sustainable Development (WBSCD) who introduced the concept of eco-efficiency emphasises that eco-efficiency is not limited simply to making incremental efficiency improvements to resource intensity but encompasses the products' entire life cycle and includes methods to reduce environmental impact such as the reduction of the quantity of toxic materials used (WBCSD 2000). Environmental innovation is thus equivalent to the improvement of eco-efficiency in its wider sense.

However, Hellström (2007) points out that in practice, the focus on eco-efficiency leads to the dominance of incremental process improvements within environmental innovations. This is a problem since radical innovations have more potential from a sustainability aspect, especially as the potential in eco-efficiency improvements is diminishing and only a new, radical innovation can open the way to further development (Murphy – Gouldson 2000).

The division into product, process and organisational innovations is widely used also for environmental innovations (Frondel et al. 2007). Organisational innovations (e.g. the introduction of environmental management systems) do not in themselves lead to the improvement of environmental efficiency but can create more favourable circumstances for technological innovations (Baranyi 2001). The present thesis is only concerned with technological, i.e. product and process innovations. Organisational innovations are not examined in themselves, only in so far as they influence the implementation possibilities of technological innovations.

Within environmental process innovations, a distinction is generally made between end-of-pipe and cleaner production (or preventive) innovations (Csutora – Kerekes 2004). End-of-pipe technology neutralises harmful substances without changing the basic production process, by introducing an additional step. Cleaner production, on the other hand, reduces the production of harmful substances from the start, by improving process efficiency, substituting raw materials, etc. Therefore the latter, although it usually necessitates larger intervention and higher initial investment, often results in cost savings in the long run. Therefore, and because end-of-pipe solutions often aggravate other environmental problems than the one that is being treated (e.g. beside clean water, sewage sludge is produced in the wastewater treatment plant; cars with catalytic converters emit more carbon dioxide, etc.), cleaner production solutions are generally considered superior to and more desirable than end-of-pipe technologies (Frondel et al. 2007, del Río 2009).

1.2.4. Basic trends in environmental innovation research

It has been mentioned that the school of economic thought founded by Schumpeter is based on the central role of innovation. Innovation is the driving force of economic development; therefore the investigation of the determinants of innovation is first priority. However, from a sustainability aspect, not only the economic role of innovation is important but also the question to what extent it contributes to environmental (and social) sustainability – thus, the primary question is the direction of the innovation (Smith et al. 2010). Research on environmental innovation is therefore usually normative; it considers environmental innovation desirable and is concerned with the question of how it can be facilitated. Although some studies point out that environmental innovation due to external motivation (e.g. pressure from the authorities) may impede other innovation activity, there are virtually no studies attempting to identify the "desirable" level of environmental innovation (del Río 2009).

Similarly to innovation in general, environmental innovation has also been studied from the aspect of several scientific schools of thought, each stressing different factors. *Environmental economics* – which is based on neoclassical economics – focuses on the necessity to internalise the externalities represented by environmental pollution. The external nature of pollution means that its costs are not borne by its originators, who therefore will not invest money and effort in pollution reduction – i.e. environmental innovation – on their own accord. The internalisation of externalities (i.e. the reversion of costs to the polluters) is made possible by environmental regulation. Thus, according to the environmental economics approach, properly planned and executed regulation is the key factor in motivating eco-innovation (Rennings 2000).

It seems, however, that the demand arising from the "right" price signals set with the help of regulation is not sufficient to motivate environmental innovation and to explain observed levels of environmental innovation activity. Beside price signals, several other factors influence environmental innovation – a wider scope of which is captured by *evolutionary economics* (Smith et al. 2010). Evolutionary economics applies the concepts of biological evolution (variation, selection, retention) to describe the innovation process (Rennings 2000). The selection environment, i.e. the sum of those external factors that influence a company's innovation decisions (e.g. factor prices, market competition, customer demand, etc.) thus plays an important role (Green et al 1994).

The company's internal characteristics, resources and capabilities are also important as these determine its ability to adapt to its environment. In the field of management sciences, the *resource-based theory of the firm* stresses the importance of these internal factors. Signals from the selection environment do not affect companies automatically – they have to be observed and interpreted, and reaction necessitates strategic action (Green et al. 1994). A significant branch of strategic literature is concerned with companies' *environmental strategy*, which is also a decisive factor for environmental innovation.

One of the most important insights from evolutionary economics is the research on *technological regimes* and path-dependency. Technological regimes or paradigms are the results of pressure from the selection environment, when a certain technology acquires such advantages due to economies of scale, learning curves, transaction costs, adaptation to existing infrastructure, etc., that it practically becomes dominant and impedes the spreading of alternative solutions. This is typically followed by incremental innovations within the given technological regime, until a significant change in the selection environment results in radical innovations and in the change of the technological regime (Dosi 1988).

Technological regimes and the lock-in into dominant technologies is a very important phenomenon from the environmental point of view, as it greatly hinders the shift towards sustainability (e.g. the central role of fossil fuels in the economy) (Unruh 2000). It seems furthermore that the phenomenon of lock-in does not only concern technology but also the institutional, social and cultural systems. Innovations aiming at real sustainability must therefore be concerned with these as well (Rennings 2000, Smith et al. 2010).

Rennings (2000) goes as far as speaking of a "technology bias" in connection with environmental innovation research, and argues in favour of the ecological economics approach, as this approach also takes into account environmental, social and institutional system processes. An important message of ecological economics is the co-evolution of the above subsystems. From an innovation aspect this means that it is not only the environment that influences innovation by selecting the most viable solutions, but technological changes may in turn also affect the selection environment (Norgaard 1984). In recent years, an important direction of environmental innovation research has been the widening of the scope from research on individual technologies to research on innovation encompassing entire systems of production and consumption (Smith et al. 2010). These phenomena, however, cannot be examined on the level of individual companies and thus fall outside the scope of the present study.

1.2.5. Determinants of environmental innovation

As seen above, several factors may influence a company's environmental innovation activity. In the following, an overview of the relevant literature is presented in the order of the theoretical approaches outlined above. First the effects of regulation are described, then the other characteristics of the selection environment (pressure from stakeholders, economic and technological factors), and finally the companies' resources, capabilities and strategy.

1.2.5.1. Regulations

The role of regulation is one of the most widely researched topics among the factors influencing the development and diffusion of environmental innovations. The theoretical explanation for the importance of regulation, as seen above, is provided by environmental economics, by stressing the external nature of pollution. However, from the aspect of innovation economics, it becomes clear that other externalities also hinder innovation, and not only environmental innovation. Usually, innovators are unable keep the profit from the innovation wholly to themselves – sooner or later other companies will share it by adopting or copying the innovation; and so will the consumers, as innovation costs can seldom be passed on to them in full.

The diffusion of innovation also involves externalities: the information and expertise accumulated as a result of the application of new technology makes its usage increasingly cheap and free from risk for other companies. Economic actors are thus moderately interested in developing costly innovations, or to be among the first to implement new technology. (This can of course be compensated if the first companies to implement the innovation can thereby secure new markets. However, this is not typical for environmental innovations as the number of consumers appreciating these innovations is rather low).

In the case of environmental innovation, therefore, both pollution and innovation externalities are present simultaneously – this phenomenon is the so-called "*double externality*" problem (Rennings 2000, Jaffe et al. 2005). As a result of the double externality, it is to be expected that the prevalence of environmental innovations will fall behind the socially desirable level, which makes public incentives for environmental innovation fully justified. These incentives can be twofold, in accordance with the nature of the described externalities: firstly, via the means of general innovation policy, secondly via environmental policy. Corresponding to their mechanism, the former group are generally labelled *supply side*, whereas the latter *demand side* policy tools.

There are several means of subsidising (environmental) innovation (e.g. direct grants for investments, soft loans, tax reduction, technological consulting services, etc.). However, these have so far received relatively little attention in the literature on environmental innovation, compared to research on the effects of environmental regulation (del Río 2009) – most likely because the latter appears specifically in relation to environmental innovation.

Several empirical studies confirm the importance of environmental regulation among the incentives for the improvement of companies' environmental performance (Green et ak. 1994, Dupuy 1997; Pickman, 1998; Cleff-Rennings 1999; Kagan 2003; Berkhout 2005; Kivimaa 2007). This proved to be the strongest factor behind innovation in a survey conducted by the OECD (comprising data from 4,200 firms from seven countries) on an international level (Johnstone 2007), and also in Hungary (Kerekes et al. 2003). By deeper analysis of the Hungarian results, Harangozó (2007) has come to the conclusion that those measures that contribute not only to the improvement of eco-efficiency but also to that of environmental indicators in their absolute sense can best be motivated by environmental regulation. It has to be added, nevertheless, that some studies (e.g. Blackman and Bannister, 1998; Belis-Bergouignan et al., 2004; Smith – Crotty, 2008) indicate that environmental policy is far less decisive for environmental innovation than generally assumed.

Some authors differentiate between different types of environmental innovation in their research on the effects of regulation (and other factors). Both Cleff and Rennings (1999) and Kivimaa (2007) found that environmental regulation is most conducive to process innovations, and, according to Frondel et al. (2007), more specifically to end-of-pipe technologies. Kammerer (2009), on the other hand, found a positive connection between environmental regulation and product innovation in the German electronics industry. Related to this, it should be noted that for a long time, environmental regulation has primarily focused on environmental damages caused by production processes. According to research on the German manufacturing industry conducted by Rehfeld et al. (2007), this is the reason why environmental process innovation in the examined companies was twice as frequent as product innovation (whereas in non environmental innovations, the frequency of product and process innovations was nearly identical).

In any case, a lot of research has been conducted on the question of what is "good" environmental regulation – that is best able to stimulate environmental innovation. Stimulating innovation in this respect is especially important as it can reduce the costs of regulatory compliance. It has often been observed that the actual costs of different environmental protection regulations are lower than initially expected, if ex ante impact assessments do not take into account innovation induced by the regulation (Pickman 1998).[2] In Michael E. Porter's influential theory, according to which strict environmental regulation does not impair the international competitiveness of the affected sectors, as traditionally assumed, but

[2] Disregarding this effect can of course be a conscious strategy of the interest groups opposing strict regulation – according to environmental NGOs, industrial impact assessments usually grossly exaggerate regulatory compliance costs (see ChemSec 2004 for examples).

improves it, the key to this positive effect are technological innovations resulting in more efficient operation (Porter – van der Linde 1995).

The ability of policy tools to stimulate the continuous improvement of environmental performance and innovation is called *dynamic efficiency*. (Static efficiency, on the other hand, means that targets are met – with the given technology – at the lowest possible cost.) In respect of dynamic efficiency direct, so-called "command and control" and indirect (economic) forms of regulation are usually contrasted. It has traditionally been assumed that the latter are more effective in stimulating technological development; however, several researchers have recently started questioning this general truth (Rennings 2000; Bernauer et al. 2006; Del Río 2009). Similarly, the effect of voluntary agreements on innovation is also uncertain, and there is virtually no research on information-based instruments (del Río 2009).

Several authors have recently stressed that from the aspect of stimulating innovation, individual environmental policy instruments cannot in themselves be classified as "good" or "bad" – rather, it is certain characteristics of the regulation that can determine the effect on innovation (Del Río 2009). One important factor is the gradual introduction and predictability of regulation so that companies have the time to adapt to the increasingly strict regulations through innovation (Norberg-Bohm 1999; Kivimaa 2007). Ashford (1993), while stressing the importance of predictable regulation, suggests that perfect predictability is not necessarily desirable, as it results in companies only aiming at minimal compliance with the regulations. Expectations concerning future regulations are shown by many to affect companies' environmental protection efforts (Geen et al 1994, Dupuy 1997, Cleff – Rennings 1999).

Beside predictability, flexibility is another important characteristic of innovation-friendly regulation (Norberg-Bohm 1999; Kivimaa 2007). This enables companies to meet the requirements in different ways – possibly with the application of new solutions. Accordingly, regulation prescribing the application of a certain technology cannot be considered favourable; it is better if only the environmental target is prescribed (Kivimaa 2007). Technological standards stimulate innovation in the sense that they ensure the diffusion of the solution prescribed by the authorities; however, it cannot be superseded (until the change of standard), and therefore the danger of lock-in in a suboptimal technological system is present (Norberg-Bohm 2000).

The question to what extent environmental regulation stimulates technological innovation clearly depends greatly on the strictness of the requirements, i.e. if the application of existing technology suffices for meeting the targets or for avoiding high taxes, or if radically new solutions are needed (del Río 2009). By analysing the data from the large sample OECD survey (in which Hungary also participated, see Kerekes et al. 2003), Frondel et al. (2007) found significant connection between direct regulation, or rather the perceived strictness of regulation, and the introduction of end-of-pipe technologies, but no connection with preventive solutions. Economic instruments did not prove to be significant for any of the environmental innovation types – according to the authors, this is most likely due to the fact that they were mostly introduced in a very "weak" form.

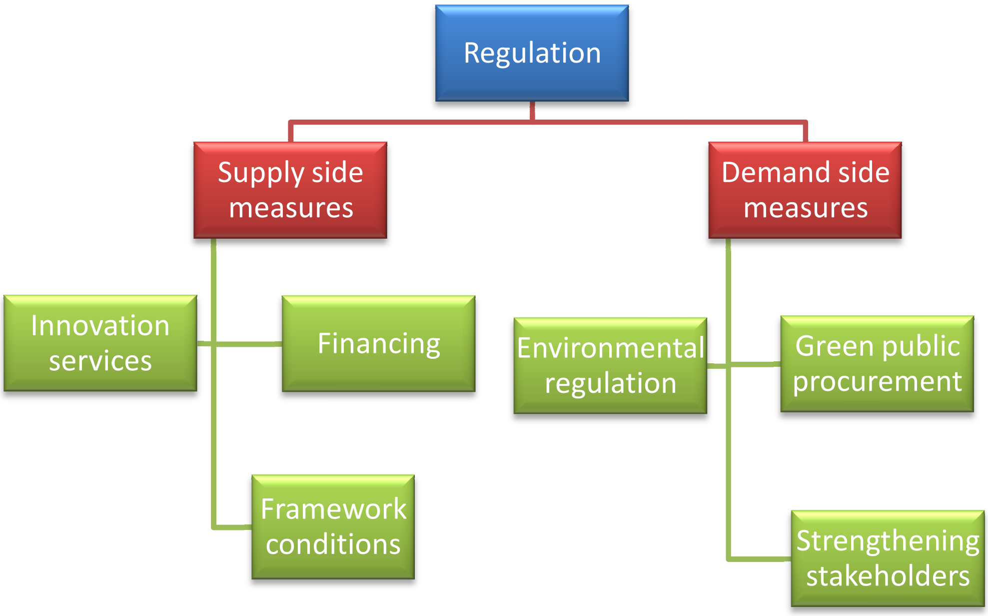
Naturally, the lobbying power of the sectors affected by the regulation, and related political considerations often hinder setting ambitious targets. On the other hand, it has happened that strict requirements were formulated due to the influence of the environmental protection industry (del Río 2009). This shows that not only regulation influences the rate of technological development, but vice versa: the scope of accessible technologies exerts great influence on regulation (Kivimaa 2007). However, as the present Ph.D. thesis is not primarily concerned with regulation but with environmental innovation, this effect is only mentioned but not elaborated on.

It has to be mentioned that the role of authorities is not restricted to the (twofold) stimulation of innovation – the *indirect influence* they exert through the civil society and market actors can also be significant. Authorities can greatly contribute to the development of the environmental sensitivity of these players, and can support them in enforcing their environmental expectations towards the companies. This indirect regulatory influence exerted via third parties has been increasingly appreciated recently. Gunningham et al. (1999) point out that globalisation and increasing international competition exert strong influence towards deregulation; nevertheless, from the aspect of the environment, a preferable policy to complete withdrawal is conscious state support for the strengthening of social control exerted via third parties.

There are several practical possibilities to achieve this in the case of the different parties; however, the key is generally the improvement of the availability of authentic information on the companies' environmental performance (e.g. via public emissions databases, labelling programmes, etc.). This facilitates pressure exertion by non-governmental organisations and the local population, the assertion of environmental preferences by market partners (consumers, buyers, investors), and the tailoring of contractual conditions to the environmental risks by financial partners (banks, insurance companies). Moreover, the state might assist NGOs with subsidies or by extending their legal possibilities (Gunningham et al. 1999). The authors also find it important to note, however, that influence via third parties can only be one element of a successful environmental policy and cannot completely replace direct regulation.

Summarising the role of the authorities, they can stimulate environmental innovation firstly by subsidising and facilitating innovation (supply side measures), secondly via environmental regulation, and thirdly by strengthening the role of other stakeholders. Due to its nature, the latter should be considered a demand side policy measure, as it does not facilitate the implementation of innovation itself but indirectly inspires the improvement of environmental performance (i.e. creates demand for this type of innovation). Figure 2 shows an overview of the authorities' means to facilitate environmental innovation.

Figure 2: Overview of the regulatory tools to influence environmental innovation



Source: own (based on the literature presented)

1.2.5.2. Stakeholder pressure

The regulatory authorities are only one of the many possible players capable of exerting pressure on companies to improve their environmental performance. Other stakeholders such as customers, suppliers, competitors, financial institutions, various non-governmental organisations and the general public can also be sources of expectations and incentives (Del Río 2009).

Unsurprisingly, *customer demands* primarily play a role in stimulating environmental product innovations (Cleff – Rennings 1999, Kivimaa 2007, Frondel 2007). Prakash (2002), however, remarks that customers are also able to initiate the greening of processes by considering not only the features of the product but also the image of the producing company during their decision-making process. This effect of course may be less present in the case of companies which build their marketing strategies around various brands and not around the companies themselves (e.g. Unilever, Procter & Gamble). (Prakash 2002)

The role of consumer demand for eco-friendly products is emphasized by the *environmental marketing* literature. In this approach environmental features are seen as possibilities for product differentiation, thus making it possible to increase market share. Of course this opportunity exists only if customers have a demand for eco-friendly products and are willing to pay more for these. In the 1980s and 1990s many in the developed countries have assumed that green consumers would gain importance in the future, but so far, the reality has not lived up to this anticipation (Bernauer et al. 2006). For many customers, it seems, positive environmental attitudes are not reflected in actual purchasing decisions (Prakash 2002). In markets where the number of "green" consumers is significant, their needs are met by the introduction of special products, while other products in the product line remain unchanged (Gunningham et al. 1999).

The environmental marketing literature therefore usually emphasizes that in the wider market, eco-friendly products can only expect success if, in addition to their eco-friendly features, they are also able to offer costumers other benefits, such as a positive effect on health, energy savings, etc.. Furthermore, it is imperative that there is relevant and credible information available about the environmental characteristics of the product. (Prakash 2002, Bernauer et al. 2006) Kammerer (2009) shows that in the electronics industry in Germany, companies have introduced measures related to the specific environmental feature improvement of a product, such as energy efficiency, toxicity, etc. significantly more often if they thought that this would provide customers with significant benefits.

If the company's products are not primarily directed at end-consumers, then it is corporate buyers whose environmental demands can have an impact on environmental performance and innovation. This influence might be particularly important in the case of smaller companies, because they are often difficult to reach with environmental policy tools. Their corporate customers, however, may use their dominant position to require the improvement of environmental performance (Gunningham et al. 1999). In Hungary and also in other countries it is typical of large companies to formulate certain environmental expectations vis-à-vis their suppliers (Zilahy 2003, Smith – Crotty 2008).

NGOs and the *local population* were among the less influential stakeholders in the large sample survey of the OECD (Johnstone et al. 2007). It is generally assumed that this type of pressure may have a more significant effect on large, image-sensitive companies (Gunningham 2009). At the same time, Blackman and Bannister (1998) have found pressure from local residents to be the most important driving force in the case of small Mexican brick making plants that switched from traditional heating using mainly different types of waste, to natural gas, doubling the costs. Burning waste, such as used tyres or pieces of wood treated with different chemicals produces toxic emissions which directly harm the health of the locals – this example illustrates well that pressure coming from the local residents and NGOs not only depends on the environmental awareness and level of organisation of the stakeholders themselves, but also on the seriousness of environmental damage caused by the company. The idea that the severity of environmental impacts encourages innovation is verified by Frondel et al. (2007).

Likewise, a company may feel the incentive to improve its environmental performance if its (perhaps more successful) *competitors* implement similar measures (Hoffman 2001).

1.2.5.3. Economic environment

The selection environment affecting environmental innovation is made up not only of the various pressures for improving environmental performance. A number of other elements may also be important, for instance, the characteristics of the economic environment. Some of these are industry specific, such as its structure or *market concentration*. The effect of the latter on environmental innovation is not clear: Schumpeter (1987) states that there is less insecurity on concentrated markets; companies therefore more easily accept innovation risks. Others (e.g. Levin, 1985) are of the opinion that as competition decreases with concentration, companies tend to become passive and this hinders innovation. Szűcs (2010) differentiates between inventive and adoptive behaviour and comes to the conclusion that increasing competition intensity boosts the number of adopting companies.

Regarding environmental innovations, Rothenberg and Zyglidopoulos (2007) examine both the munificence and the dynamism of the external environment. They anticipate that in a resource-poor environment, with intensive competition, companies will consider only investments with immediate returns and neglect environmental protection. Dynamic – fast-changing, unpredictable – environments, however, were expected to stimulate the speedy adoption of innovations. A survey conducted among US printing companies has confirmed the latter presumption, but not the former – this implies that companies do not necessarily consider environmental investments as cost-increasing or less important (Rothenberg-Zyglidopoulos 2007).

Though mentioned by few (e.g. Green et al 1994, Schwarz 2008), it is likely that environmental innovations are also influenced by the *price of input factors*. A price increase in energy or raw materials may make efficiency-increasing technologies more attractive.

1.2.5.4. Technological environment

The technological parameters of the sector may also be important for environmental innovation. The first aspect here is the *technological maturity of the sector*. Abernathy and Utterback (1978) have proposed in their influential model that at the outset of a sector's development, companies test many different types of products. As demand increases, a dominant version will emerge, and the focus will shift to optimising production processes and decreasing costs – in other words product innovations are gradually outweighed by (incremental) innovations of processes. This tendency can also be observed for environmental innovations, which also means that in different sectors with different maturity levels the different incentives have different effects (as could be seen above, market factors are more important for product innovations, while regulations have a greater influence on process changes) (del Río 2009)

Dominant technologies and path dependence were mentioned earlier. Introducing innovations affecting the entire supply chain therefore is extremely difficult and costly, which strengthens the incremental nature of environmental innovations (Montalvo 2008). Belis-Bergouingnan et al. (2004) point out, for example, that in different sectors of the French chemical industry different – radical and less radical – methods to decrease VOC-emissions have become widespread.

Insofar as the company wishes to decrease its environmental effects by adopting solutions developed by others, *the characteristics of technologies available on the market* will be decisive (Montalvo 2008). Factors determining the diffusion of technologies, such as relative advantage or complexity, cited by Rogers (1962), may be also important in terms of environmental innovation (Kemp – Volpi 2008). Cost reductions often appear as a motivating factor in connection with cleaner production innovations (Green 1994, Dupuy 1997, Cleff – Rennings 1999, Frondel et al. 2007, Kivimaa 2007, Smith – Crotty 2008); initial investment costs, however, appear as a barrier (Hansen et al. 2002, Kagan et al. 2003, Belis-Bergouignan 2004).

1.2.5.5. Resources and capabilities

As mentioned above, according to their individual characteristics, companies respond differently to pressures from the selection environment.

The importance of the company's internal characteristics in terms of corporate competitiveness and innovation is emphasized by the firm level application of evolutionary economics, and the resource-based view of the firm. According to these theories the primary explanation for the heterogeneity among companies, as well as the differences in innovation activities lies in the company's capabilities and in the resources available (Kiss 2004, Bernauer et al. 2006).

Important resources related to innovation include a well-trained *workforce*, the company's *technological competence* in general, as well as *financial resources* (Montalvo 2008, del Río 2009). It is commonly assumed that, because large companies usually command more of the above mentioned resources, their (environmental) innovation activity will also be on a higher level (del Río 2009). In light of the empirical evidence, however, there is no clear connection between *company size* and environmental innovation activity. Rehfeld et al (2007), Rothenberg – Zyglidopoulos (2007) and Kammerer (2009) found a positive connection, as did Cleff and Rennings (1999) for certain types of innovations (product innovation, soil remediation). On the other hand, Cleff and Rennings (1999) for other innovation types, and Dupuy (1997) found no connection, while Bellas – Nentl (2007) found a negative connection. Similarly, company size also has no clear effect on the direction of environmental innovation (preventive or end-of-pipe) (del Río 2009).

According to Bernauer et al. (2006) it is possible that company size has different effects in different industrial sectors; furthermore, Rose and Joskow (1990, in Bellas-Nentl 2007) draws attention to the fact that most surveys are biased in favour of large companies. The reason for this is that measuring innovation activity is mainly based on the number of innovations introduced. However, in the case of larger companies with a larger number of plants, equipment and products, the likelihood of some type of modernisation over a given time period is higher, even if this only means replacing broken equipment. (Csutora (1999) points out a similar methodological bias when corporate environmental performance is evaluated based on the number of environmental management tools applied.)

Although smaller firms typically have fewer resources to mobilize, certain benefits may result from their size which may make innovation easier for them. Hansen et al. (2002) summarize the strengths and weaknesses of smaller firms with respect to (environmental) innovation as shown in Table 1. From the factors in Table 1 it can be concluded overall that smaller firms are capable of flexibly implementing incremental changes within their existing technological and relational framework, however, implementing measures beyond these boundaries proves difficult for them. The small size often means one single or a small number of customers or suppliers, which significantly limits the information flow on environmental issues and technological opportunities for these firms.

Table 1 Strengths and weaknesses of small firms in terms of (environmental) innovation

Strengths	Weaknesses
• Flexibility • Close relationship to customers • Capacity for adaptation to new situations: an ability to react more rapidly than their larger counterparts • Rapid decision making • Customer oriented	• Lack of financial means • Lack of education and training resources • Dependency on existing network: Lack of ability to establish new relations • Lack of vision and of capacity to innovate

source: Hansen et al. (2002), p.39

The importance of technological capabilities and specific *environmental know-how* is emphasized by many (see Montalvo 2008) – Frondel et al. (2007) also state that these abilities (for which R&D spending is used as a proxy) are more important for preventive than end-of-pipe measures. This is understandable because preventive solutions normally require the company to significantly alter production processes. As previously mentioned, and as is also revealed in environmental innovation surveys (e.g. Dupuy 1997, Hansen 2002) the company's *relational networks* are of great importance, as they may help to widen the pool of resources and skills necessary for innovation from outside sources.

Hart (1995), extending the resource-based theory of the firm to include the natural environment, introduced the concept of "green capabilities", the central element of which are the processes related to collecting information on environmental issues and identifying and implementing response options. Use of *environmental management tools*, especially audited environmental management systems (ISO 14001, EMAS) may improve the organizational conditions for the introduction of environmentally friendly technologies. With the help of an eco-audit, the company gains information regarding its environmental effects, is able to identify the most efficient possibilities to improve its environmental performance, and certified systems also require setting specific environmental targets.

The large-scale survey of the OECD (Johnstone et al. 2007) also confirms (overall and also for Hungary) that the environmental innovation performance of manufacturing firms applying these systems is better. Bradford et al. (2000) come to the same conclusions after examining the EMAS system, as do Rehfeld et al. (2007), and Kammerer (2009) specifically in relation to environmental product innovation. Based on the OECD survey data Frondel et al. (2007) examine in detail which environmental management tools are connected to the different types of environmental innovations, i.e. end-of-pipe and preventive measures. Their results show that environmental accounting and the existence of a written environmental policy have a positive correlation with both types of process innovations, while environmental reports and internal environmental audits are significant only for cleaner production innovations.

1.2.5.6. Environmental strategy

Since environmental innovations often require a significant investment, the management's commitment to environmental protection and environmental strategy is crucial (Kagan 2003). Hansen et al. (2002) thoroughly investigated the environmental innovation decisions of 20 small and medium-sized companies and found that facing increasing regulatory stringency the search strategies of firms for eco-friendly solutions were fundamentally different – while some only sought information to ensure that compliance costs stayed as low as possible, others displayed a much more proactive attitude in hopes of potential competitive advantage. The survey also found that the approach to environmental technologies is closely related not only to the environmental but also to the general competitive strategy of the company: companies with cost leadership strategies based their environmental innovation decisions solely on the impact of innovation on costs, while for companies with product differentiation strategies considerations related to quality and product characteristics were the decisive factors.

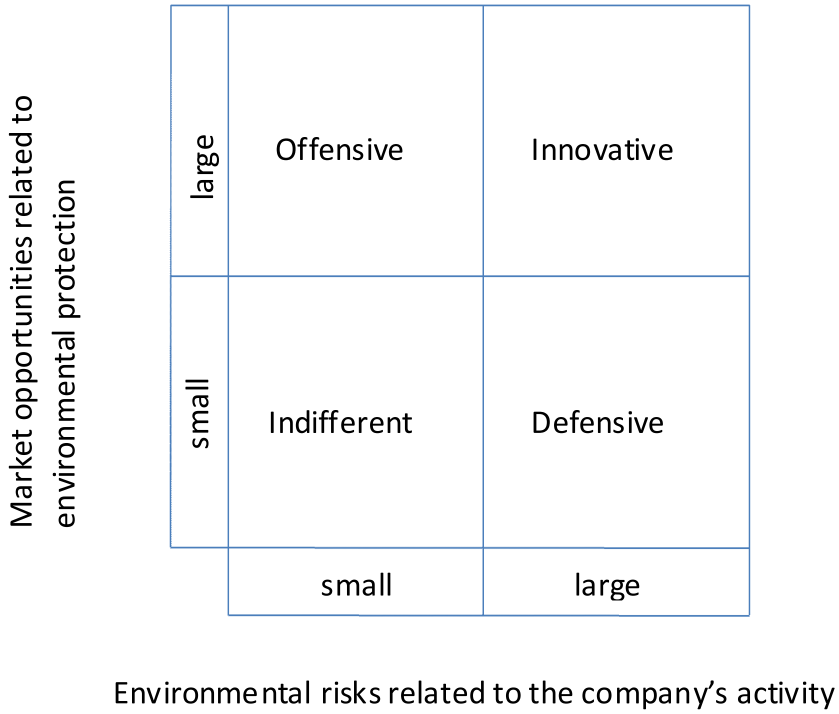
The environmental strategy literature generally distinguishes companies by their *approach to environmental regulation*. In this framework, there are companies ignoring regulation, sometimes even going against it; companies which aim at minimum compliance with regulations, and companies which do more in order to improve their environmental performance (see Baranyi 2001). In addition, some sources distinguish companies for which the environment is important in terms of their corporate reputation, communication and marketing, but this is not accompanied by high-level measures to improve environmental performance (Baranyi 2001, Harangozó 2007).

The fundamental question is, what factors will determine the company's decision to choose one or the other approach, or which approach it *should* choose? In relation to environmental strategy Kerekes et al. (1995) emphasize the *environmental risks* accompanying the company's activities;

differentiating between endogenous risks, which can be influenced by corporate management and exogenous risks, which are dependent on the external environment. The first type of risks can and should be handled at the plant level, applying technological solutions, while high exogenous risks demand more attention from top management. Overall, low-risk companies can afford not to address environmental protection, or to address it on the level of regulatory compliance only, while a high level of risks requires strategic risk management and continuous innovation. The importance of perceived risks is empirically demonstrated by the OECD's large-scale international survey, where (as mentioned earlier), the perceived magnitude of environmental impact was found to significantly increase the environmental innovation activity of the companies, both in terms of end-of-pipe and preventive measures (Frondel et al. 2007).

In addition to risks, according to Ulrich Steger (1993) *business opportunities* related to environmental protection explain differences in companies' behaviour (Figure 3). For indifferent companies (characterised by low risks and opportunities) environmental protection is of secondary importance. If risks are high but the environmental efforts are not rewarded by the market, companies will adopt a defensive position, in other words, will try to downplay environmental problems, aim at minimal compliance with environmental legislation (perhaps with occasional infringements), and will principally apply end-of-pipe solutions. If, on the other hand, environmental protection brings business opportunities, companies will tend to take steps going beyond the legislation, to apply preventive measures, emphasising innovation and positive environmental communication (offensive environmental strategy). If opportunities and risks are equally high, then high-level environmental management and continuous innovation are essential to the company's survival (innovative strategy).

Figure 3: Types of corporate environmental strategy according to Steger (1993)



For a profit-oriented company it will certainly be of crucial importance how efforts to improve environmental performance impact the company's profitability. Harangozó (2007), through a survey conducted among Hungarian manufacturing companies, empirically demonstrates that companies seeing business opportunities in environmental protection more often implement environmental protection measures.

Exploring *the relationship between environmental protection and business success* has long been a central issue in the environmental management literature, since proving the existence of a positive relationship could give much greater confidence not only to company executives but also to policy makers to take environmental protection to a higher level. The public perception on the costliness and the "necessary evil" nature of environmental protection for companies was shaken by Porter and van der Linde's (1995) influential article in which it is alleged that a higher level of environmental protection, due to increased efficiency, is more likely to improve competitiveness both on the corporate and the national level.

Many have since attempted to prove or disprove the „Porter hypothesis”, but the empirical studies have not provided conclusive results. (For a summary of the relevant literature see Salzmann et al. 2005; Harangozó 2007). It seems that the economic impact of environmental measures is largely dependent on the specific circumstances; therefore, the real question is how and under what conditions environmental protection can become a source of competitive advantage (see e.g. Reinhardt 2000, Orsato 2010). According to Harangozó's (2007) results, among Hungarian small and medium-businesses there is a positive connection between the relative decrease of environmental impact (eco-efficiency) and the company's business performance. This, however, does not imply the absolute decrease of environmental impact, since in the case of commercially successful companies increased production generally overcompensates the impact of eco-efficiency improvements.

There are several ways to realize the potential competitive advantage in environmental protection, parallelly to the company's overall competitive strategy. In Porter's (1980) classic work he identifies three fundamental ways of ensuring competitive advantage: cost-leadership, product differentiation and focus. In the first case it is through the reduction of the company's costs, in the second, through the uniqueness of the product or service offered that the company aims to increase market share. In the third case, the company targets a smaller market segment with special needs and attempts to meet these needs as perfectly as possible.

These approaches are distinguishable also in terms of environmental protection: the environmentally-oriented cost leadership strategy aims at cutting costs by using natural resources in the most efficient possible way (in other words, through process innovation), the environment-oriented differentiation strategy, on the other hand, offers eco-friendly products – first to a narrow, environmentally-conscious, high-income consumer group, then gradually attempts to penetrate the wider market (Schaltegger et al. 2003). According to the authors, potential in the first strategy gradually becomes depleted, as companies take advantage of all the options offered by eco-efficiency improvements. If they wish to gain a competitive advantage through environmental protection, in the long term they will have to pay attention to increasing revenues and satisfying customer demand.

Ultimately, how the company's environmental impact and the business opportunities in environmental protection are viewed is highly subjective, therefore a lot depends on the *manager's personality and environmental commitment* (Gunningham 2009). Several authors have tried to capture the specific personality traits and skills that characterise environmentally successful corporate leaders (for an overview of relevant literature see Fernández et al. 2006).

Sharma (2000), after having examined 99 Canadian oil and gas companies, concluded that the behaviour of companies operating in similar environments differed significantly, depending on whether the management considered environmental issues as an opportunity or as a threat. According to Hansen et al. (2002) environmental innovation decisions are characterized by bounded rationality, where organizational processes and the values, routines and preferences influencing these are crucial. Harangozó's (2007) above mentioned survey found, for example, that the majority of economically successful measures implemented in certain companies could be applied in a wider range of firms.

1.2.5.7. Other company characteristics

Finally it is necessary to mention certain company characteristics which are not related to resources or strategy but may also influence environmental innovation activity. The role of management attitudes towards the environment was mentioned previously, as was the influence of external stakeholders on the innovation process. *Owners* and *employees* are other stakeholders whose influence may be present but is rarely included in studies of environmental innovation.

Regarding management attitudes, the general openness to innovation and *readiness to accept the risks connected to new solutions* is also relevant (Kemp-Volpi 2008). (The importance of risks and risk acceptance is of course lower when adopting innovations already widespread on the market.)

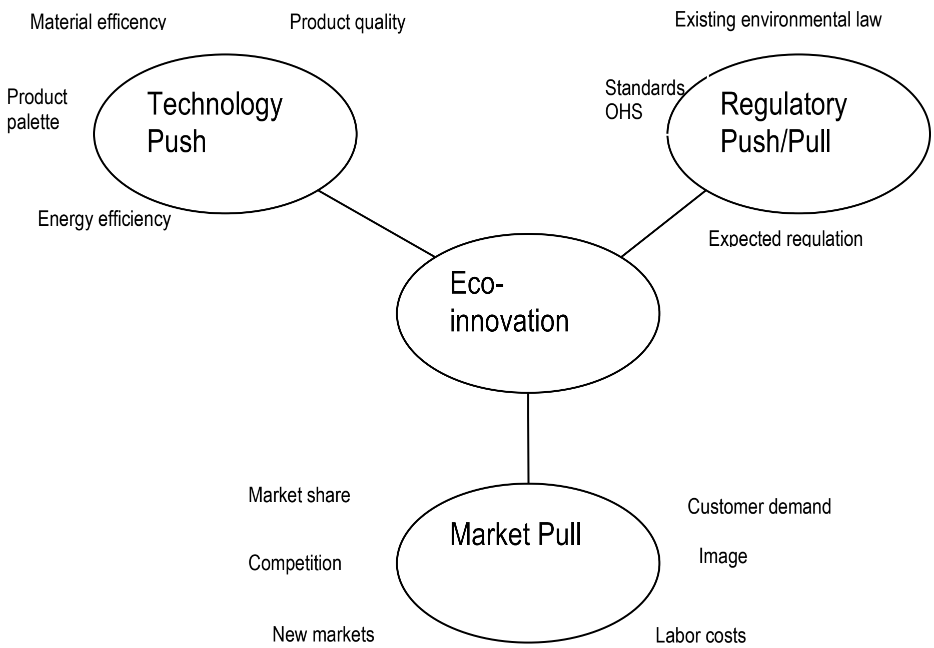
Several studies highlight the fact that environmental innovation decisions and their timing is influenced by the *life cycle of the company's assets* (e.g. Dupuy 1997). If replacing the equipment is necessary anyway, the chance of adopting environmentally friendly solutions is much higher than when this can only be done by scrapping recent investments. Sunk costs are mainly a problem in connection with cleaner production solutions which require substantial changes in the production processes, therefore the existence of sunk costs increase the probability that the company will choose end-of-pipe solutions (Kemp-Volpi 2008).

1.2.6. Some comprehensive models

Given the diverse nature of the factors influencing environmental innovation, there have been some attempts to construct comprehensive models. In the following two such models with different theoretical backgrounds will be presented.

The "technology push" and "market pull" factors known from innovation economics are complemented with the factor of regulatory push/pull by Cleff and Rennings (1999) (Figure 4). The extension (i.e. the additional motivation) is necessary because of the external nature of environmental pollution (see the above discussion on the double externality problem). In the case of environmental innovations the technological factor is the emergence of new, environmentally friendly technologies, and the market factor is the demand for green products. At the same time it is strange, that while regulations also comprise demand and supply side tools, the graphical representation of the model does not include supply side elements (support for environmental innovations). As described earlier, the significance of certain elements of the model was supported by the research undertaken in the German manufacturing industry, but beyond the factors in the model, the study also included other factors (e.g. firm size, sector) – this also shows that the model does not cover the entire range of factors influencing environmental innovation.

Figure 4: The determinants of environmental innovation in the model of Cleff - Rennings (1999)



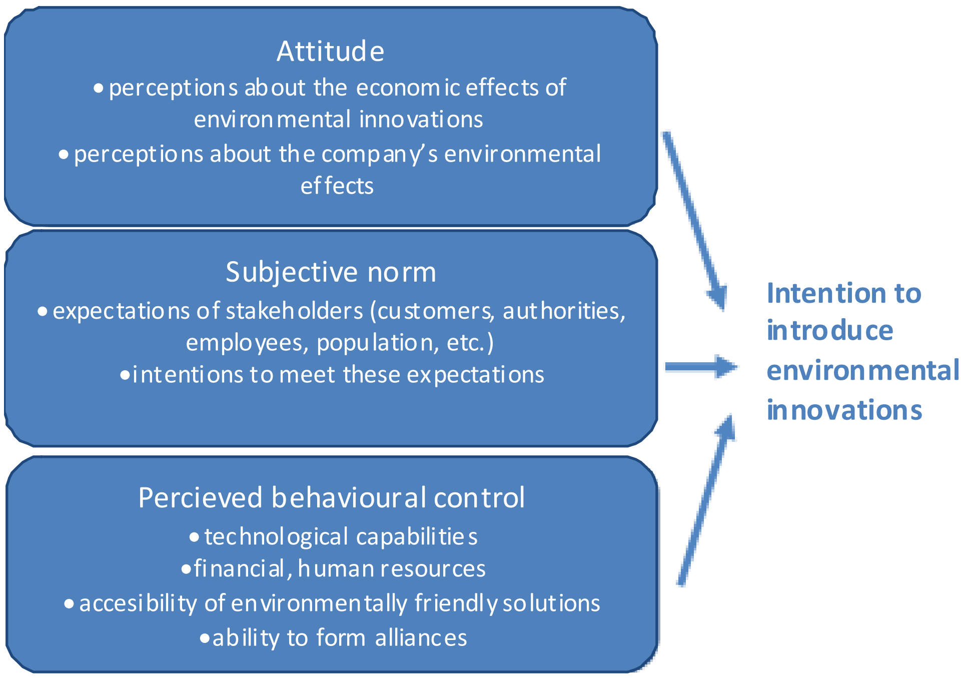
source: Cleff – Rennings (1999) p.193

A much wider scope of determinants is included in the model of Montalvo (2002), who adapted Ajzen's previously presented behavioural model, the Theory of Planned Behaviour (Ajzen 1985) to the field environmental innovations (Figure 5).

According to Ajzen's theory, the intention to act is shaped by three main factors: attitude, subjective norm and perceived behavioural control. Attitude towards the behaviour depends on the expected consequences of the behaviour and the desirability of these consequences. In Montalvo's approach, attitude towards environmental innovations depends on two factors: first, how the decision makers regard the economic effects of environmental innovations; second, how they evaluate the company's environmental effects, as the severity of these is expected to strengthen the intention toward reduction.

The second factor in Ajzen's theory, the subjective norm, contains the expectations of parties relevant for the actor, and the desire to meet these expectations. In case of environmental innovations this means the expectations of the company's various stakeholders and the pressure they put on the company to improve its environmental performance. Ajzen's third factor, perceived behavioural control, refers to the extent to which the actor feels able to carry out the behaviour in question (given the intention to act, the actual action will of course also be influenced not only by the perceived but also the actual behavioural control). According to Montalvo, how much the company will feel able to introduce environmental innovations depends on its technological capabilities, human and financial resources and the accessibility of environmentally friendly technologies.

Figure 5: The determinants of environmental innovations in Montalvo's (2002) model



source: based on Montalvo (2002)

The above model was tested by Montalvo among firms of the in-bond industry on the US-Mexican border. He found that the factors examined provide a good prediction for the company's willingness to introduce environmental innovations (which is low, because the companies feel that there is a lack of technological and financial resources, also they do not feel any pressure from their customers to improve environmental performance). However, Montalvo only examines the (reported) intentions to introduce environmental innovations, not the companies' actual innovation activity.

1.2.7. Summary of existing studies on environmental innovation

In the above chapters I have presented an overview of the factors which according to the literature may influence corporate environmental innovation activity. A summary of the empirical studies reviewed can be found in Table 2.

It can be seen that the empirical studies on environmental innovation are very diverse regarding the types of innovation examined, the factors included in the analysis as well as the methodology applied. Regarding the factors in the analysis it can be seen that some surveys only deal with the effects of one or two factors – these naturally cannot be able to supply comprehensive explanations to the evolution of corporate environmental innovation activity, which, as is clear from the above, is shaped by the interaction of several determinants. Such a narrow approach is justified in certain cases (for example, looking at a specific industry or technology, these effects can be controlled for), but in other cases the analysis omits important factors.

Among the determinants described there are several which influence corporate innovation activity in general (financial and human resources, risk acceptance, etc.) while others are specific for environmental innovations. Since there are many common determinants, it can be assumed that companies which are more innovative in general will also be more active in the field of environmental innovations – this is supported by Rehfeld et al. (2007), Rothenberg – Zyglidopoulos (2007). However most studies do not examine corporate innovation activity in general, although this would provide an interesting comparison regarding the influence of the common factors.

Table 2. A summary of empirical studies on environmental innovation

Study	Scope	Method	Results
Belis – Bergouignan et al. 2004	Reduction of VOC emissions in the French metallurgical and chemical industry	case studies	Regulations are not sufficient to overcome the barriers to innovation which are dependent on the technological regimes dominant in the industry, therefore the regulations should also be tailored to the specific industries
Bellas – Nentl 2007	Introductions of air filters in US power plants (only firm –internal characteristics examined)	econometric analysis	Smaller firms and older plants tested the new technology earlier
Blackman – Bannister 1998	Traditional Mexican brick makers decision to switch to using gas	econometric analysis	Switching to the cleaner fuel is largely determined by the owners' level of education and knowledge of the adverse health effects of the traditional fuel. Small firms operating in the informal sector are not reached by regulations therefore the most important incentive is community pressure.
Cleff – Rennings 1999	Product and (different types of) process innovations in the German manufacturing industry (only environmentally innovative companies)	survey	The most important motivation behind the innovations is regulatory compliance followed by image and environmental considerations, cost reduction and finally (for product innovations) increasing market share. Different policy tools are able to affect the various types of innovations to a different extent.
Dupuy 1997	Effects of new water pollution regulations on Ontario chemical firms	case studies	Normative regulation promotes the diffusion of existing technologies. The second most common motivation is cost reduction and plant modernization. The effect of firm size is not significant.
Frondel et al. 2007	Process innovations in manufacturing plants with more than 50 employees in 7 OECD countries (including Hungary)	large sample survey	End-of-pipe solutions are encouraged by regulations, the management, the corporate headquarters and environmental effects. Cleaner production solutions are encouraged by cost reduction, internal R&D, environmental management tools, the management, the corporate headquarters and environmental effects.

Study	Scope	Method	Results
Green et al. 1994	Manufacturing companies interested in environmental innovation in the UK	survey	Main motivations of product innovations: existing regulations, expected regulations, increase of market share. Main motivations of process innovations: existing regulations, expected regulations, cost reductions.
Hansen et al. 2002	Innovations adopted by small and medium size enterprises – 5 European countries, 4 sectors	case studies	Most SMEs only introduce environmental innovations to comply with the regulations, but there are exceptions. Strategy determines what kind of solutions the company is seeking, its network relations determine what solutions it is able to access and its capabilities determine which it is able to implement.
Kagan et al. 2003	Paper companies' measures to decrease water pollution (Australia, Canada, New-Zealand, USA)	case studies	Regulations resulted in significant pollution reduction investments, but they do not explain the differences between the companies' performance. Management attitudes, and, in some cases pressure from the local population and environmental pressure groups is also important.
Kammerer 2009	Product innovations in the German electronics industry	survey	Regulations encourage innovation, but do not have an effect on the degree of novelty. Larger companies apply introduced product innovations to a wider range of their products. "Green capabilities" (such as environmental management tools) are able to increase the number as well as the novelty of product innovations. The chance for implementing a product innovation increases if it is perceived by the management to provide customer benefits.
Kivimaa 2007	Process and product innovations in the Scandinavian paper and packaging industries	case studies	The main incentives for product innovations are market demands; for process innovations, regulations. Customer demands and cost reductions aims are also present with process innovations. The characteristics of the regulations (flexibility, predictability, gradually increasing stringency) are important.

Study	Scope	Method	Results
Pickman 1998	The effect of regulatory stringency (measured by environmental protection expenditures) on environmental patents in the US manufacturing industry	econometric analysis	Regulatory stringency has a positive impact on environmental innovations, but this may divert resources from other types of innovation (the overall intensity of the innovation activity does not decline).
Rothenberg – Zyglidopoulos 2007	Introduction of environmentally friendly technologies (13 specific product and process innovations) in the US printing industry	survey	Company size and general innovation activity have a significant positive effect on environmental innovation activity. Environments low in munificence do not have a negative effect on environmental innovations, while dynamic environments have a positive effect.
Smith – Crotty 2008	The effect of the EU end-of-life vehicles directive on product innovations among automotive suppliers in the UK	survey	The ability of the directive to promote innovation is limited, it mainly leads to incremental innovations. Market incentives are more important.
Rehfeld et al. 2007	Product innovations in the German manufacturing industry (companies with more than 50 employees)	survey	Positive effect of environmental management systems and waste management procedures. Regulations, company size, internal R&D, customer orientation and firm age also have a positive effect on product innovations.

As we have seen, there are factors that have received a lot of attention in the literature (such as regulations and environmental strategy), while others we know little about. One such issue is the effect of innovation policy which is an important gap because, as described, related to the idea of ecological modernization promoting environmental innovations has become a political priority in many places (also in the European Union) and the corresponding support mechanisms have been established.

In newer studies the different types of environmental innovations (product/process, end-of-pipe/cleaner production) are often examined separately. Because the results show that the various determinants indeed have different effects in the different cases, this approach is certainly justified and useful. Differentiation also appears and yields interesting results in the field of regulation regarding the different policy tools (Cleff – Rennings 1999, Frondel et al. 2007). While it is common for studies to include novel as well as adopted innovations, differentiating according to this dimension is rare although the results of Kammerer (2009) also point to the existence of interesting variations.

There are huge differences between the studied papers in the measurement of innovation itself. Some studies only examine whether the company in question has introduced any environmental innovations or not; or whether it has introduced a specific technology – this approach does not provide information on the extent to which environmental innovations are present in the company's operation. Almost entirely missing is the examination of the changes in the companies' environmental effects brought about by the innovations. A few authors explicitly address the barriers to environmental innovation, but this usually only appears in case studies. It also happens that only environmentally innovative companies are included in the studies, which naturally provides a biased picture.

1.3 Innovation in the Hungarian private sector by European comparison

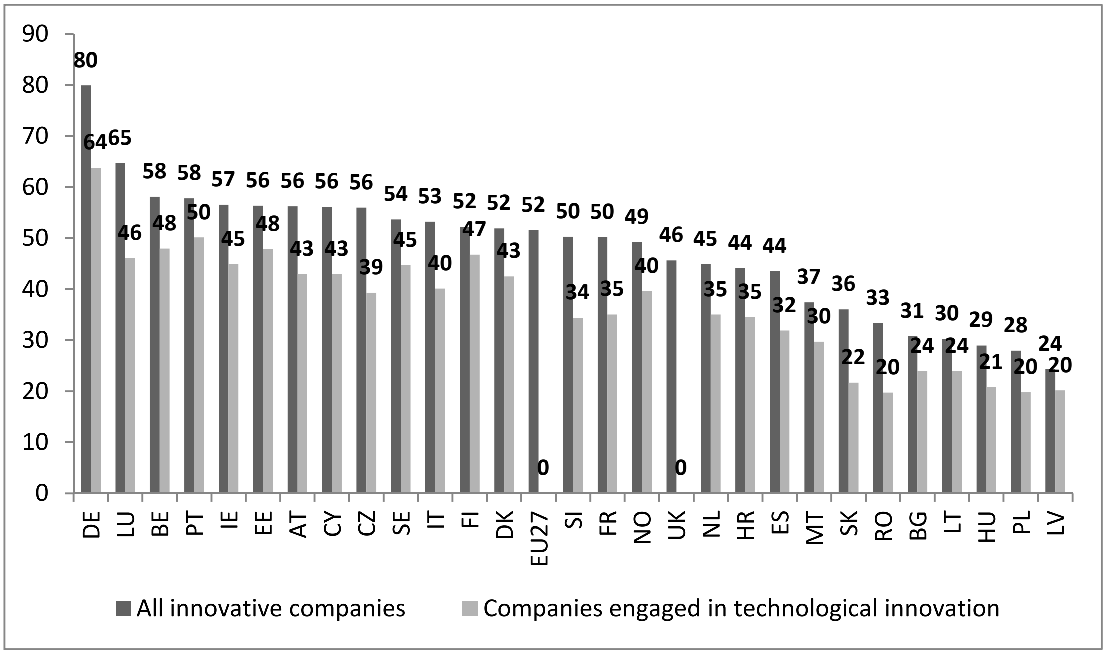
The economic importance of innovation means it regularly constitutes the subject of detailed and large-sample surveys in the EU and in Hungary, while the identical methodology used allows comparisons between Hungarian and EU data. After giving an outline of innovation surveys I will briefly review the main features of Hungarian innovation policy, before moving on to the research results of Hungarian companies in relation to environmental innovation.

1.3.1 Community Innovation Survey

The Community Innovation Survey (CIS) is a large-sample statistical survey (conducted in Hungary by the Central Statistical Office, KSH); it is carried out once every two years and does not include micro enterprises employing fewer than 10 people. The data currently available is from the 2008 survey (this was the 6th wawe of the CIS).[3] The most important message of the survey was the ratio of innovative companies: it can be seen (Figure 6) that 29% of companies responding in Hungary carried out some form of innovation between 2006 and 2008 (also including projects in progress and suspended), placing the country at the rearguard in the EU (where the average is 52%). In terms of technological innovation (processes and products) the other countries in Central and Eastern Europe (apart from the Czech Republic and Slovenia) performed largely the same (i.e. poorly).[4]

[3] The sample included approximately 6 400 of the roughly 20 000 Hungarian enterprises involved in mining, industry and certain service sectors with at least 10 employees: all companies employing more than 99 people, and 1 in 4 smaller companies. The response rate was 85% (KSH 2010).
[4] The EU average cannot be calculated for lack of data on the United Kingdom.

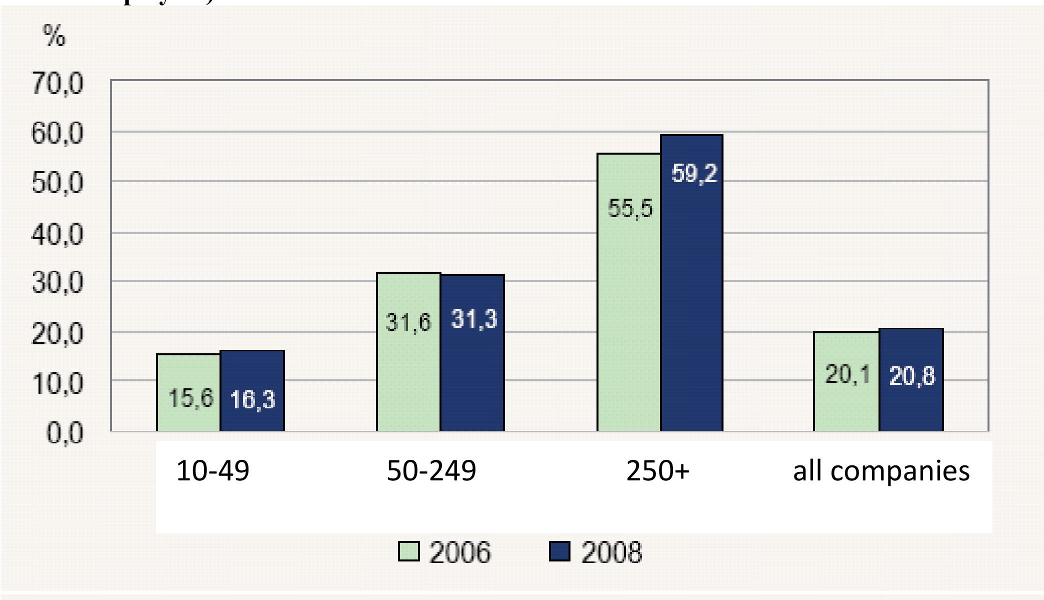
Figure 6: Ratio of innovative and technologically innovative enterprises according to CIS6 (%, including pending and suspended innovations)



Source: EUROSTAT

In Hungary, therefore, 20.8% of enterprises responding carried out some form of technological innovation between 2006 and 2008 – this ratio has barely changed since the 2006 survey (Figure 7). The ratio rises sharply as the size of the company grows, and the gap between Hungary and the EU average is also smaller with larger companies. Of course, the frequency of innovation differs strongly, depending not only on the size of the enterprise, but also on the sector in which it operates. Taking manufacturing as a whole, the ratio of enterprises carrying out technological innovations – 21.6% – is essentially the same as the Hungarian average, but this figure glosses over significant differences. The ratio of innovative clothing manufacturers was extremely low, almost negligible (0.7%), but other sectors that also fell short of the average included food production (17.5%), wood processing, paper and printing (17.3%), manufacturing of fabricated metal products (16.4%) and the repair of machinery and equipment (13.4%). That said, a few other sectors achieved results that were far in excess of the average, such as the chemical industry and refined oil products (31.6%) – including, first and foremost, the pharmaceutical industry (60%) and the manufacture of coke and refined oil products (60%) – as well as electronic products, electrical equipment, machinery and vehicles (32.2%)

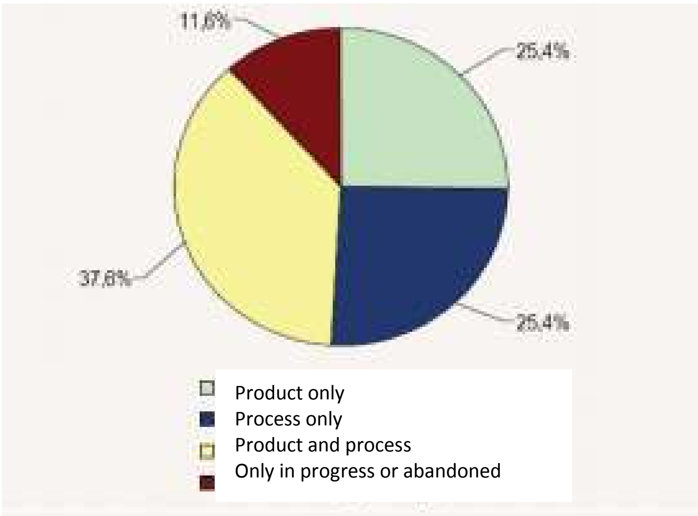
Figure 7: Ratio of companies carrying out technological innovations in the past three years (by number of employees)



Source: KSH 2010

In terms of the type of innovation the ratios are the same for companies innovating only with products or only with processes, but most innovative companies focus on both types of innovation (Figure 8).

Figure 8: Ratio of technologically innovative companies by type of innovation, 2006-2008



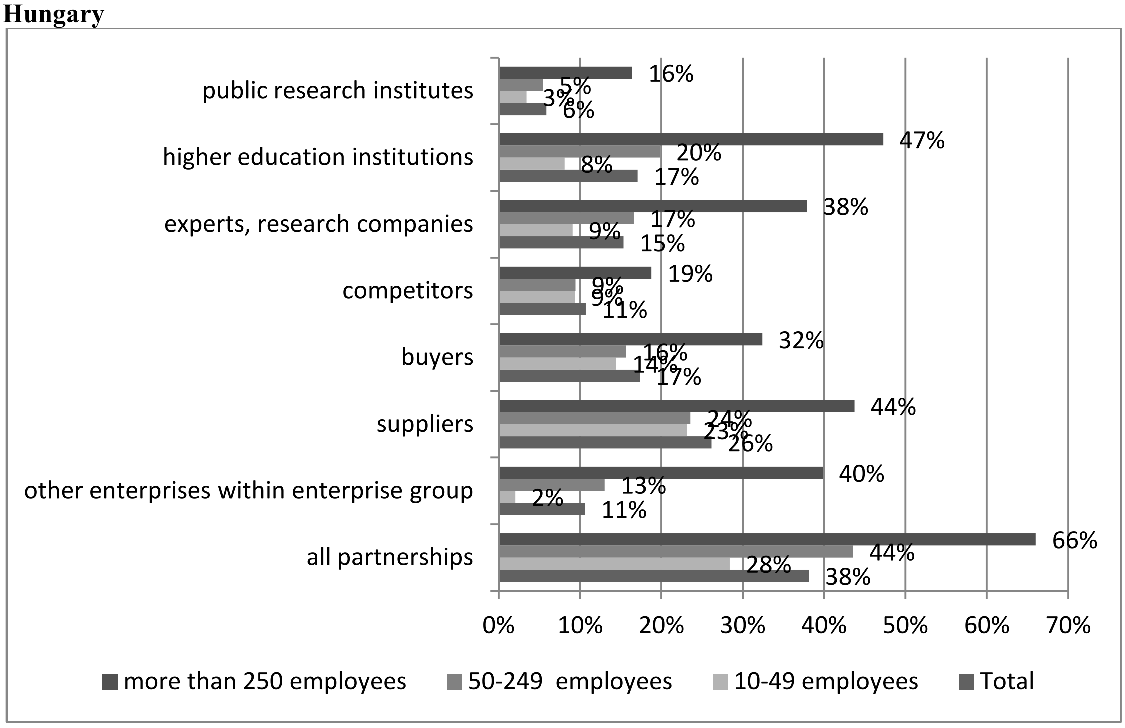
Source: KSH 2010

Altogether 27.5% of Hungarian companies carrying out technological innovations received some form of innovation assistance: 19% from the Hungarian state and 13% from the EU (some obviously received both). These figures are relatively high by

European comparison – since data is missing from a few countries it is not possible to calculate an EU average; that said, of the 21 countries providing statistics, in only 5 states did more innovative businesses receive some form of assistance than in Hungary (source: EUROSTAT CIS6 database).

The CIS surveys demonstrate that innovation partnerships are more common in Hungarian companies engaged in technological innovation than the EU average (in both 2006 and 2008, 38% of manufacturing companies participated in some form of innovation partnership; the EU average for 2006 was 26%). As far as partnerships with other players are concerned, it is clear (Figure 9) that small enterprises tend to work together with their suppliers and customers most in the field of innovation, while large enterprises are more interested in higher education institutions, private research centres and intra-group collaboration (on the whole, all types of partnership are more frequent at large companies). Partnerships with public-sector research institutions are rarely seen, a trend that is reflected in most European countries. However, according to Havas-Polgár (2009) this is a problem for Hungary as the weighting of such institutions in the innovation system (in terms of R&D spending, for example) is very high by international standards.

Figure 9: Innovation partnerships among technologically innovative manufacturing companies in Hungary

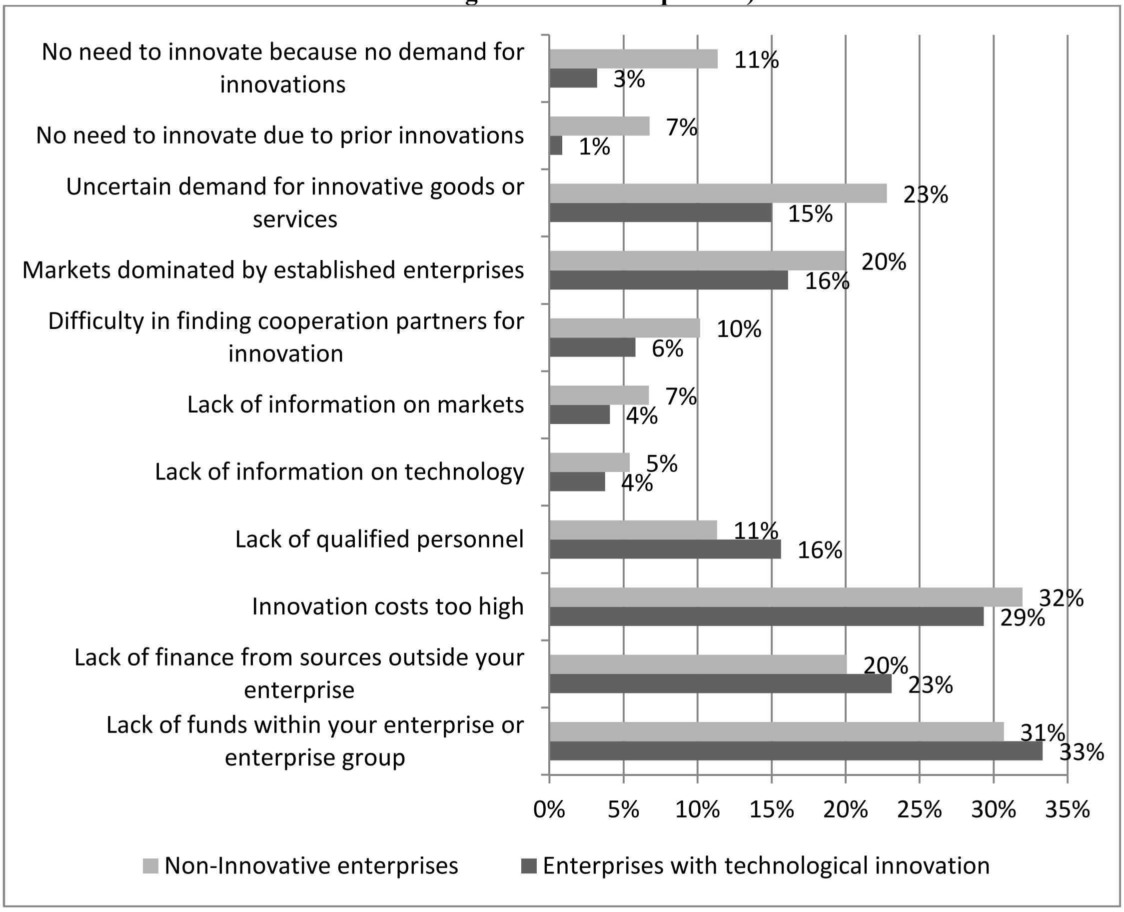


Source: EUROSTAT

Factors impeding innovation were last surveyed as part of the 2006 CIS, where financial aspects were cited by Hungarian respondents as being the main causes. This was followed by market-related problems and the lack of qualified workers – the majority of those surveyed did not believe a lack of necessary know-how was an obstacle to innovation. It is worthwhile comparing these barriers for companies that carry out technological innovations and those which do not (Figure 10). It transpires – not surprisingly – that the majority of these obstacles are more important according to companies that are not innovative, while capital and workforce constraints are felt more by the enterprises who actively pursue innovation. Of course, a significantly higher number of the companies that are not innovative believe there is no need for innovation anyway, and they are seemingly affected much more by the uncertain demand and the difficulties of establishing an innovation partnership.

There are correlations between these impediments and the sizes of enterprises too. Generally speaking the influence exerted by individual factors tends to decline as the size of company grows, but the really significant difference is observed between SMEs and large corporations employing more than 250 people. In case of the latter, apart from financial constraints, the other factors essentially play a negligible role (less than 1%) – irrespective of whether the company is innovative or not. The only exception to this rule is the factor 'the markets are dominated by entrenched companies', which is not a problem for large innovative businesses but is an issue for 12% of large corporations that are not innovative. Furthermore, among large companies, even those that are not innovative do not maintain that there is no need for innovation at all.

Figure 10: Factors impeding innovation among Hungarian enterprises (% of such firms who believe a given factor is important)



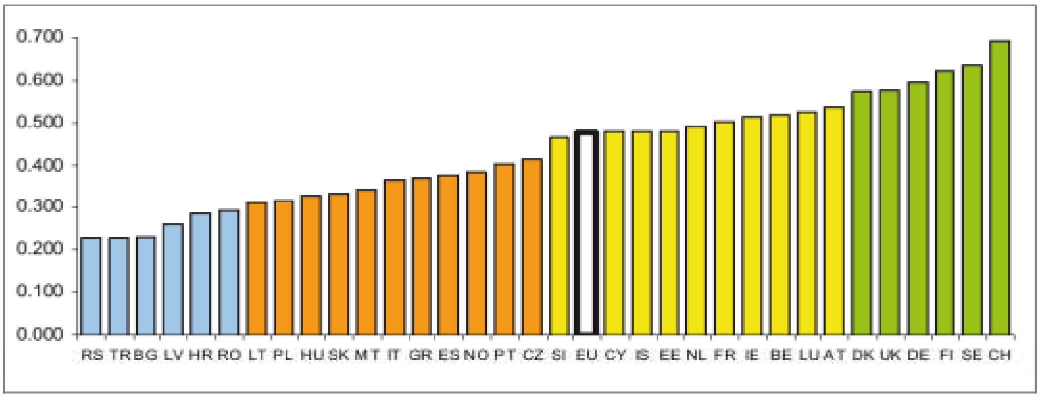
Source: EUROSTAT

1.3.2 European Innovation Scoreboard

The European Innovation Scoreboard (EIS) evaluates the innovation performance of EU Member States based on the results of the CIS surveys (number of innovative companies, development partnerships, patents, new-to-market sales, etc.) together with macro-indicators on overall conditions (e.g. features of the education system and the labour market, public and private R&D spending, venture capital investments, exports from knowledge-intensive sectors, etc.). According to the 2009 results[5] Hungary is considered to be a moderate innovator (Figure 11), with an innovation performance well below the EU average, but it is catching up faster than the average.

[5] The data used to calculate the summary index are derived from 2005-2008.

Figure 11: Ranking of European countries based on the summary innovation index of the European Innovation Scoreboard

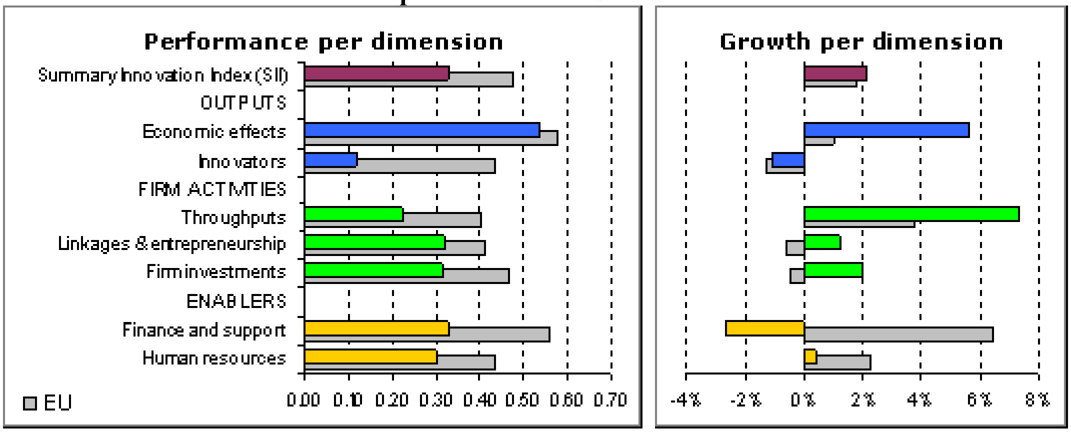


Source: EIS 2009

Hungary's performance relative to the EU average in terms of the various components in the summary index is shown in Figure 12 and Table 3. It is clear that the most ground has to be made up with innovators, especially the number of innovative SMEs, and this ratio is not even growing at present. Looking at financing conditions Hungary falls well short of the EU average in terms of venture capital availability in particular; moreover, this reading has fallen sharply over the last year by 26.1%, which is obviously a side effect of the economic crisis. Hungary is fairly well placed with its research and development spending in the public sector in comparison to corporate expenditure; however, this structure is gradually evolving and private-sector spending is becoming increasingly significant in Hungary too.

The number of Community patents, trademarks and design registrations in Hungary is very low relative to the EU average, but the latter two have displayed steady and robust growth in recent years. The export of knowledge-intensive services is growing strongly too, as is the revenue from new-to-market sales. On the whole, it is economic effects (including the two indicators mentioned above) where Hungary almost reaches the average of the EU Member States. Hungary's performance surpasses the average in terms of employment and exports from medium-high and high-tech sectors. (Hungary also exceeds the EU average in terms of the ratio of those with secondary education qualifications, the firm renewal rate and the technology balance of payments.)

Figure 12: Comparison of Hungary and EU average based on the main dimensions of the European Innovation Scoreboard



Source: EIS 2009

Table 3 Detailed breakdown of components of the European Innovation Scoreboard

	Current performance		Growth performance	
	EU-27	HU	EU-27	HU
ENABLERS				
Human resources				
S&E and SSH graduates per 1 000 population aged 20-29 (first stage of tertiary education)	40.5	29.4	5.1	2.9
S&E and SSH doctorate graduates per 1 000 population aged 25-34 (second stage of tertiary education)	1.03	0.46	2.4	1.9
% of population with tertiary education aged 25-64	24.3	19.2	2.8	3.7
% of population in life-long learning aged 25-64	9.6	3.1	0.8	-6.2
Youth education attainment level of those aged 20-24	78.5	83.6	0.5	0
Finance and support				
Public R&D expenditures (% of GDP)	0.67	0.45	1.2	-1.1
Venture capital (% of GDP)	0.118	0.022	5.1	-26.1
Private credit (% of GDP)	1.27	0.7	5	11
Broadband access by firms (% of firms)	81	72	15.2	10.7
FIRM ACTIVITIES				
Firm investments				
Business R&D expenditures (% of GDP)	1.21	0.53	1.1	10.2

	Current performance		Growth performance	
	EU-27	HU	EU-27	HU
IT expenditures (% of GDP)	2.7	2.5	0	1
Non-R&D innovation expenditures (% of turnover)	1.03	0.72	-2.4	-4.5
Linkages & entrepreneurship				
SMEs innovating in-house (% of SMEs)	30	13.2	-0.5	0.1
Innovative SMEs collaborating with others (% of SMEs)	9.5	6.5	1	-0.2
Firm renewal (SME entries plus exits) (% of SMEs)	4.9	8.4	-4.4	1.8
Public-private co-publications per million population	36.1	19.2	1.5	3.3
Throughputs				
EPO patents per million population	114.9	13.7	1.3	1.9
Community trademarks per million population	122.4	27.6	5.2	11.7
Community designs per million population	120.3	19.5	4.2	9.7
Technology Balance of Payments flows (% of GDP)	1	1.99	4.5	6.2
OUTPUTS				
Innovators				
SMEs introducing product or process innovations (% of SMEs)	33.7	16.8	-1.3	-1.1
SMEs introducing marketing or organisational innovations (% of SMEs)	40	26.4	could not be calculated for lack of data	
Share of innovators where innovation has significantly reduced labour costs (% of firms)	18	6.2		
Share of innovators where innovation has significantly reduced the use of materials and energy (% of firms)	9.6	7.2		
Economic effects				
Employment in medium-high & high-tech manufacturing (% of workforce)	6.59	9.26	-0.3	2.7
Employment in knowledge-intensive services (% of workforce)	14.92	12.17	1.3	2.7

	Current performance		Growth performance	
	EU-27	HU	EU-27	HU
Medium and high-tech manufacturing exports (% of total exports)	47.4	66.4	-0.4	-1.6
Knowledge-intensive services exports (% of total services exports)	48.8	28.3	1.2	12.1
New-to-market sales (% of turnover)	8.6	7.82	4.1	17
New-to-firm sales (% of turnover)	6.28	2.7	0.1	1.9

Source: EIS 2009

Based on the data outlined above there are several signs pointing towards a significant concentration of innovation activity in the Hungarian private sector. This would explain not only the extremely low ratio of innovative companies, especially SMEs, but also the relatively encouraging development of indicators displaying the economic effects of innovation. Another factor implying the dominance of large corporations active in high-tech sectors is that the ratio of the market's revenue from new-to-market sales exceeds 90% of the EU average, while the ratio of new-to-firm sales (adopted innovations) is only around 43%. (One other possible explanation for the difference between firm surveys and macro-indicators could be the greater degree of subjectivity in the former.)

The majority of authors in this field (Havas-Polgár 2009, Pitti 2008) believe that one of the main problems in the Hungarian innovation system is the concentration of a considerable part of innovative activities in a few sectors (e.g. pharmaceutical industry) and at a handful of large multinational corporations, most of which are located in the Central Hungary region, while the majority of Hungarian SMEs do not conduct any such activities at all.

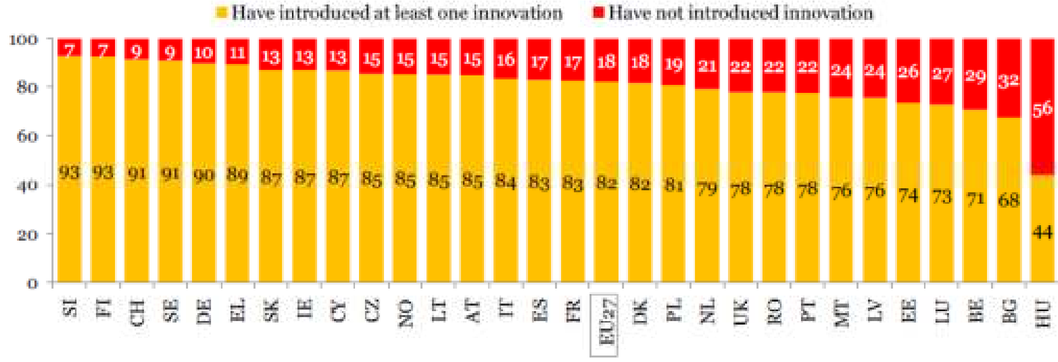
1.3.3. Innobarometer

The ratio of innovative enterprises and the activities of firms related to innovation in Hungary are also extremely low by European comparison based on the Eurobarometer 2009 innovation survey (Innobarometer 2009).[6] Altogether 56% of the companies surveyed had no innovation to report on at all, in contrast to the EU average of 18% (Bulgaria produced the second worst figure with 32%) (Figure 13). Hungary is way behind in technological innovation too, especially in terms of processes (12% of Hungarian companies indicated some such innovation, compared to the EU average of 46%) (Figure 14). The ratio of enterprises introducing a product innovation is generally higher: 38% in Hungary compared to the EU average of 67% (Figure 14). According to the findings of the Innobarometer (2009), Hungarian enterprises do not rely as much on innovation support activities by European comparison, such as improving the communication skills of staff, encouraging creativity, involving customers in product development activities and seeking innovation alliances, etc.

The country's current economic situation was obviously instrumental in the negative assessment, yet as the results are significantly worse than even neighbouring countries, the question nevertheless arises of whether the answers were perhaps distorted by some difference in interpretation or culture. For example, the Innobarometer survey (in contrast to the CIS questionnaire) does not define the concept of innovation prior to asking the questions on innovative activity. This means it is conceivable that some of the Hungarian enterprises only reported novel innovations, whilst in other countries the companies deemed adopted developments to be part of the innovation process as well (as does the official EU interpretation). That said, it is quite obvious that Hungarian enterprises lag significantly behind their Western European peers when it comes to innovation.

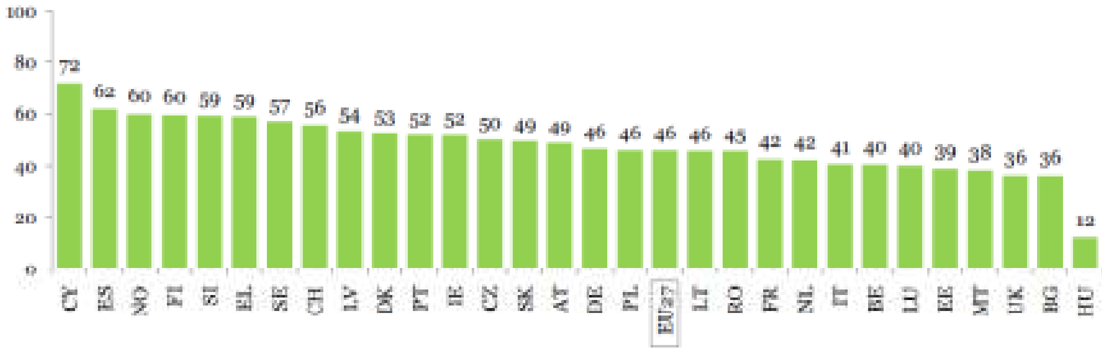
[6] This telephone survey queried 200 companies with at least 20 employees. The enterprises themselves were chosen from innovation-intensive sectors.

Figure 13: Ratio of innovative companies according to Innobarometer 2009 (enterprises that have introduced at least one product, process, organisational or marketing innovation in the last 3 years)



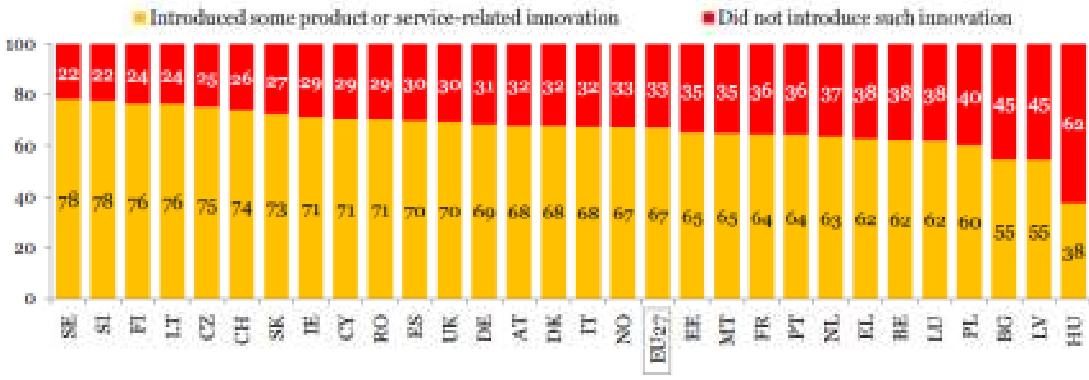
Source: Innobarometer 2009

Figure 14: Ratio of companies introducing process innovations according to Innobarometer 2009 (in the last 3 years)



Source: Innobarometer 2009

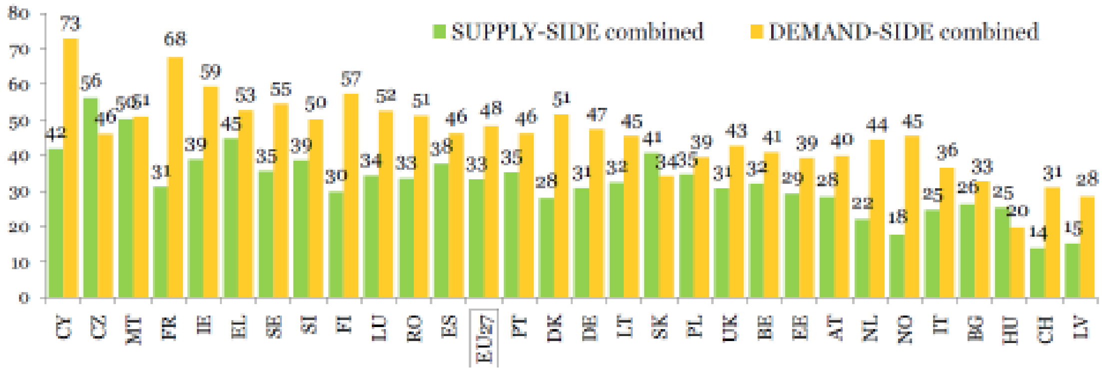
Figure 15: Ratio of companies introducing product (or service) innovations according to Innobarometer 2009 (in the last 3 years)



Source: Innobarometer 2009

Another interesting finding of the latest Eurobarometer innovation survey is that in Hungary – alongside the Czech Republic and Slovakia – supply-side policies (subsidies and tax credits encouraging innovation) that are new (since 2006) have been a greater incentive to innovation in recent years than new demand-side policies (environmental regulations and other industry/technical standards). This is quite unique in the European Union (Figure 16). However, we should note that the Innobarometer – rather confusingly – classifies services from intermediaries (e.g. technology transfer agencies, patent offices, etc.) under demand-side policies, even though this does not comply with the European Commission's innovation policy initiative, PRO INNO Europe (see Cunningham 2009), nor does it make any logical sense.

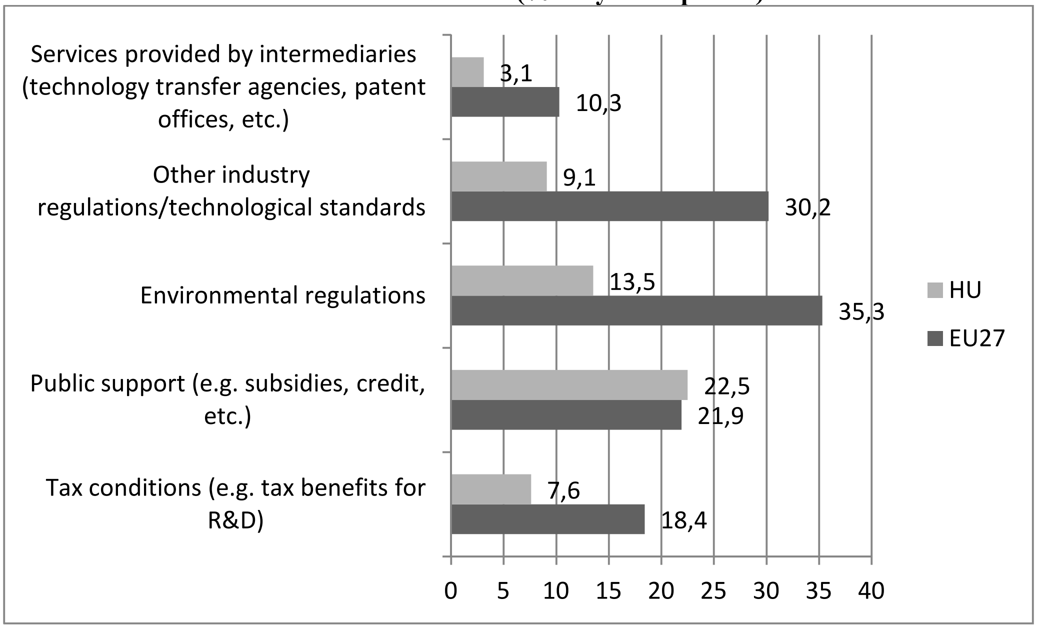
Figure 16: Have changes in innovation policies introduced since 2006 had a positive effect on innovation? (% of 'yes' responses)



Source: Innobarometer 2009

If we look at the examined innovation policies one by one (Figure 17), we see that Hungarian respondents on the whole did not believe that changes in policy-related areas since 2006 had had a positive effect on innovation. The one exception was the change in innovation subsidies, where a slightly higher ratio of Hungarian enterprises thought this acted as an incentive. This is a worthy finding in the light of the very negative overall assessment of Hungary in the Innobarometer (2009), and definitely indicates that over the period under review there has been a substantial improvement in the financing options for innovation projects. Altogether 13.5% of the Hungarian enterprises surveyed perceived some incentive from changes in environmental regulations, compared to the EU average of 35.3%.

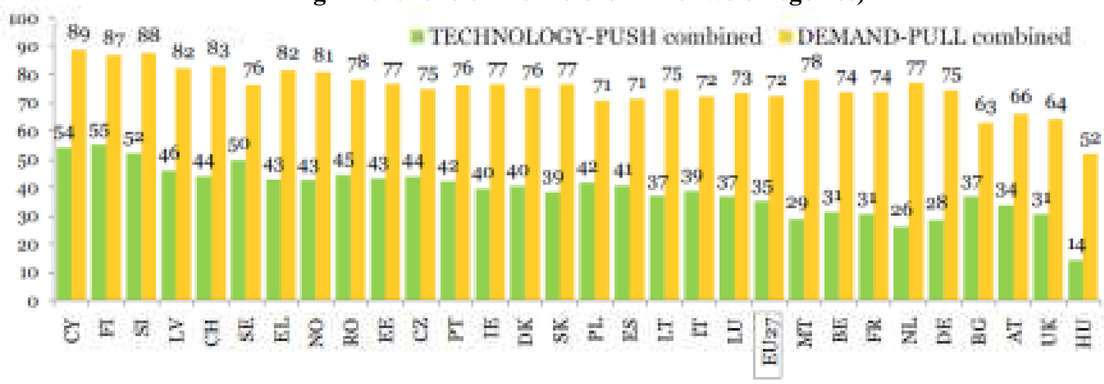
Figure 17: Have changes in the following innovation policies introduced since 2006 had a positive effect on innovation? (% of 'yes' responses)



Source: Innobarometer 2009

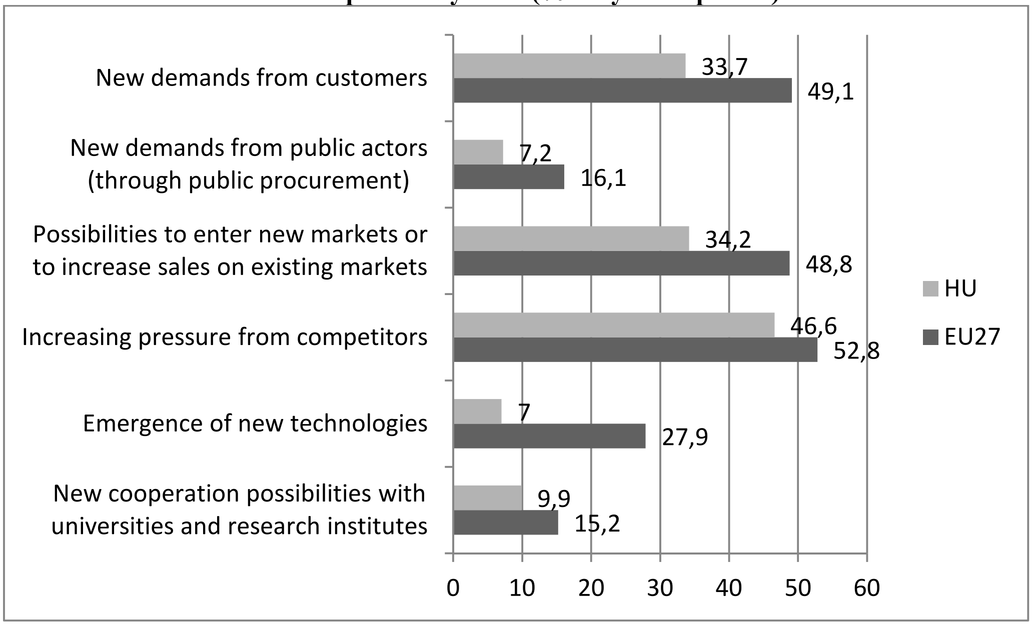
However, in terms of incentives that lie outside public-sector regulations, the situation in Hungary is similar to that in the rest of the Member States, where market (demand-pull) factors have been far more influential in recent years than those derived from new technologies and scientific opportunities (supply-side) (Figure 18). Looking at the various factors it is obvious that using new technologies as a factor encouraging innovation is where Hungarian enterprises lag most behind the EU average, while market factors are relatively strong in this respect (Figure 19).

Figure 18: Have other factors encouraged innovation in previous years? (ratio of companies naming at least one of the factors in the two categories)



Source: Innobarometer 2009

Figure 19: Have any of the following factors had a positive effect on innovation in previous years? (% of 'yes' responses)



Source: Innobarometer 2009

1.3.4 Hungarian surveys and analyses

Alongside the EU statistics, various other surveys have been conducted in Hungary (obviously on much smaller samples than the CIS), most of which display a visibly higher innovation performance for Hungarian enterprises. Since newer research projects generally employ the definition and types of innovation specified in the Oslo Manual, the results are comparable.

For example, according to the results for 2001-2003 of the 'Competing with the World' survey carried out by the Department of Business Economics at Corvinus University of Budapest, 51.2% of the 295 industrial companies responding introduced new products, and 37.6% new technologies, which is high even if we take into account that medium-sized and large companies were overrepresented in the sample. (By far the top factor of aspects facilitating innovation was considered to be support from senior management, followed by highly trained employees. The prime obstacle was the lack of funding, followed by inadequate taxation policies and regulations.) (Kiss 2005)

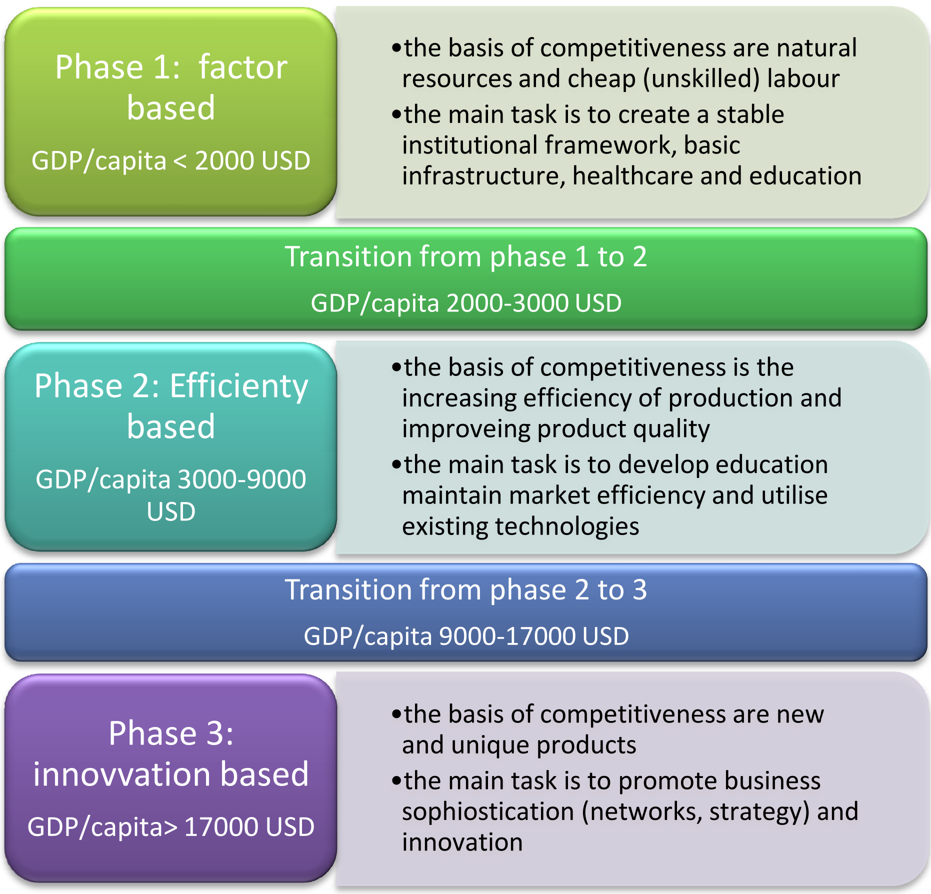
In a 2009 survey by the GKI Economic Research Company, 53.2% of the 124 industrial firms participating introduced a product innovation and 44.4% a process innovation. The main constraint here was also financial problems, but more than half of the enterprises surveyed are trying to survive the economic crisis by stepping up their innovative activities (small enterprises made up the majority of the sample) (Némethné 2010a). Inzelt and Szerb (2003) examined the innovation activity of enterprises in Baranya county between 1998 and 2000, with micro enterprises accounting for 30% and small enterprises a further 30% of the sample from the manufacturing sectors selected (less technologically intensive / more technologically intensive). A technological innovation was implemented by 60.1% of the sample (46.8% rolled out a new product and 39.1% a new technology).

Thus the question arises of what causes the difference between the EU survey statistics and the results of the other surveys. There are several possible explanations for this. The surveying method in the CIS is fundamentally different from unofficial surveys, in so far as it is carried out in Hungary by the Central Statistical Office and participation is compulsory (in 2008 the response rate was 85%). However, with other research there is a risk self-selection bias, i.e. it is likely that companies carrying out innovative activities will be more willing to participate in the survey. For the CIS, however, the compulsory nature can trigger the opposite reaction: as the survey is long and completing it can involve complicated calculations, it is possible that even innovative enterprises answer ‘no’ to the first question exploring the existence of innovation to avoid having to fill out the rest of the survey (Némethné 2010a).

With international surveys, the different definitions of novelty or innovation in various countries can also lead to significant distortions (Smith 2006, Dodgson et al. 2008). There are suspicions of such distortion with the Innobarometer in particular, as the Hungarian data is markedly worse than the rest of the survey here and also when compared to the results of other countries in the region; furthermore, as mentioned earlier, the concept of innovation was not defined precisely in the survey. This means the actual situation is probably somewhere between the CIS data and the results of the much more optimistic Hungarian surveys.

At any rate, there is no denying that the innovation performance of enterprises in Hungary is low compared to the rest of the Europe – even if we do not know by exactly how much. At the same time, Hungary is gradually reaching a level of economic development where it is not able to base its competitiveness on the same driving forces it used to (cheap labour, attracting foreign direct investment) (Pitti 2008). This is well illustrated by the competitiveness report published every year by the World Economic Forum, in which countries are grouped into three categories in accordance with the main competitiveness factors in line with their level of development (see Figure 20). Based on the most recent report from the Forum (Schwab 2010) Hungary is in a transitional group between stages 2 and 3, which means future development is increasingly dependent on the success of innovation.

Figure 20: Sources of competitiveness at various stages of economic development



Source: based on World Economic Forum Global Competitiveness Report 2010-11 (Schwab 2010)

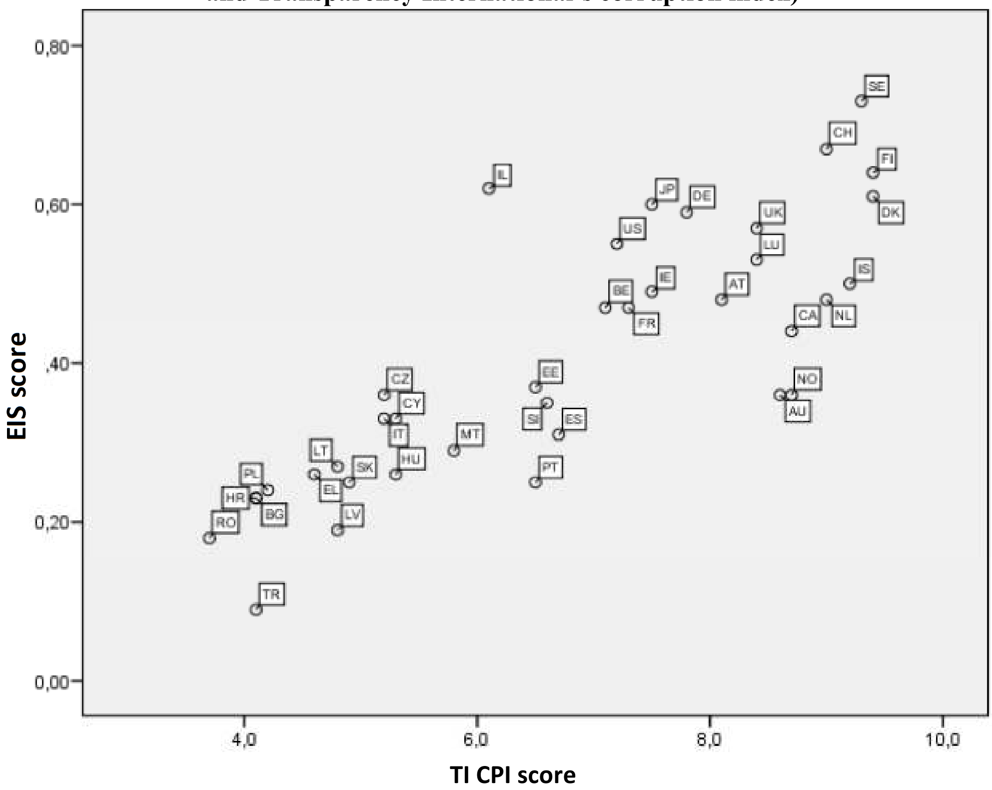
Knowing the importance of innovation, many analysts try to find some explanation for Hungary's weak performance. In view of the country's economic position there are many aspects that could contribute to a low level of innovation that is concentrated on large corporations. What we can say in general about the Hungarian economy is that the gap between (the mostly foreign-owned) large corporations and the small and medium-sized enterprises producing mostly for the local market is massive.

Zoltán Pitti (2008) used the word 'atomised' to describe Hungarian SMEs, referring to the lack of economies of scale and links to large corporations. One problem he mentions is the low capitalisation of Hungarian enterprises and that the Hungarian capital market does not provide them with affordable financing constructions. The duality within the private sector is also derived from the fact that a significant number of Hungarian SMEs are essentially a result of "forced entrepreneurship" established by their owners with a view to avoiding unemployment (Kerekes et al. 2003). Most of these companies are only set up to secure livelihoods, and there is a lack of entrepreneurial spirit and growth potential, which also means these companies rarely focus on innovation (popa-CTDA).

Looking at large foreign-owned companies the question is to what extent their activities in Hungary are innovative. Havas-Polgár (2009) ascertains that in some of the sectors officially considered high-tech industries (e.g. the automotive industry and electronics) the activities carried out in Hungary (assembly) actually require a low level of knowledge. GKI researchers also believe (Borsi et al. 2010) that Hungary has considerable high-tech imports alongside significant high-tech exports, which means this added value is not primarily created in Hungary; however, they find that based on positive initial experience the multinational companies who do set up in Hungary go on to establish more knowledge-intensive activities in the country.

Examining the reasons for the differences in EIS scores between countries, Hollanders and Arundel (2007) concluded – perhaps somewhat surprisingly – that of all the socio-economic and institutional features it is not economic conditions but social capital (measured in terms of public confidence and corruption levels) that displays the strongest correlation to the innovation performance of countries. In Hungary, Katalin Némethné Pál conducted research into the correlations between perceived corruption and innovation (Némethné 2010b). She found that while there was indeed a striking correlation at the level of macro data between the level of corruption and the innovation performance of countries (Figure 21), this was not confirmed in a survey among Hungarian enterprises. The author also noted that although companies identifying unfair practices on their own markets were no less innovative, the perceived corruption was nevertheless an impediment to innovation in that it can prevent a company from entering what is considered to be a corrupt market.

Figure 21: Innovation performance and corruption in various countries, 2007 (based on EIS score and Transparency International's corruption index)



Source: Némethné 2010b

Finally, innovation policy along with the institutions and tools of innovation support naturally exert a strong influence on the innovation policy of countries – as demonstrated below.

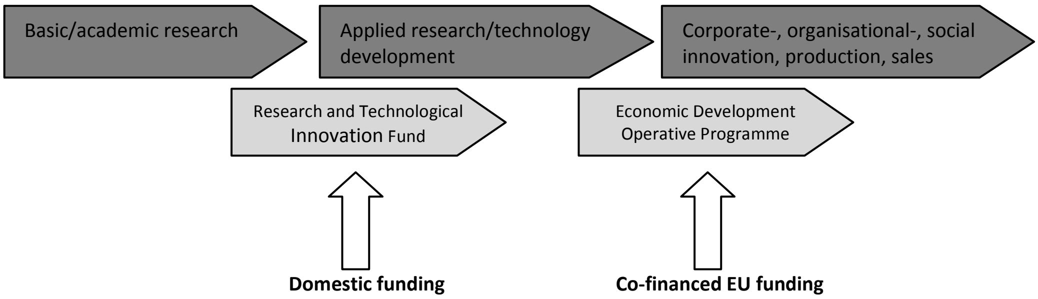
1.3.4. The key features of Hungarian innovation policy

In the decades since the regime change in Hungary, the management system used by the government to coordinate and foster science, technology and innovation has undergone a great many modifications. The OECD Review of Innovation Policy for Hungary (OECD 2008) found this persistent lack of stability detrimental in terms of innovation policy development and adoption of best practice. Decision-making for the most part is not based on rigorous analysis or systematic evaluation of technological and economic trends and the impact of earlier measures, but is driven instead by short-term considerations and interests. According to the study, innovation policy in Hungary has generally tended to be pushed into the background while more immediate and pressing economic problems are dealt with. The authors of the review also point out that Hungary's innovation policy is characterised by a narrow interpretation of innovation, equating innovation with research and development (R&D).

Hungary's first comprehensive piece of domestic legislation on innovation was passed in 2004 (Act No. CXXXIV of 2004 on research and development and on technological innovation). The Act lays down the basic principles of government support for innovation. Then, in 2007, the government passed its 'Mid-term Science, Technology and Innovation Policy Strategy' (STI policy strategy). The STI policy strategy sets very ambitious goals – basically to catch up with the European Union (EU) average by 2013 as measured by the main indicators for R&D and innovation; key areas identified are environmental technologies, energy efficiency, and alternative, renewable energy sources. Implementation of the strategy, however, has been considerably delayed as a result of the economic and political difficulties that arose in 2008 (Havas-Polgár, 2009).

Financial support awarded on a competitive tender basis is the primary means of providing incentives for innovation. This funding, awarded through the operational programmes of the New Hungary Development Plan (NHDP, Új Magyarország Fejlesztési Terv) (most notably its Economic Development Operational Programme - EDOP), comes primarily from European Union development resources (supplemented by co-funding from the Hungarian government, together totalling EUR 350 million for innovation purposes in 2009), and the national Research and Technological Innovation Fund (RTI Fund, with funds of around EUR 250 million in 2009). These two sources differ not only as regards the origin of the funds, but also their intended purpose. While the RTI Fund is designed to support the early stages of the innovation chain, the EDOP is targeted at supporting successful practical implementation and market application of innovations (including adapted innovations) (Figure 22).

Figure 22: Domestic funding along the innovation chain

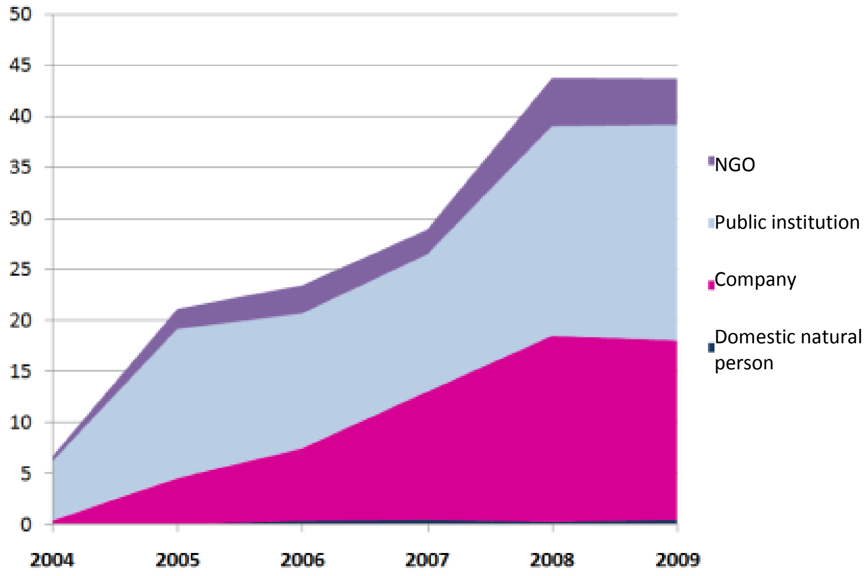


Source: Varga (2009)

The Research and Technological Innovation Fund (RTI Fund) was established in 2004. It operates on the principle that companies (except small businesses) are required to pay a set percentage of their income (innovation contribution) into the fund, and the total amount contributed by companies is then matched by the government out of the public budget. The Fund provides a dual incentive for innovation, first by awarding funding, and second directly by allowing companies to reduce their innovation contribution by the amount they spend on conducting R&D activities. A study evaluating the RTI Fund's activities from 2004-2009 (Borsi et al, 2010) found that overall the Fund succeeded in boosting R&D activities in the bodies to which it awarded funding, and in fostering cooperation among the various institutional players; around 10-15% of RTI Fund-supported companies achieved significant market success. As of late 2009 the RTI Fund had provided support to around 2 600 companies. Although this represents only a tiny proportion of businesses, the positive spillover effects of this funding are evident.

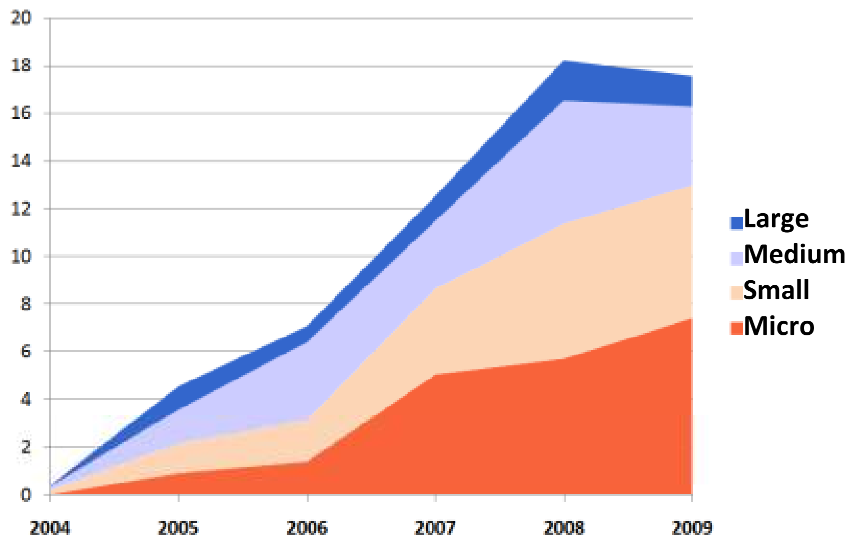
The evaluation study also identifies a number of problems that have impaired the RTI Fund's effectiveness over recent years. These were primarily a result of the failure to ensure financial independence for the Fund's operations amid the budgetary difficulties of recent years. The government contribution to the Fund regularly fell short of the amount calculated on the basis outlined above, while any funds remaining at the end of the year were used to reduce the budget deficit. It was originally intended that at least 50% of the support provided by the Fund would go to companies (to ensure that the introduction of the mandatory innovation levy would not place an extra burden on companies), but to date the main beneficiaries have been public sector research bodies. (The ratio has shifted in favour of companies since the Fund commenced operations, but it has yet to reach the 50% mark.) (Figure 23). One reason for this may be that direct government financial support to publicly-funded research institutions was cut at the same time as the Fund was set up, so there was great pressure to make up for the lost funding out of the RTI Fund. Over the years since its establishment, the share of RTI Fund resources going to small and medium-sized enterprises (SMEs) has also risen steadily, but this too still falls short of the desirable level (Figure 24). (Borsi et al, 2010)

Figure 23: Resources disbursed by the RTI Fund by type of beneficiary (in HUF billions)



Source: Borsi et al, 2010

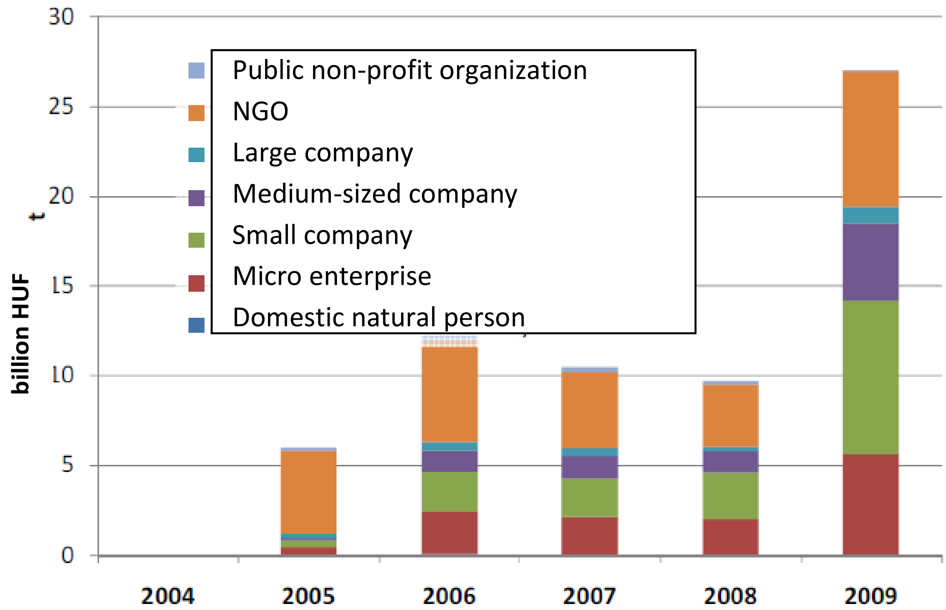
Figure 24: Resources disbursed by the RTI Fund to companies (in HUF billions)



Source: Borsi et al. 2010

Companies represent a much higher proportion of the beneficiaries of funds paid out of the EU Structural Funds through the New Hungary Development Plan (NHDP) (Figure 25) The Economic Development Operational Programme (EDOP) of the Plan is expressly targeted at companies. In exchange for 50% company co-financing, EDOP generally provides non-repayable financial support for company R&D activities and technology development (funding intensity in the case of the RTI Fund is generally higher; in the case of smaller companies it may be as high as 80-90%). EDOP priority axis 1 specifically addresses the objective of promoting innovation and supporting innovative companies. Under this scheme, a total of nearly HUF 200 billion has so far been awarded to nearly 600 applicants, with a total of around HUF 28 billion having been disbursed to date. Within EDOP's priority axis 2, aimed at promoting the complex development of enterprises (focusing especially on SMEs) around HUF 137 billion have so far been awarded to 6 400 applicants for company technology development. HUF 6.6 billion of this has been so far been disbursed.

Figure 25: Trends in the disbursal of Structural Fund resources for research, development and innovation



Source: Borsi et al, 2010

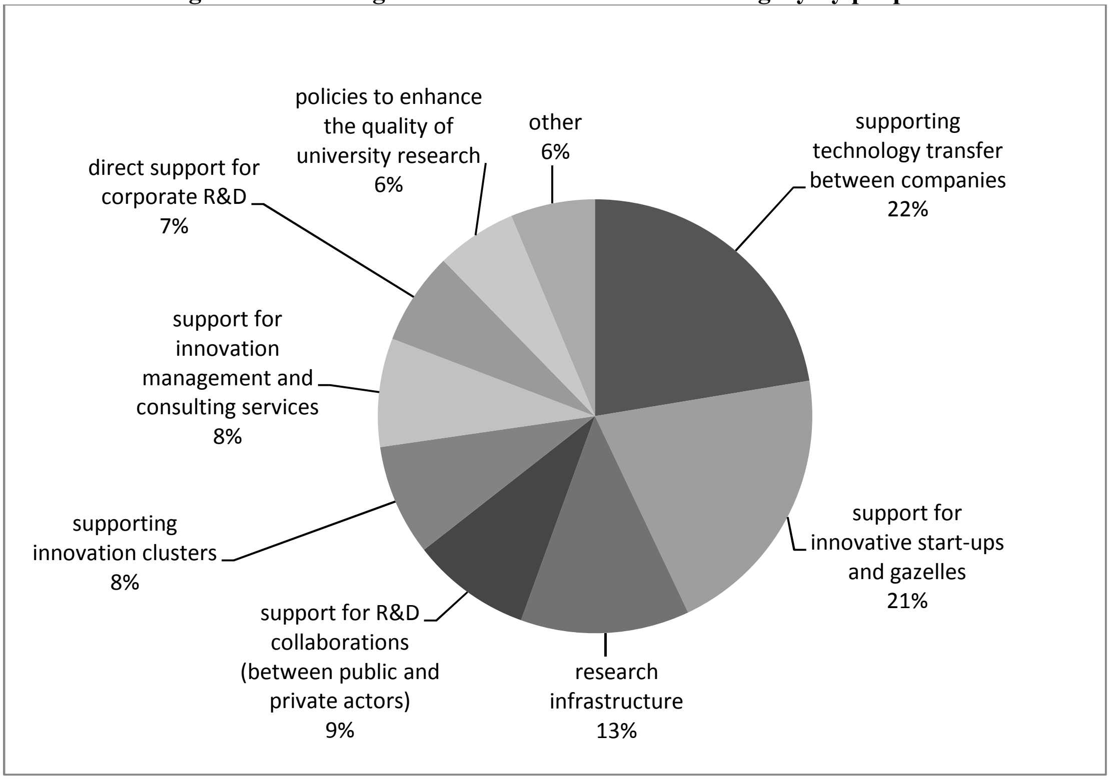
The conclusion to be drawn from these figures is that the programmes are popular and that there is demand for these grants. One exception to this is scheme c. 'promoting innovation activities of firms', where only 50% of the resources have been awarded, presumably due to the high minimum level of own resources required (HUF 25 million) (Havas – Polgár, 2009). The appraisal report on innovation policy in Hungary produced in 2009 for the European Commission (Havas – Polgár, 2009) also highlights the risk that EDOP resources may go to firms which would implement the development measures in question even without these funds, while smaller, less innovative firms are not being adequately targeted. According to the authors, the approach of EDOP (and Hungarian innovation policy as a whole) is characterised by a bias towards R&D-based innovation and high technology areas, whereas the development of Hungarian SMEs would be better served by a greater emphasis on promoting adopted innovations. The authors of the report also found that Hungarian innovation policy tends to neglect organisational innovation in favour of technological innovation. Némethné (2010a) also considers the excessive focus on R&D in both the Hungarian and European innovation system to be a problem. She highlights that for firms the most crucial aspect is the competitiveness-enhancing effect of innovation, and innovations which are successful in this sense often come about independently of any R&D activity.

The above resources relate to innovation as a whole. Funding for R&D and investment can of course also be used for environmental development (or developments which have positive environmental impacts), but no separate information is available on these. Environmental considerations are commonly included among the selection criteria for tender applications, and yet there is no way of assessing the impact of funded investments on the relevant firms' environmental performance. Of course there are also other schemes targeted specifically at promoting environmental innovation. In numerical terms, the proportion of these is rather higher in Hungary than the EU average (about 6% of innovation policy tools are dedicated to environmental protection and energy respectively – see Havas-Polgár, 2009). No comparative data are available, however, from the budgets of these schemes.

The Environment and Energy Operational Programme of the New Hungary Development Plan (NHDP) in principle is not targeted at firms. However, its 'energy efficiency' priority, includes HUF 540 million in resources that may be awarded to support measures to improve energy efficiency in small and medium-sized enterprises. Another similarly specific scheme is included in EDOP objective 2.1.4 ('environment-centred technology development'). So far, however, a mere 16 applicants have been awarded a total of HUF 800 million (HUF 200 million of this has been disbursed to date). In other words, this scheme clearly only provides a narrow range of firms with possibilities for undertaking environment-centred development measures. Also within the EDOP framework, there is another scheme ‘promoting introduction of quality, environmental and other management systems and standards’, which has awarded around HUF 600 million to 657 applicants (most of which has already been disbursed). Again, however, we do not know how much of this was spent on environmental and how much on other systems.

Figure 26 shows the distribution of funding resources for R&D and innovation in Hungary by purpose (based on the classification system established by the European Commission). It is clear from this that the largest amount of funding goes to support technology transfer between firms. The category ‘support for innovative start-ups’ in essence covers the New Hungary Enterprise Development Credit Programme. In this case the classification is a little misleading as existing firms as well as start-ups can apply to the Programme for the purpose of technological modernisation or capital expenditure on environmental protection. Unlike the other programmes, this scheme, as its name suggests, provides low-cost loans rather than non-repayable funding. Of course an important part of the resources listed below are aimed not at companies but at other institutions (e.g. universities, research institutes). It should also be mentioned that support for innovation comes not only in the form of funding, but also a variety of benefits and tax rebates, the most significant of which is a 200% deduction from taxable income for R&D expenditure (300% in the case of a company research unit operating within a university or public-sector research institute).

Figure 26: Funding for R&D and innovation in Hungary by purpose



Source: Havas-Polgár, 2009

Recent appraisals of innovation in Hungary (OECD, 2008; Havas-Polgár, 2009) have found that, all in all, the main problem with domestic innovation policy at present is not a lack of financial resources. The resources available in the country have expanded significantly in recent years as a result of Hungary's EU membership and the establishment of the Research and Technological Innovation Fund, and these resources are also largely independent of the economic crisis[7]. Reasons for the corporate sector's persistent poor innovation performance are to be sought instead in the instability of the institutional environment and the lack of coordination among the many different support mechanisms. All these things make it exceedingly difficult for companies to obtain information, while frequent delays in funding decisions and in the disbursal of funds awarded create serious problems in terms of planning innovation projects.

Némethné (2010a) also highlights the fact that the best way to foster innovation is not necessarily by (re)distributing financial resources. She points out that subsidies have little impact in terms of boosting innovation, and that the government could do a great

[7]In the case of the RTI Fund, this is far from clear. According to Borsi et al, 2010, and Némethné, 2010a, the RTI Fund has hitherto tended to operate by financing public research institutions out of the resources levied from companies.

deal more to increase domestic innovation performance by managing demand (e.g. measures with an impact on demand, public procurement), combating corruption and promoting cooperation among corporate innovation actors.

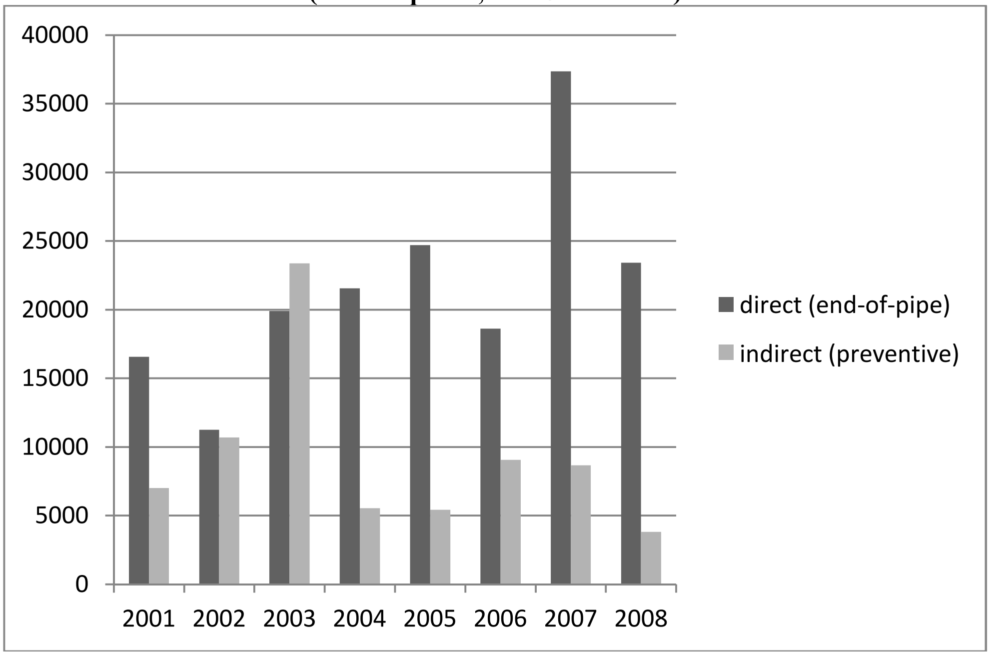
1.3.3. Environmental innovation activity of Hungarian companies

1.3.3.1. Community Innovation Survey (CIS) data

Within the available statistical data, the indicators for capital expenditure on environmental protection provide the best basis for making inferences with regard to environmental innovation. According to the data from Hungary’s Central Statistical Office (KSH), companies’ capital expenditure on environmental protection totalled HUF 136.5 billion in 2008. HUF 27.2 billion of this expenditure took place in the manufacturing industry. Figure 27 shows the dynamics of capital expenditure in the manufacturing industry. It can be seen that capital expenditure varies considerably from year to year, with spending on integrated (preventive) environmental protection generally falling below spending on direct (‘end-of-pipe’) measures.

In comparison with other European countries (based on Eurostat data) capital expenditure on environmental protection by Hungary’s manufacturing sector in 2006 was equivalent to 0.12% of GDP, or twice the EU average. (In general, this figure is higher in the new EU Member States than in western European countries.) Due to the strong fluctuations, it is difficult to draw any general conclusions regarding the nature of this spending. If we consider the average for the 27 EU Member States, however, the share of capital expenditure on preventive measures within total spending on environmental protection in the manufacturing sector is around 34%. In Hungary, this figure varies between 18% and 71% over the past ten years, without any clear trend emerging.

Figure 27: Capital expenditure on environmental protection in the manufacturing industry (current prices, in HUF millions)



Source: Central Statistical Office (KSH)

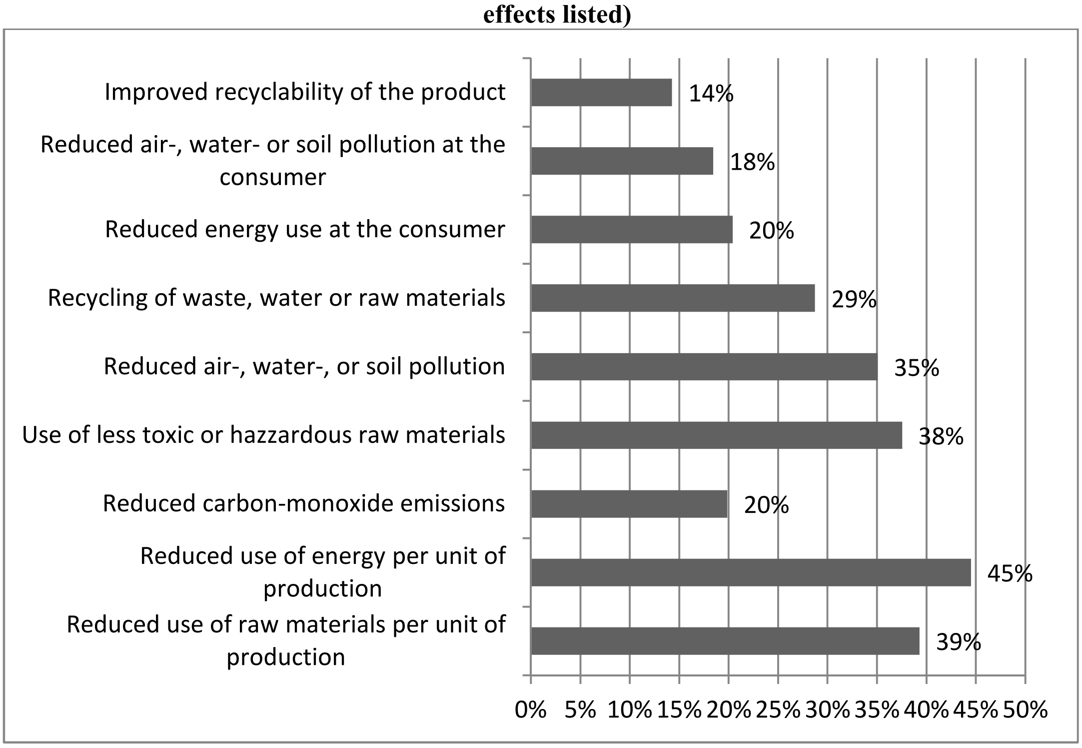
The level of capital expenditure on environmental protection clearly depends not only on the general economic climate, but also to a large extent on developments in environmental legislation. (Some studies (e.g. Bellas-Nentl, 2007), for want of a better approach, use capital expenditure by companies on environmental protection as a measure of regulatory stringency.) All in all, however, data on environmental protection capital expenditure clearly provide only limited information on developments in environmental innovation. For one thing, it is clear that the amount of capital expenditure is not necessarily in direct proportion to its environmental effects. Second, indicators for environmental protection capital expenditure only include investments specifically aimed at environmental protection, and this does not correspond to the interpretation most often applied, by the present author included, which classifies a given innovation as environmental on the basis of its effects.

In the European Union's Community Innovation Surveys (CIS) mentioned above, issues relating to environmental protection have cropped up with increasing frequency in recent years concerning types and drivers of innovation, so the CIS data may provide some insight into environmental innovation. Earlier CIS data also examined impact on the environment as an aspect of the impact of innovations. In 2006 7.2% of companies in Hungary implementing technological innovations reported that this development led to a significant improvement in energy and resource use efficiency; the EU average was 9.6%. 13.6% of companies reported reduced environmental impact or improved health and safety. (In 2004 the EU average was 14%, while the figure for Hungary was 13.2%.) In 2006, technological innovators in Hungary invested in order to comply with legislative provisions (of various sorts) in 19.8% of cases. (In 2004 the percentage for Hungary was 19.4%, while the EU average was 18.3%). It seems, therefore, that although Hungarian companies were less innovative on the whole than their counterparts elsewhere in Europe, they were devoting almost as much attention at their own level to environmental protection issues.

In the 2008 CIS data, environmental innovation is discussed as a separate issue and in much more detail than in previous surveys. Environmental innovation is defined as innovation which 'creates environmental benefits compared with alternatives', regardless of whether this was the primary objective of the innovation. Figure 28 shows how many manufacturing companies carrying out innovations (of any type) reported that the innovations implemented by them in the period 2006-2008 created an environmental benefit for any of the parameters listed. Unfortunately several mistranslations occurred in the Hungarian version of the questionnaire, undermining the value of the information obtained. For example, the questionnaire elicits information about carbon monoxide instead of carbon dioxide emissions; noise is omitted from the list of pollution types, and water pollution is missing from the types of pollution produced by the end-user. (The figure gives the responses to the uncorrected questionnaire actually used in the survey). It is evident from the figure that innovations which increased environmental efficiency were the most common, while those that produced environmental benefits for the end-user (in other words relating to product use) were the least frequent.

Overall, large enterprises reported innovations that created environmental benefits more often than SMEs; it is also interesting that around 10-20% more large enterprises than SMEs mentioned production-related benefits, while after-sales benefits to the end-user occurred only 5% more often in the case of large enterprises. These considerations, in other words, are clearly not the focus of their innovation activities. Naturally, some sectors diverged markedly from the average, in line with the particular nature of the industry. For example, the number of innovative companies replacing materials with less polluting or hazardous substitutes was extremely high in the chemical industry (63%), the electronics industry (50%) and the printing industry (48%); pollution reducers were likewise most numerous in the chemical industry (63%) and in the beverages sector (51%); post-use product recycling efforts were most prominent in the paper industry (47%), the rubber and plastics industry (41%) and in the electronics sector (39%); reducing energy use for the end-user was more important to electrical equipment (39%) and machinery (36%) manufacturers; product recyclability was a particularly important consideration in the rubber and plastics industry (39%).

Figure 28: Environmental impact of innovations implemented by Hungarian companies in the manufacturing sector (percentage of innovative companies whose innovations produced the effects listed)

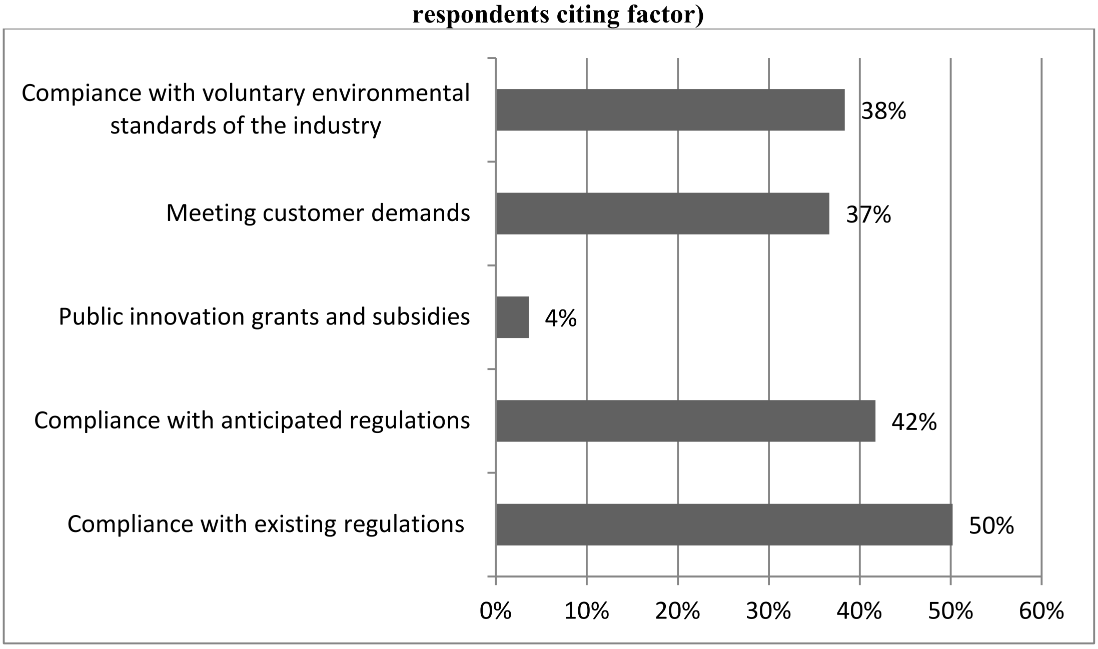


Source: EUROSTAT

As regards the primary motives for environmental innovation we can see (Figure 29) that in the case of half of the companies the most important motivating factor was compliance with existing environmental regulations. Anticipated environmental legislation, however, was rated only marginally more important than complying with voluntary undertakings within the sector or meeting consumer demands. Access to grants and subsidies was evidently not in itself a motivating factor for the majority of companies. The share of companies citing financial support as a major motivating factor was particularly high in the pharmaceuticals industry (14%), while customer demand for environmental innovation had by far the least important role in this sector (14%). Sectoral voluntary environmental standards played a major role especially in the beverages industry (60%), the wood and wood products industry (52%), and in transport equipment manufacturing (52%).

It is regrettable that reducing costs was not included in the list of possible responses to the question concerning motivating factors for environmental innovations, although this may be a paramount consideration in the case of innovations aimed at improving energy and resource use efficiency, or waste recycling. As the CIS questionnaire frames questions on environmental innovations not around environmental objectives but around environmental benefits, it is very likely that a significant proportion of environmental innovations come about in this way. A whole host of other possible motivating factors was also omitted, ranging from improving occupational health and promoting good relations with the local population and non-governmental organisations, to public image considerations.

Figure 29: Motivating factors for environmental innovation in the manufacturing industry (% of respondents citing factor)



Source: EUROSTAT

The Innobarometer surveys do not cover environmental innovation, although they do include an interesting question aimed at eliciting the effects of potential future trends on innovation: 21% of Hungarian respondents thought that increasing demand for sustainable or energy-efficient products over the next two years could be a potential source of innovation opportunities (the EU average was 32%) (Innobarometer, 2009).

1.3.3.2. Hungarian studies

Researchers at the faculty of Environmental Economics and Technology at the Budapest University of Economic Sciences and Public Administration (now Corvinus University) conducted two surveys in Hungary examining companies' environmental activities, including environmental innovation activities. Both surveys examined companies with fifty or more employees in the manufacturing industry. The first was carried out in 1999 and included 152 firms (Kerekes et al. 2000), while the second – part of a broader OECD study (see Johnstone et al. 2007) – was carried out in 2003 with 466 respondent firms.

The first survey (Kerekes et al. 2000) covered all aspects of companies' environmental protection activities (management tools, communications, marketing, concrete environmental protection measures), and the drivers and obstacles relating to these. As regards environmental innovation, the survey found that measures aimed at efficient use of energy, raw materials or water were mentioned most frequently (the percentages of companies stating that they had not introduced such measures in the previous five years and did not intend doing so in the near future were 13.8%, 19.1% and 26.9% respectively). Next came measures aimed at reducing emissions of various types, and last came measures relating to waste management, which half of the companies surveyed had not put in place and did not plan to. It should be noted, however, that the formulation of the question in the questionnaire ('Have you introduced measures in the areas listed below?'), did not indicate whether it was referring to measures undertaken with this express purpose or measures with this outcome. It is therefore possible that some measures usually covered by the term environmental innovation were not mentioned by the respondents.

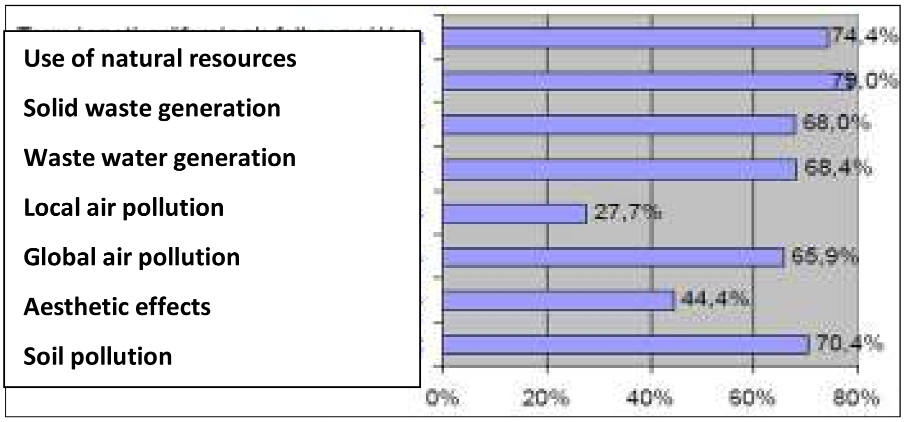
The study also examined how the environmental protection measures introduced had impacted on the company's operations: beneficial impacts included better sales in the

EU market, improved product quality, and long-term profit trends; negative impacts mentioned included increased production costs and short-term profit trends. Among the motivating factors for environmental protection measures, legislation (whether Hungarian, EU, or of the country of the market targeted) was deemed by the respondents to have the strongest influence. Responses varied considerably, however, as regards the importance of market and cost factors, and of social and environmental responsibility. The majority felt that environmental risks and demand for environmentally friendly products had only a very weak influence. The top factors hampering environmental measures were financial, but other important factors included inadequate technical conditions and the low profits to be made from environmental protection measures. The knowledge base and willingness of the company's management were considered adequate by the majority of respondents (Kerekes et al, 2000).

The second survey (Kerekes et al, 2003) focused on the use of environmental management tools, but it too contained questions on specific environmental measures. The frequency of concrete environmental measures is shown in Figure 30 while distribution by type of measure can be seen in Figure 31. One striking difference compared to the 1999 survey is that measures relating to waste management had moved up to top place. As regards types of measures, process-related innovations are clearly in the majority, which is in line with the fact that about 85% of respondents felt that market opportunities relating to environmental protection were negligible. A significant majority of these process innovations, meanwhile, were preventive measures.

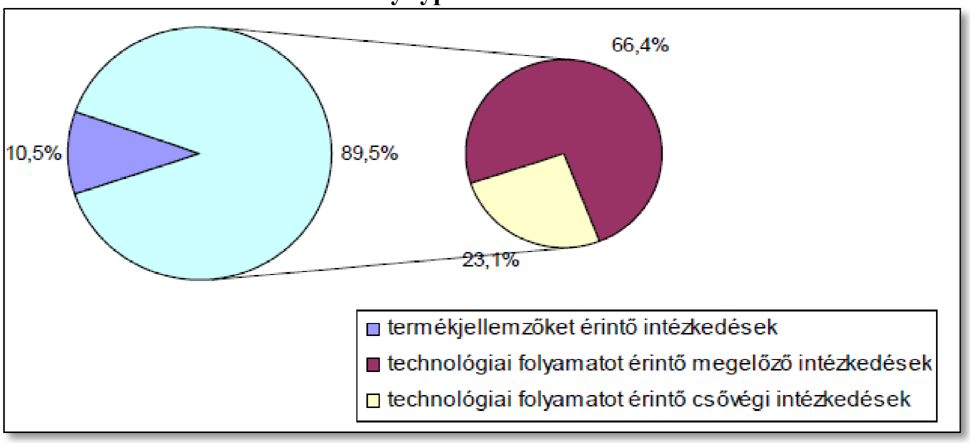
In this questionnaire, the question on environmental measures asked whether the company had put in place any measures *for the purpose of* mitigating various types of environmental impact. The importance of how a question is formulated can be seen clearly here: the percentage share of measures aimed at reducing global air pollution is small, whereas a high percentage of measures is geared to more efficient resource use. Of course in most cases energy efficiency measures reduce greenhouse gas emissions, although cutting costs may in fact have been the objective rather than reducing emissions. (It is a pity that natural resource use was not broken down to give a differentiated picture of energy efficiency measures; on the basis of the research discussed above, we may hazard a guess that the percentage of these would have been high.)

Figure 30: Frequency of measures in the Hungarian manufacturing industry to reduce environmental pollution



Source: Harangozó, 2007, p.178.

Figure 31: Environmental protection measures undertaken by Hungarian manufacturing firms, by type of measures



Source: Harangozó, 2007, p.178.

In this survey, examination of motivating factors was concerned with environmental protection practice as a whole, and therefore no distinctions were drawn between factors influencing specific environmental measures (innovations). According to the firms surveyed, the most important motivating factors were compliance with legislation, accident prevention, company image and cost reduction (Kerekes et al, 2003).

2. Research model and hypotheses

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 outcomes may be different. Therefore in my research model (Figure 32), I differentiate between end-of-pipe, cleaner production and product innovations, as well as novel and adopted innovations.

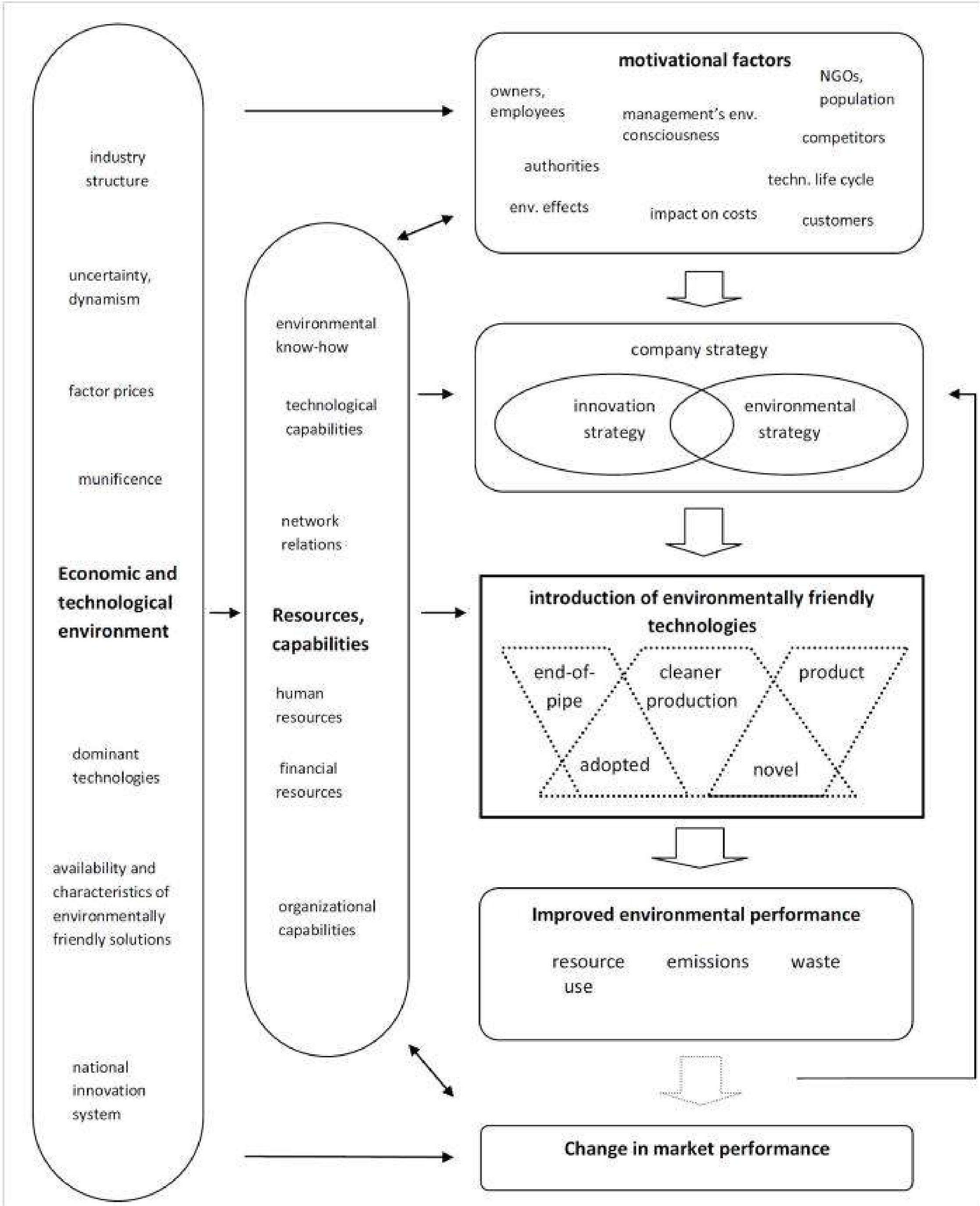
The determinants are divided into three main groups: the first is that of factors which influence companies' motivation to engage in environmental innovation. Examples include the expectations of various stakeholders or the cost-saving potential associated with environmentally friendly solutions – at 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 easily 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.

The environmental innovation strategy of the company is formed (not necessarily in an explicit way) based on the assessments of the motivational factors and the company's resources and capabilities. This strategy shows whether the company wishes to adopt a leading or following position in the technological sense; whether it wishes to focus on regulatory compliance or aims at environmental excellence. (Environmental innovation strategy can be interpreted as the junction between innovation strategy and environmental strategy.) The strategy and the actual possibilities together will decide what specific environmental innovations will be realized by the company (I assume that the proportion of novel and adopted technologies will not be the same for end-of-pipe, cleaner production and product innovations, this is indicated by the groupings on the figure – see hypothesis 4c. below).

As a result of the environmental innovations the environmental performance of the company will improve (this is true in every case, since environmental innovations were defined by their results in the first place). The question is "merely" the extent and exact nature of this improvement. It was mentioned previously that there is a lot of uncertainty regarding the connection between environmental and economic performance – my research does not wish to address this topic in detail, it is only interesting insofar as that the economic results of earlier environmental innovations may influence the company's openness to such projects in the future.

Figure 22: Research model



Regarding the connections concerning environmental innovations and their various 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.

3 A study of the environmental innovation activities of Hungarian manufacturing companies using a questionnaire survey

3.1 Survey and sample characteristics

Because available statistical data is only partially suitable for investigating environmental innovation activity and is not at all suitable for examining most of the determinants, a questionnaire survey was implemented in order to examine the relationships and test the hypotheses presented above. The survey was carried out with the participation companies from the Hungarian chemical industry, food industry, machine industry, vehicle industry and electronics industry. The choice of industries is justified on the one hand by their economic weight (the chosen industries account for more than 2/3 of the added value produced in the Hungarian manufacturing sector); while on the other hand I was aiming to ensure a relatively heterogeneous sample from the point of view of the intensity of innovation activity as well as the nature and severity of environmental effects.

Before the survey was undertaken, in order to ensure that the questionnaire would reveal meaningful and relevant information, the following (industry and innovation) experts were interviewed:

- Dr. János Pakucs, Honorary President of the Hungarian Innovation Association
- Dr. Magda Bada Gáspárné, Deputy Director of the Hungarian Chemical Industry Association, responsible for environmental protection issues
- Péter Biacs, leader of environmental management at SPAR Hungary Ltd.
- Dr. Jenő Igaz, managing director of the Machine Industry Scientific Society
- László Bogdanovits, secretary general of the National Association of Vehicle Parts Manufacturers

The survey was first administered to the chemical industry (in the spring of 2010), then rolled out to the rest of the selected industries during the summer of 2011. The questionnaire was supplemented on the basis of the lessons learned from the chemical industry survey – however, there was no need to make any modification that would have lead to issues with comparability (in the following discussion it is noted each time where the issue discussed was not included in the chemical industry questionnaire and therefore does not include data from the chemical companies). The questionnaire consists of three main parts: after questions concerning the general features of the companies followed questions on company environmental innovation activities (at first on the general level, then related to particular innovations), and finally came questions concerning the drivers and barriers to environmental innovation (the questionnaire can be found in Appendix 1).

The questionnaire was administered through personal interviews by students from the Corvinus University of Budapest. The use of face-to-face interviewers provided considerable advantages, as it made it possible to survey a large number of companies without the need to compromise on the benefits of personal contact. This made it possible to include several open-ended questions and benefit from a relatively high response rate. Efforts were made to ensure the quality of the interviewing and identical interpretation of the questions through a thorough coaching of interviewers before they were sent into the field.

During sampling it was a more important goal to construct a database suitable for analysing differences between industries and firms of various sizes (that is, to collect a sufficient amount of data from each industry and size category) than to ensure statistical representativeness of the sample. This means that the chemical and vehicle industries – much smaller groups within the total population of manufacturing firms than the others chosen sectors – are overrepresented in the sample. We also involved medium and large size companies to a larger extent than their actual proportion in the total industry population would suggest (while preserving the dominance of micro and small enterprises). The interviewers contacted 1126 companies altogether, from which 297 agreed to take part in the survey. This is a response rate of 26.4%. The companies contacted were selected using a random sampling method (from a database purchased from D&B Marketing Ltd.).

Figure 33 shows the characteristics of the sample according to company size, while Figure 34 shows sample distribution by industry. It can be seen that, in the examined industries, the distribution of the sample by company size is by and large even, except for the electronics industry where micro-enterprises (less than 10 employees) are strongly represented, while small enterprises (between 10 and 49 employees) are less well represented. (For a comparison of the composition of the whole population and the sample, see Appendix 2).

Figure 33: Distribution of companies in the sample by industry

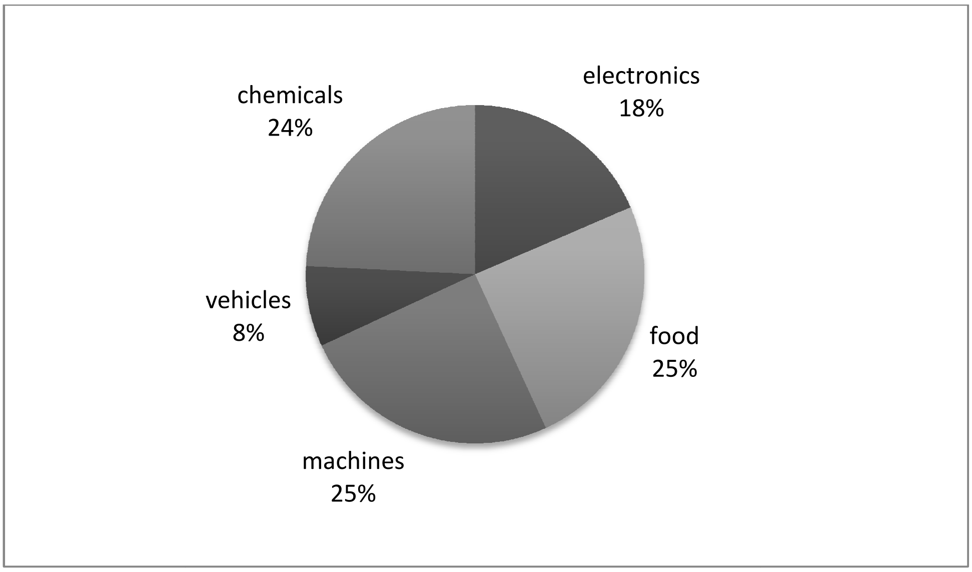
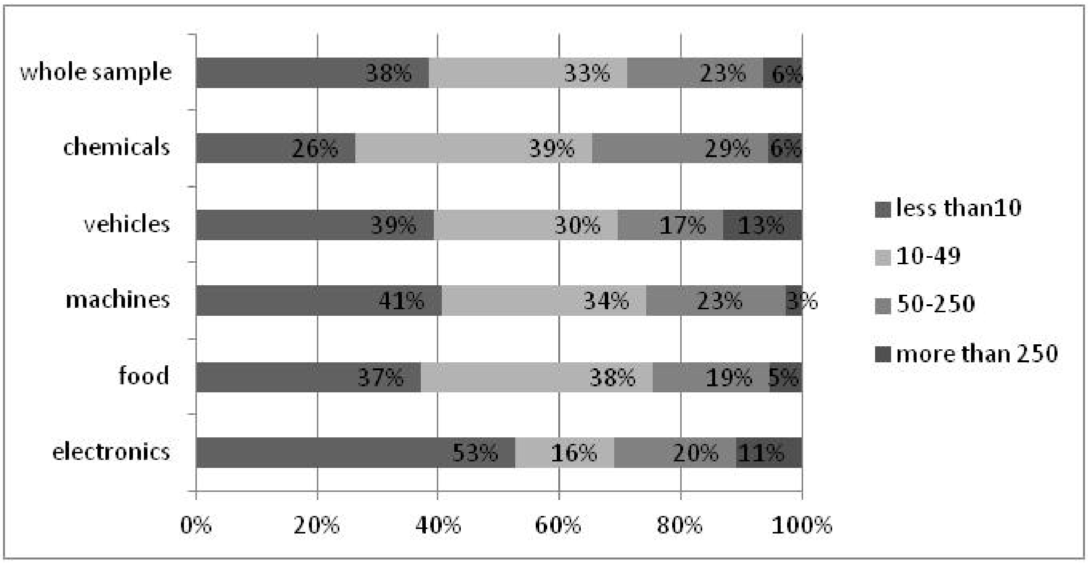
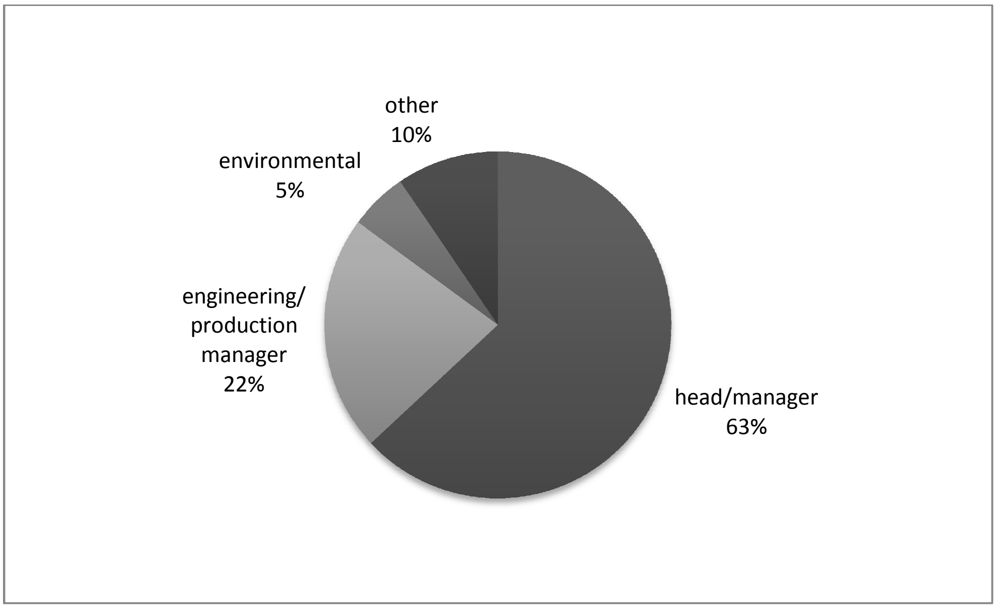


Figure 34: Distribution of companies according to size (number of employees)



Concerning the identity of the respondents, it was an important aim to survey company representatives who were adequately familiar with the production processes of the company. As can be seen in Figure 35, in most cases (more typically at smaller companies) the interview was made with the head manager, while at larger companies it was made with the head of production or engineering. In addition, there were also respondents who work in environmental protection, while the "other" category comprises a very diverse group of people (office managers, financial, etc.).

Figure 35: Position of respondent within the company



Data analysis and hypothesis-testing was carried out by means of frequency analyses, cross tabulations and examination of correlations, as well as through using a multivariate model (logistic regression). For a summary table of the variables used in the analysis, see Appendix 3.

3.2 Basic characteristics of the companies

The data concerning the size and industrial sector of the companies surveyed was presented in the chapter above, however, before going on to describe findings from the analysis of their innovation activities, it is useful to examine some further general features of the firms in the sample.

Concerning the market position of the interviewed companies, the influence of the economic depression can be strongly felt: 41% of the respondents reported a decrease in the company's financial standing after taxation and 78% of them specified the economic depression and a decrease in demand related to it as a cause (some also mentioned a growth in factor costs and stronger competition – mostly brought about by foreign companies). 33% of the companies in the sample reported to having a more or less unchanging financial position over the last couple of years – interestingly, almost half (48%) of this subgroup also specified the economic depression as a reason for this, which indicates that these companies are otherwise growth-oriented. In addition, 18% reported largely constant demand for their products and services, while 9% reported the opposite, namely an unpredictable fluctuation. The companies which succeeded in improving their financial performance despite the difficult market conditions over the last few years (27%) mostly explained this through pointing to increasing demand for their products (49%), while 27% of them attributed it to their own innovations and newly introduced products, and 11% specified growth in operational efficiency.

In the sample, vehicle industry companies clearly suffered most from the drop in demand caused by the economic depression (about 70% reported decreases in profits after taxation), while electronics companies performed the best (here, the proportion of companies with increasing and with decreasing results was the same - 32%). It appears that the size of the company was not the primary variable behind the financial changes, although medium-sized companies (with between 50-250 employees) were in a slightly better situation (with 1/3 of them reporting a 'decreased' and 1/3 of them reporting an 'increased' financial performance after taxation).

The expectations of respondents concerning the future are considerably more positive than the tendencies of the recent past: 17% expect a 'significant' and 48% a 'moderate' improvement in their market position during the next couple of years. 28% of those who expect improvements rely on an economic boost occurring following the current depressionary period; 25% put faith in the effects of various developments made at the company, while 23% see the opportunity for gaining new markets. In the case of 14 respondents (8% of the total sample) positive expectations are only based on their own personal optimism, whereas about the same number make their future plans based on knowledge of specific commissions or tenders won. Those with negative expectations (11% altogether) are mainly afraid of the economic crisis enduring, and many who expect their position to stagnate also refer to this (almost a quarter of the respondents, 31% of whom reported concerns about the crisis ongoing). Interestingly, the most positive responses regarding expectations come from vehicle industry companies who have performed worst in the recent past (78% of whom expect an improvement of some sort in the next few years; for comparison, this proportion is only 56% in the food industry).

The following figures indicate the markets of the companies featured in the sample. It can be seen (Figure 36) that 38% of the companies 'exclusively' and 33% 'mainly' (i.e. to more than 50%) produce for the domestic market. Companies which have significant export activity, produce predominantly for the EU market. In this regard, the differences between the industries are considerable as in the food industry 82% of production is for the domestic market, while this proportion is between 52 and 59% for the machine, electronics and vehicle industries (64% in the chemical industry). Chemical industry companies produce in the highest proportion for markets outside the EU (12.53%; the average of the sample is 7.97%). It is hardly surprising that the intensity of export activities is also influenced by the size of the company – while micro-enterprises with less than 10 employees only export about 20% of their products on average, companies with 10 to 49 employees export 35%; in the 50 to 249 employee range the proportion is already 56%, and in the case of large companies with more than 250 employees it is 62%.

Figure 36: What kind of market does the company produce for?

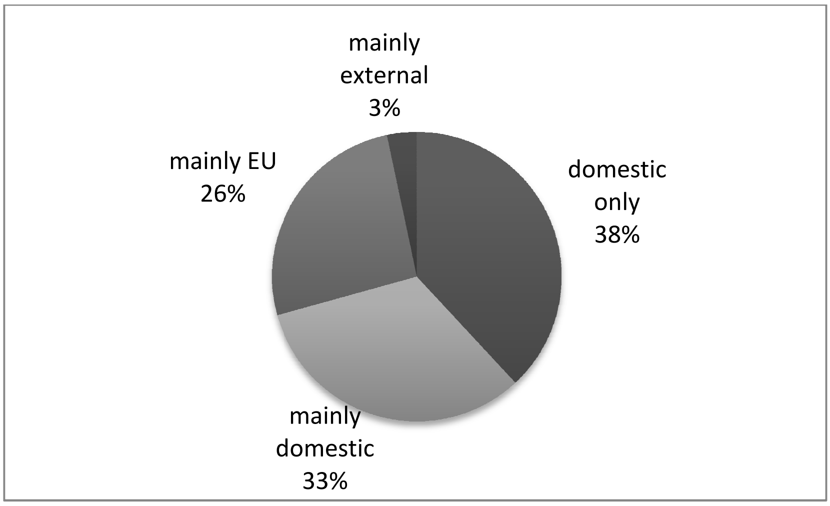
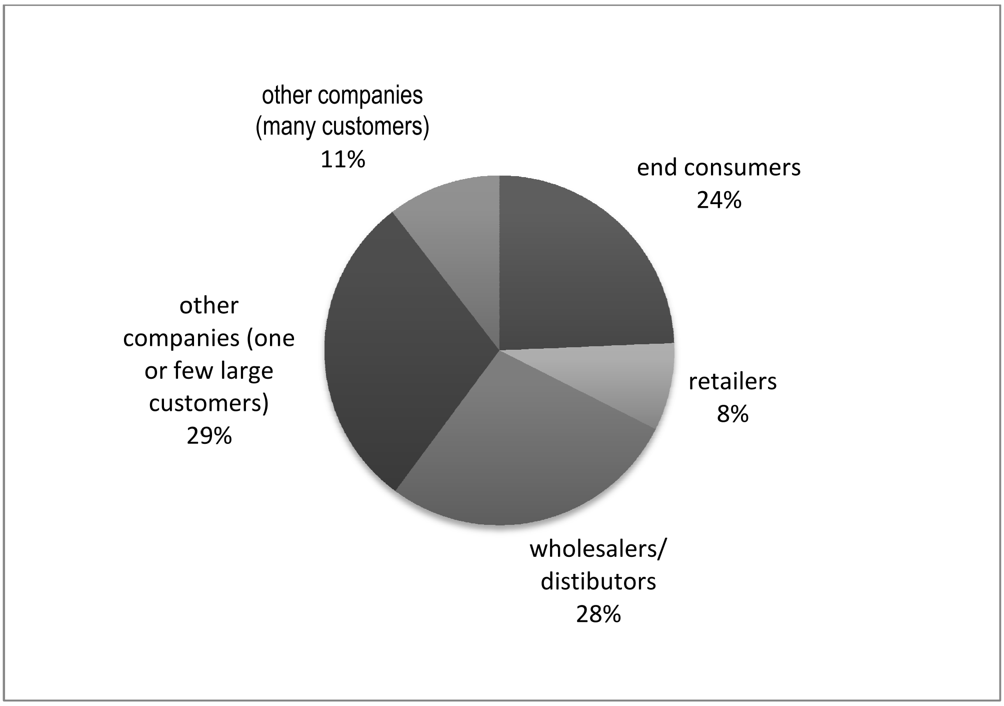


Figure 37 displays the main customers of the companies in the sample. Here the different characteristics of the industries prevail again. Having other companies for customers is not typical of the food industry - which is much more likely to sell to end consumers (32%), as well as retailers and wholesalers (23% and 36%). Wholesalers are the most typical customers of chemical industry companies (47%), while the companies from the three "technical" industries most typically sell to a small number of company customers (52% in the vehicle, 46% in the electronics and 42% in the machine industry). The relation of customers to company size appears significant only in that larger companies less frequently sell directly to end consumers.

Figure 37: Who are the main customers of the company?



The age of the production equipment was investigated since innovation activity can be greatly influenced by the limitations and life-cycle of the technology. The reported age of the interviewed companies' production equipment is between 0 and 50 years; 11 years being the average (standard deviation is 8.1 years). Environmental equipment tends to be much newer; 5.5 years old on average (standard deviation is 5.9 years; the maximum is 30 years). Concerning the age of production equipment no significant correlation was found with size (number of employees), or with industry.

However, in the case of environmental technologies, at micro-enterprises with less than 10 employees the average age of such equipment is much less (at 3.5 years) than for other companies which indicates that these companies started to pursue environmental protection activities later than larger firms (another explanation for this difference would be if micro-enterprises replaced their environmental equipment more frequently – this obviously does not seem likely, and the innovation data that are later presented do not support this supposition). The comparison of industries shows that the average age of environmental equipment is similar in the food, machine and vehicle industries (at a little over 5 years), is significantly lower in the electronics (2.6 years) and higher (8.85 years) in the chemical industry. This is in line with the knowledge that electronics is generally a “younger” industry in Hungary, and is characterized by dynamic development, while the chemical industry was already an important sector 10-20 years ago (and has always been sensitive in terms of environmental protection).

3.3 The environmental innovation activities of companies

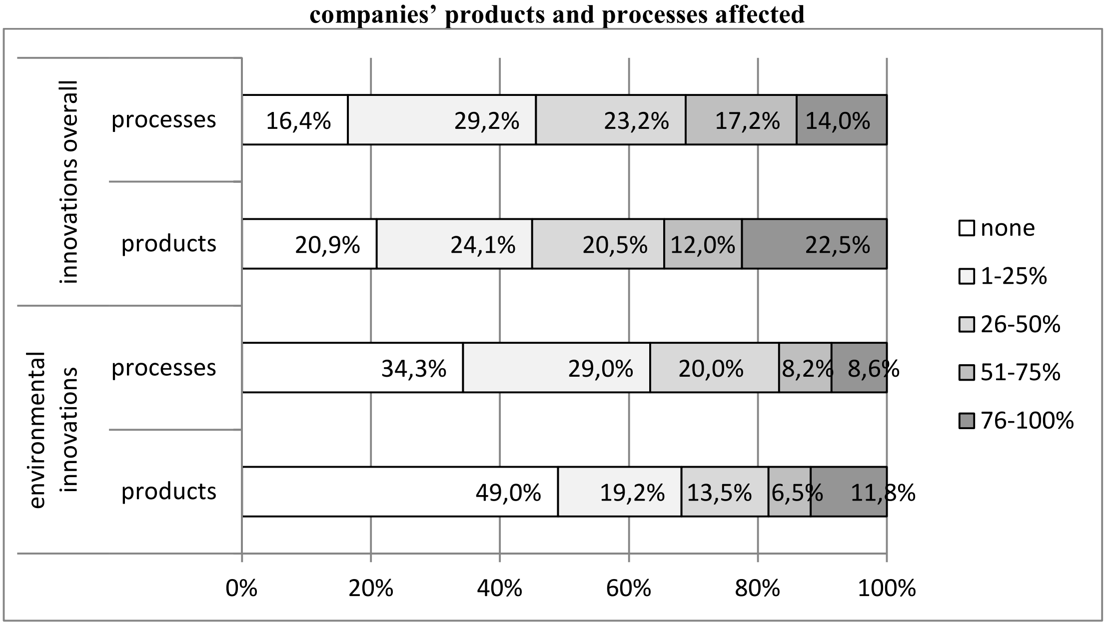
3.3.1 The intensity of innovation activity

The environmental innovation activity of the companies in the sample was examined using two approaches. On the one hand, by identifying the percentage of the company’s processes and products affected by environmental innovation in the last three years; and, on the other hand, at the level of specific innovations. From these specific innovations we asked our respondents to introduce three environmental innovations – provided that the company had that many innovations in the studied period of time.

The percentage indicators were elicited regarding all innovation activities, so that they could serve as a point of reference concerning environmental innovations. The comparison is shown in Figure 38. It can be seen that there are considerable differences between the companies in the sample regarding the intensity of both their general and environmental innovation activities. It can be seen that, while there is no difference of magnitude between the innovations related to products and to processes for all innovations, in the case of environmental innovations there are a lot more companies where there was no product innovation during the examined period of time.

Examining the connection between general and environmental innovation activity, I found a strong relationship in the case of processes as well as products (Cramer's V is 0.495 and 0.517 respectively – for details of the crosstabulations and the statistical tests see Appendix 4).

Figure 38: The intensity of general and environmental innovation activity as a % of the companies' products and processes affected



There are significant differences in the intensity of innovation activity depending on company size (Figure 39) and industry (Figure 40). In terms of size it appears that smaller companies are lagging behind their larger counterparts also in terms of the share of products and processes affected by environmental innovation (although the difference is more pronounced in the proportion of companies which do not perform any innovation activity at all than on the higher levels of innovation activity). It can also be pointed out that (besides the fact that the incidence of innovations overall as well as environmental innovations was lower at smaller firms) the innovation lag of smaller companies behind their larger counterparts is more significant when it comes to environmental innovations; i.e. they show is a larger difference between the share of products and processes affected by all kinds of innovation and by environmental innovation than bigger companies (see Appendix 5 for detailed statistical results).

Comparing industries, the higher performance of electronics companies is striking, especially in the area of product innovation (despite the fact that this sector had the largest share of micro-enterprises in the sample), as well as the low showing of machine and food industry companies, which was again more distinct in relation to products. This is understandable, as the life cycle of a product is generally shorter in the electronics industry and the sector is more dynamic, while in the machine industry there is a strong presence of product standards which restrict the possibilities of the producers to innovate. In the food industry – as interviewee Péter Biacs pointed out – product innovations are typically not of an environmental nature; on the contrary, the predominant trend is increasingly towards more and more elaborate packaging of products.

Figure 39: Intensity of innovation activity by firm size (number of employees)

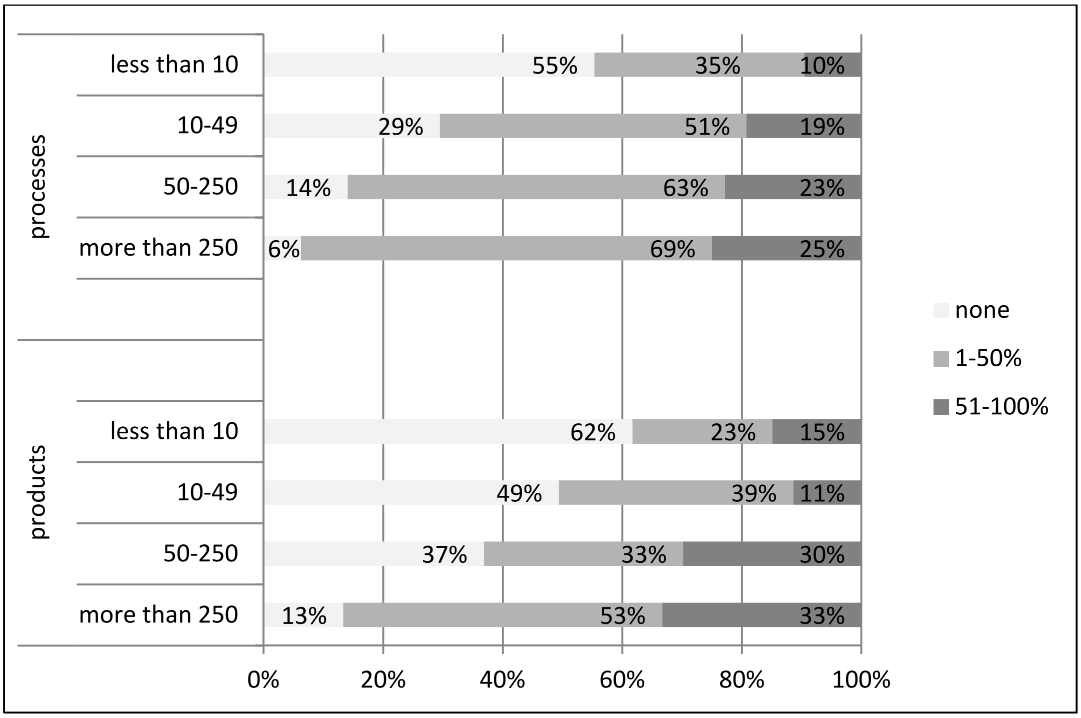
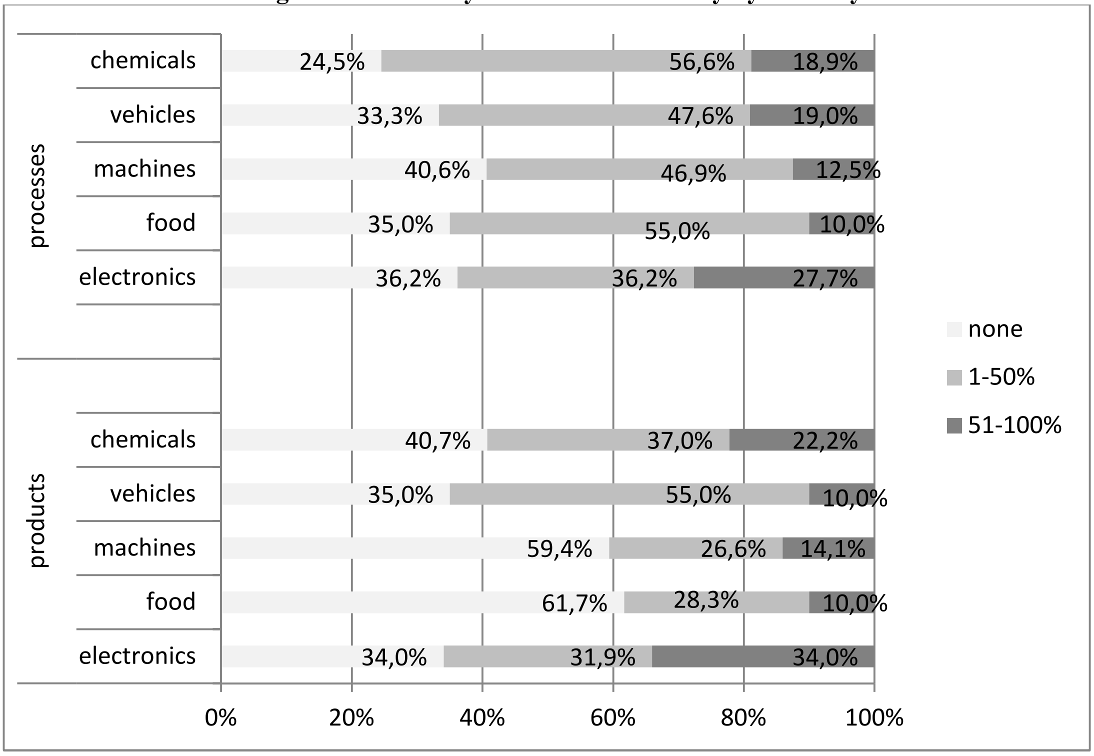


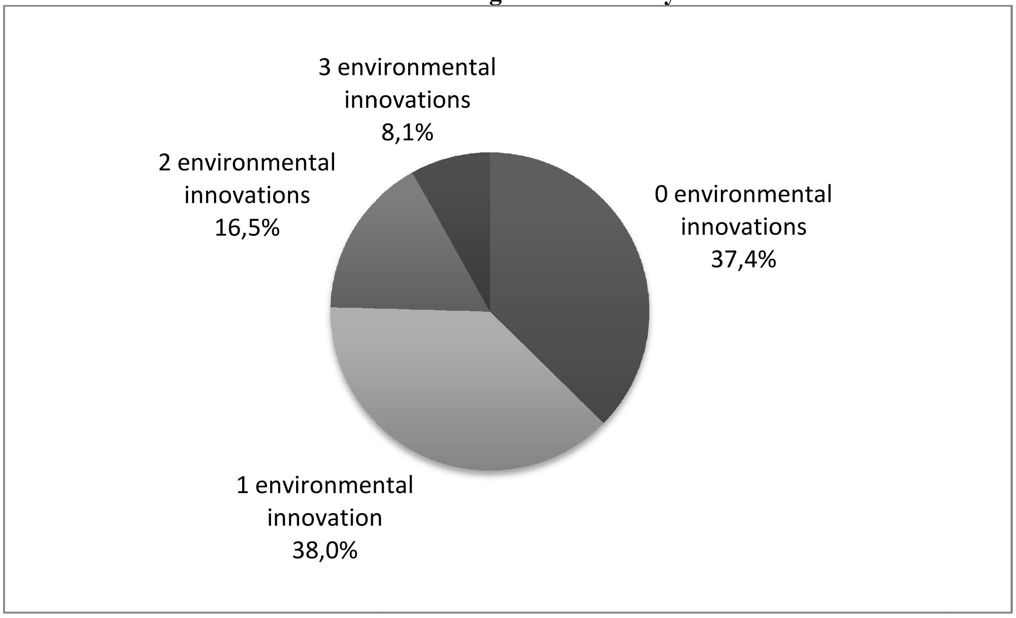
Figure 40: Intensity of innovation activity by industry



3.3.2 Specific innovations

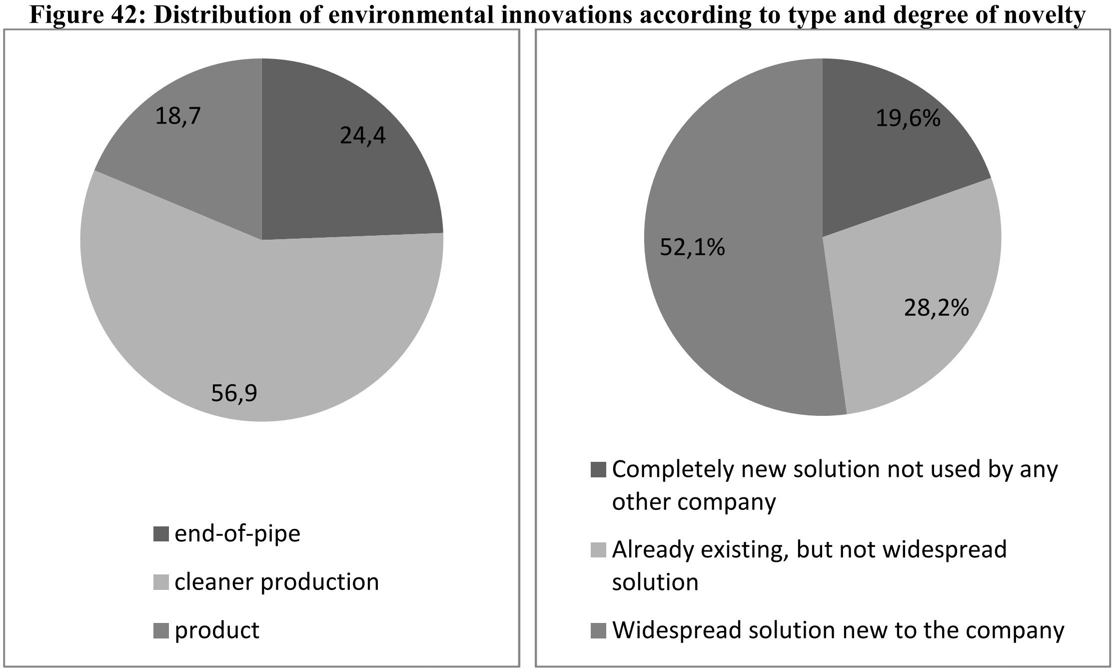
The companies in the sample reported introducing 319 environmental innovations altogether in the last three years (we asked every company to present three environmental innovations). From these we had to exclude 36 as not being environmental (or not technological) innovations on the basis of their description, so in the end we identified 283 innovations in the sample altogether. This means that the companies reported an average of 0.95 innovations – see Figure 41 below for the distribution.

Figure 41: Distribution of companies according to the number of environmental innovations carried out during the last three years



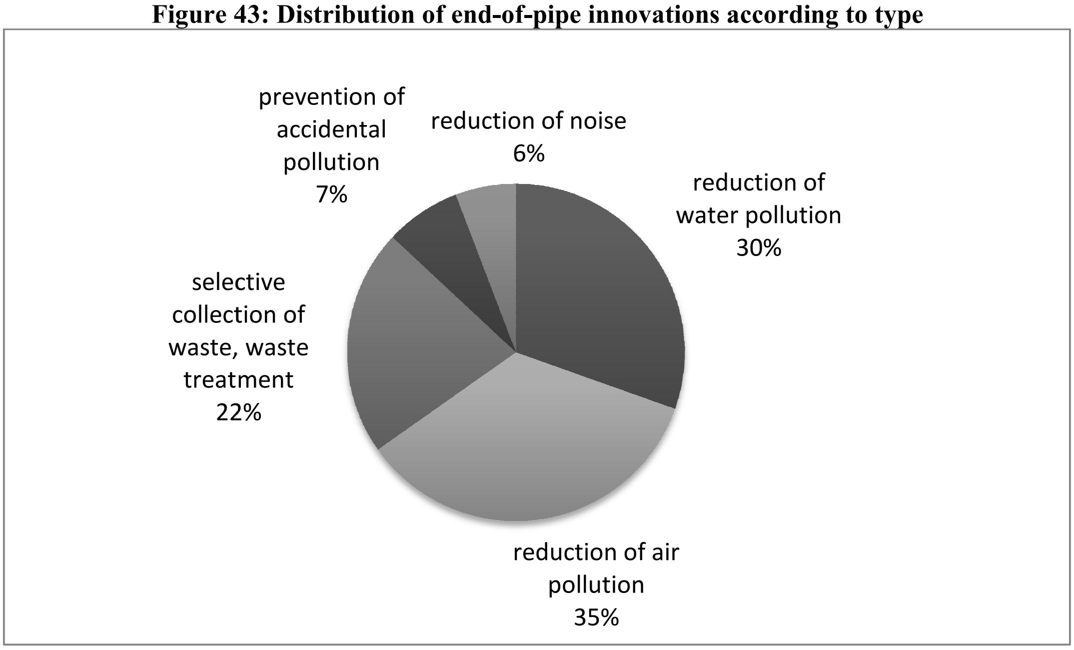
The distribution of innovations according to type and degree of novelty can be seen in Figure 42. It can be seen that the majority were process innovations (more specifically, preventive types of improvements). Concerning the degree of novelty it was assumed that completely new innovations were relatively rare, so in the questionnaire I distinguished between widespread and not so widely-used improvements. It can be seen that more than half of the innovations may be placed in the 'widespread' category, while the share of completely new solutions is about 20%.

Figure 42: Distribution of environmental innovations according to type and degree of novelty



End-of-pipe and preventive innovations were further classified according to the environmental issues they were related to (during the classification I also took into account the environmental effects of innovations beside their written descriptions). It can be seen (see Figure 43) that measures designed to reduce air and water pollution comprise the biggest proportion of end-of-pipe innovations followed by measures concerning waste. In the case of sewage cleaners, air filters and extractors, the answers make it clear that while certain companies had put this kind of technology into operation for the first time during the examined period, others were already engaged in upgrading these pieces of equipment. Concerning waste, many companies had introduced selective collection during the period examined or had found a partner to hand over the waste to (I classified the cases where the company itself recycled or fed the waste created back into the production cycle as being a preventive innovation). Innovations that served to ensure safe storage of hazardous substances and to prevent release into the environment, or early detection of leakages, can mainly be found in the chemical industry.

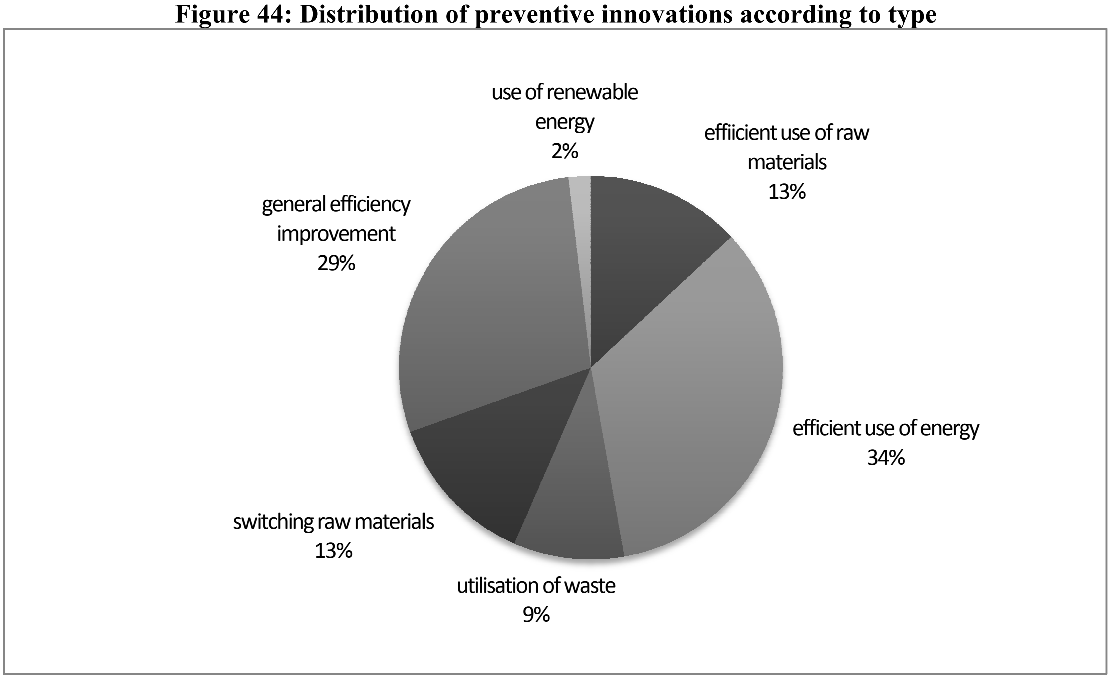
Figure 43: Distribution of end-of-pipe innovations according to type



The most frequently used preventive measures were innovations designed to increase energy efficiency, and there were many general technological upgrades which resulted in improvements in several dimensions (energy-, raw materials use, pollution, etc.) (Figure 44). The measures designed to save energy are very diverse; common examples are replacement of ovens and furnaces, the switching of fuels and new cooling technologies, as well as different heat exchanging and heat capturing solutions. Besides the development of the efficiency of production technologies, several companies had managed to save energy by modernizing plant heating or lighting systems. Concerning raw materials, apart from recycling measures, solutions to reduce the use of solvents either by recycling or complete replacement e.g. with powder based paints, water-based glues, etc. were reported. Related to painting processes, several companies had put modern painting cubicles into operation.

Concerning preventive innovations it can be observed that the improvement of environmental efficiency in some cases was realized simply by replacing an old appliance with a newer, more energy-efficient or more precise, less waste-producing machine without making changes in processes. However, others altered the production process itself – a typical solution was the creation of closed loop systems for the use of water, solvents and other hazardous substances, which made it possible to reduce consumption, along with pollution.

Figure 44: Distribution of preventive innovations according to type

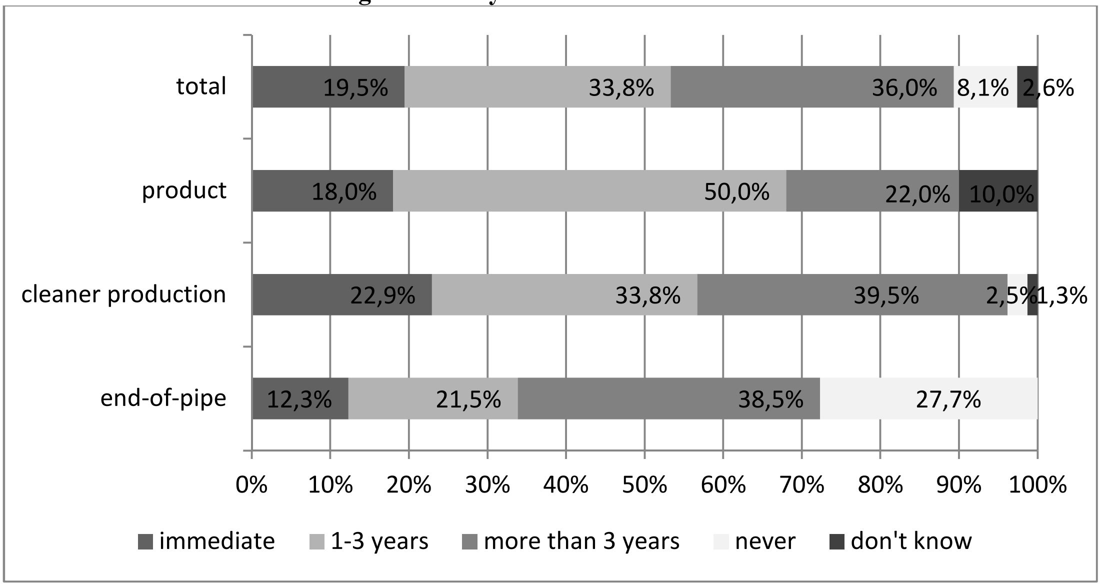


It is difficult to classify product innovations because of their great diversity, although it can be noticed that, while in certain cases the improvement of the environmental features of existing products took place (e.g. the reduction of the energy consumption of the produced machines/appliances, reduction of product weight or reduction of emission of hazardous substances, change to biodegradable packaging, etc,); in other cases completely new environmentally friendly products were introduced to the market.

As can be seen in Figure 45, a significant proportion of environmental innovations were also cost-effective for companies. Most of the innovations not predicted to provide financial returns are end-of-pipe innovations; there are also certain preventive innovations which involved a change of raw materials in this category (among end-of-pipe innovations it was mainly selective collection and handing over of waste which provided immediate return). According to respondents, about half of non-cost effective improvements were motivated by efforts to meet environmental regulations, while the other half was motivated by environmental protection goals. Companies reported the fastest payback time for innovations that improved the efficiency of use of raw materials or involved a change in raw materials. The payback time for energy-efficiency and general modernization projects is typically somewhat longer – probably because of greater investment demands (see Appendix 6 for detailed charts).

Comparing the payback time for innovations between companies of different sizes, the only considerable difference is that micro-enterprises (at a rate of 34.4%) introduced a lot more improvements with immediate or short payback (no longer than 3 years). These companies, because of their low operational capital, obviously cannot afford to start an environmental project with a long payback period, let alone one with no payback at all. At the same time, the pressure from regulatory authorities influences their operations less (the sectoral experts interviewed all agreed that the smallest companies can still often succeed in “hiding” from environmental regulations, or frequently are not even aware of the rules which are relevant to them. On the other hand, they can get into very difficult situations because of this if they are hit with unexpected fines).

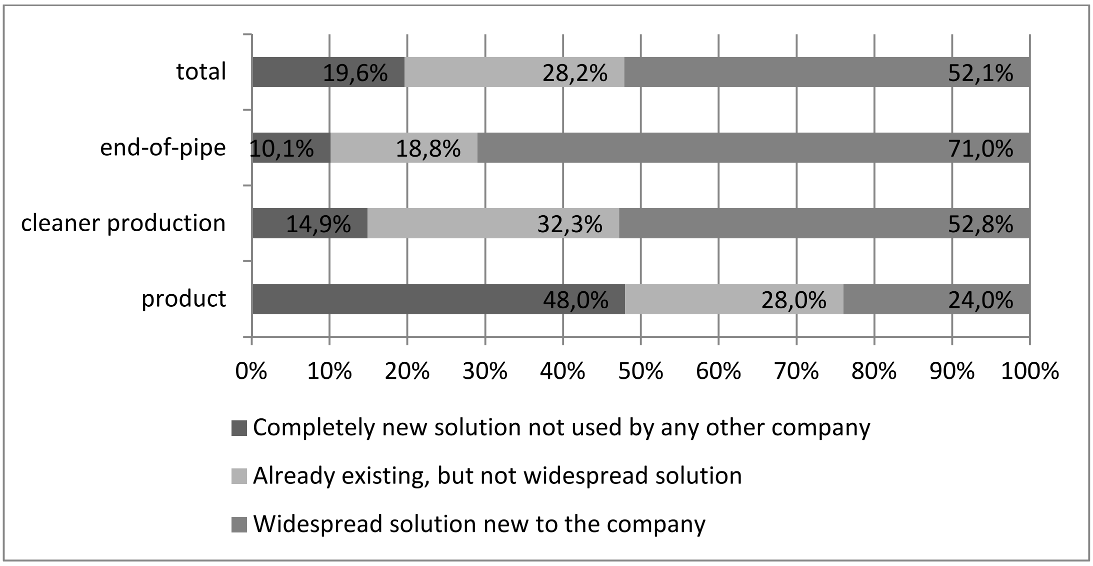
Figure 45: Payback time of innovations



Concerning the financing of innovation, a predominance of internal financing was reported – on average, 85% of innovation costs are financed by the companies themselves. 10% of the innovations were partly financed from credits, and 15.5% benefited from some sort of subsidy. From the 40 (partly) subsidized innovations 31 were of a preventive nature, mostly being energy or general efficiency improvement projects. Looking at the identities of the companies which drew on subsidies, industrial sector does not factor, but in terms of size we can see that medium-sized companies managed to receive the largest proportion of subsidies during the examined period of time (28% of them introduced some kind of innovation which was partly financed from subsidies), while small and large companies benefitted less from subsidies (14% and 16%, respectively), and micro-enterprises practically not at all (0.3%).

The type and degree of novelty of environmental innovations are related (Figure 46). End-of-pipe innovations mostly involved the introduction of already widespread technologies, while half of all product innovations were solutions developed in-house. Among preventive improvements there was a large majority of adopted innovations, but within this group there are more less-common improvements than for end-of-pipe innovations (the associative relationship between the type of innovation and degree of novelty is significant at the 99% level and Cramer's V is 0.268, which indicates a medium strength relationship – see Appendix 7 for details of the crosstabulation and statistical results).

Figure 46: Type and degree of novelty of environmental innovations



Not only the prevalence but also the type of environmental innovation is dependent on the industry and the company size (the connection is significant at the 95% level in every case; see Appendices 8 and 9 for detailed tables and statistical results). Looking at the differences between industries there is a strikingly high proportion of product innovations in the electronics industry, of preventive improvements in the vehicle industry and an important role for end-of-pipe innovations in the chemical industry (Figure 47). Concerning the novelty of innovations, the electronics industry clearly takes the lead, while food industry companies are in the most laggard position (which again demonstrates the "high-tech" nature of the electronics industry and the "low-tech" nature of the food industry (Figure 48).

Figure 47: Types of innovation according to industry

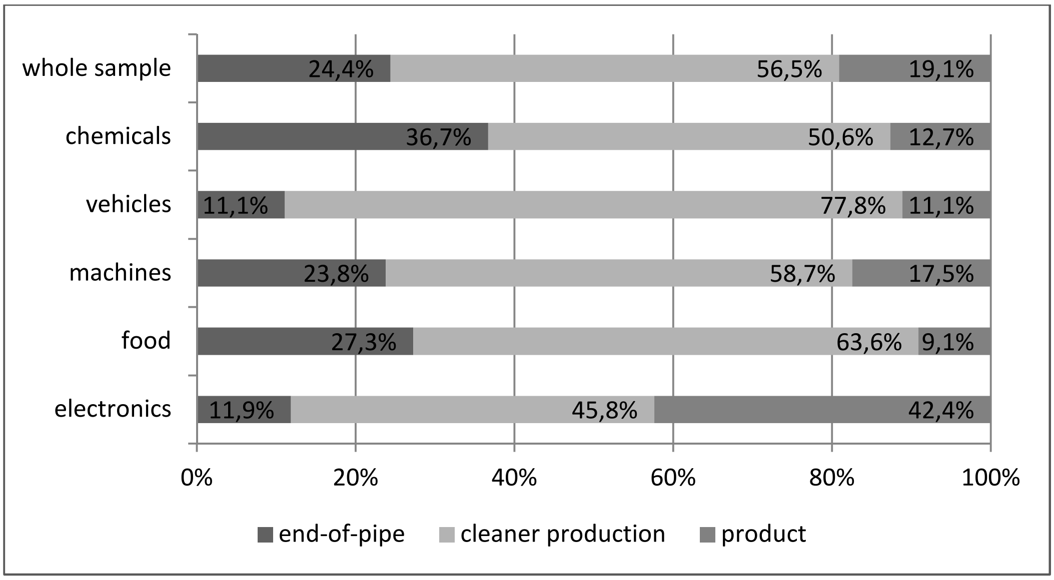
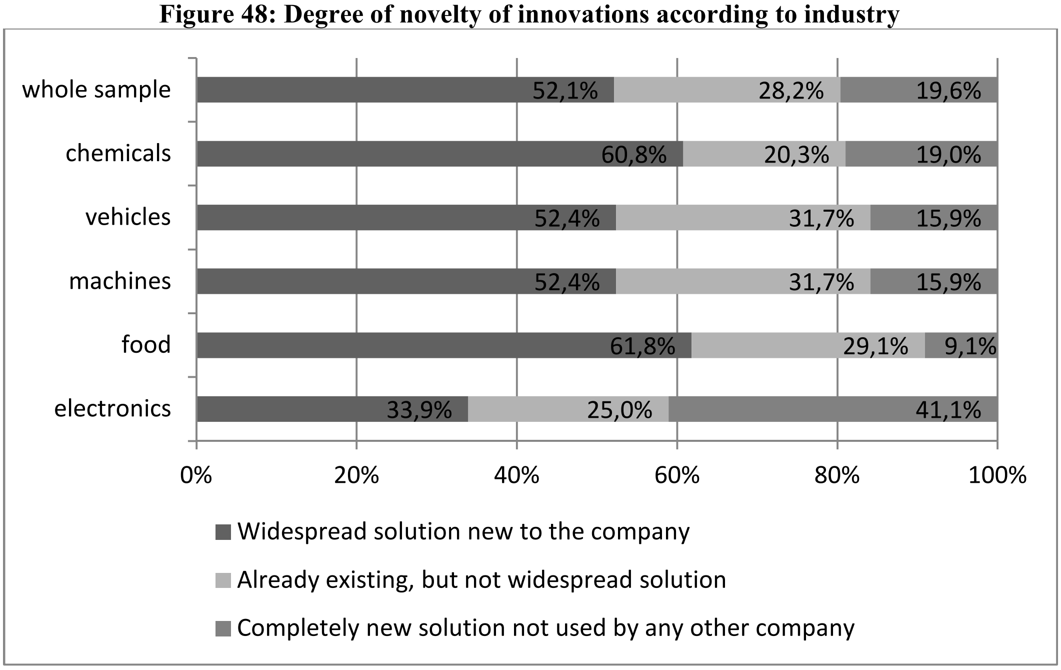


Figure 48: Degree of novelty of innovations according to industry

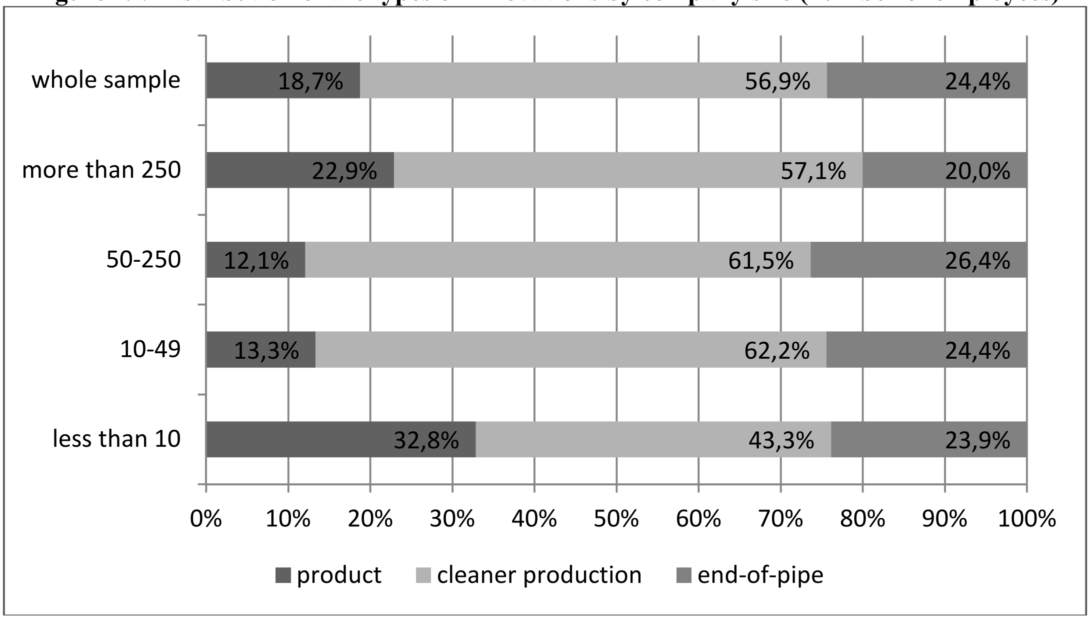


Concerning the influence of company size on the types (Figure 49) and degree of novelty (Figure 50) of the innovations, similarities can be observed between micro-enterprises with less than 10 employees and large companies with more than 250 employees as opposed to small and medium-sized companies – in the two extreme size categories there is a higher proportion of product innovations and genuinely new solutions[3] among environmental innovations. This can be best explained by the fact

[3] Because there was an outstandingly large number of product innovations in the electronics industry and the proportion of micro-enterprises is also the largest here, this tendency was examined to see if it

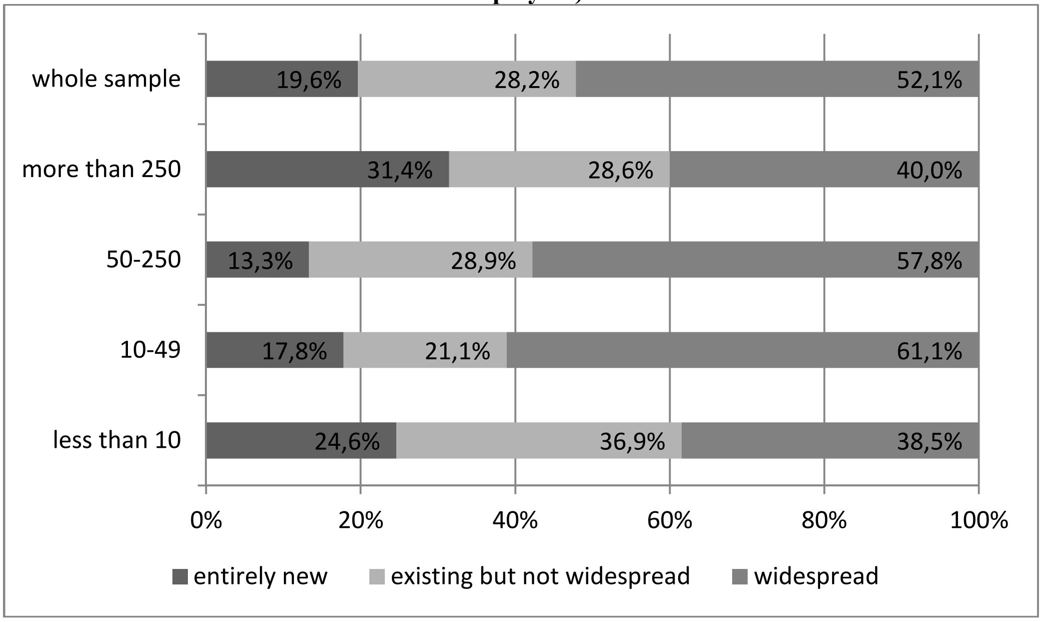
that many micro-enterprises cater to individual orders with non-standard processes, and because of this often need to adjust their environmental measures to their activities according to the specific order; something which they can do in a relatively flexible way due to their small size (this became clear from the description of the companies' activities and specific innovations). Moreover, inventors who started their own companies in order to bring into existence a specific product idea can also be found among the heads of micro-enterprises (on the basis of the answers to the open-ended questions it can be seen that the sample also includes some such entrepreneurs who are mainly developing products aimed at the use of renewable energy). On the other hand, the size of large companies enables them to create non-standard solutions economically. Hence it is mostly small and medium-sized companies which are interested in the "off the shelf" environmental technologies available on the market.

Figure 49: Distribution of the types of innovations by company size (number of employees)



was merely caused by the special characteristics of the electronic industry and the makeup of the sample. However, the relationships and tendencies identified remained valid after leaving out the electronics companies.

Figure 50: Distribution of degree of novelty of innovations by company size (number of employees)



3.4 The determinants of environmental innovation activity

Among the determinants of environmental innovation activity – in line with the research model – the following factors were examined: the company's resources and capabilities, the factors that determine motivation, perceptions about how environmental innovations influence economic performance, the environmental impacts of the company, as well as pressure coming from various stakeholders. In the following, after presenting how these factors arose in the sample, the connections between these factors and the level of environmental innovation activity are described. Analytical tools include cross tabulation and related statistical tests, as well as correlation calculations. As has previously been noted, company size is closely correlated to innovation activity and is also correlated with almost all the other variables. It therefore seems sensible to control for company size so that it is possible to better understand the influence of the individual factors on innovation activity.

However, the number of respondents is often not sufficient to carry out layered cross tabulations (not even after the reduction of the 6 level scale used to measure the variables to 3 levels). I therefore opted to create contracted variables (e.g. by summing up the various stakeholders or environmental effects and expressing their power of influence in percentages). The resulting variables are appropriate for partial correlation calculations controlling for company size (it should be noted that these are not continuous but categorical variables measured on an ordinal scale, so the calculation is more suitable for estimating the magnitude of the connection than its exact strength)[4]. Cluster analyses were carried out to reduce the number of variables (in the case of ordinal variables this is a better solution than principal component analysis). Clustering gives interesting information in itself about the relations between the studied variables, besides also being a point of reference for the contraction.

Concerning the examination of the combined effects of variables, a difficulty is posed in that the intensity of innovation activity appears as a categorical variable and – like the explanatory variables – does not follow a normal distribution. Logistic regression analysis is a good solution for this situation because it is capable of dealing with both continuous and categorical variables and does not demand the fulfilment of strict conditions concerning the distribution of independent variables (as opposed to, e.g. discriminant analysis). The essence of the method is that the group membership of the elements of the sample (in our case, the presence or absence of environmental innovations) can be predicted with the help of a regression function created from the independent variables (in this case the determinants of environmental innovation activity).

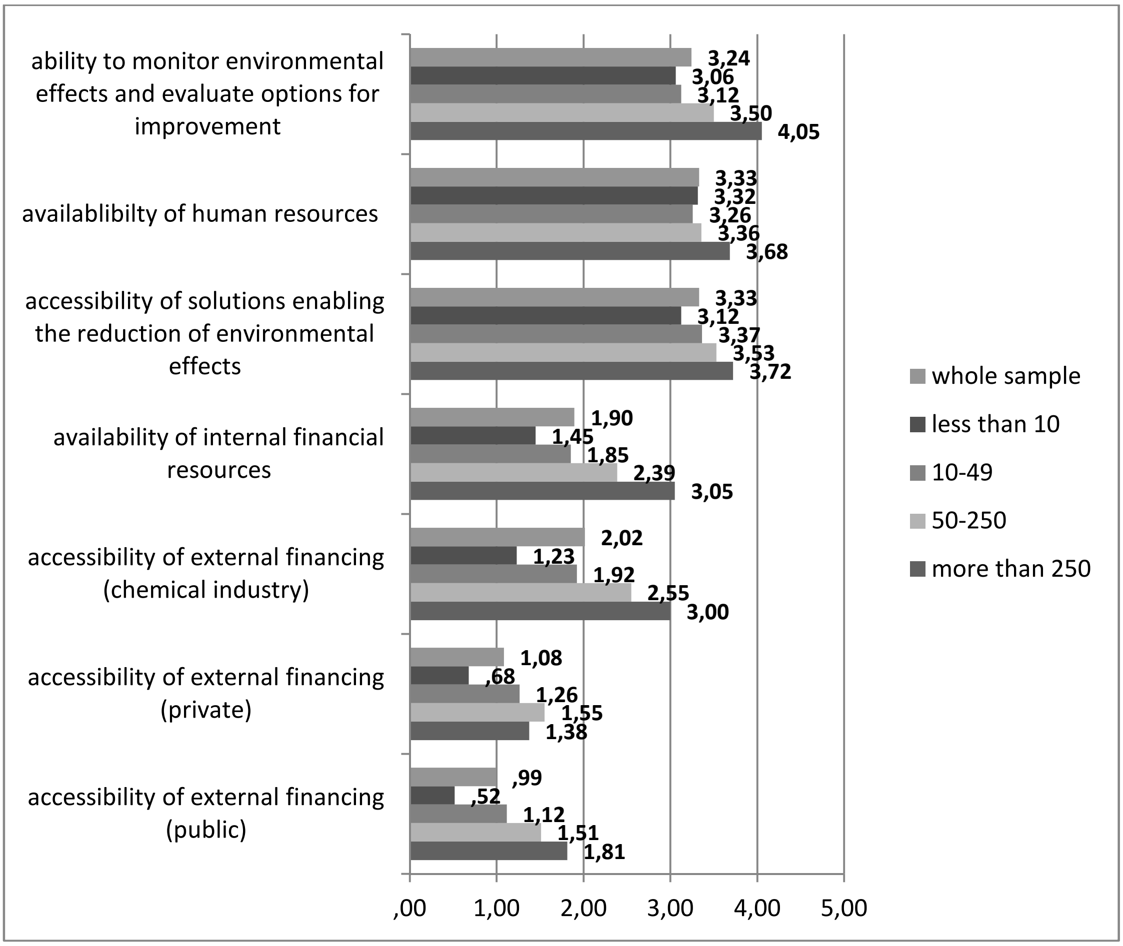
3.4.1 The company's resources and capabilities

The availability of various resources and capabilities needed for environmental innovations (more precisely, the perception of the company representatives concerning these) in the sample is shown in Figure 51 according to company size, and in Figure 52 by industry. On the whole it can be said that the majority of respondents feel that the availability of 'non-material' conditions – like the ability to measure and evaluate the company's environmental effects, as well as the availability of human resources

[4] During the correlation calculation the intensity of environmental innovation activity was expressed as the proportion of products and processes affected by improvements together.

and the accessibility of environmentally friendly technologies – are adequate, while they are much less satisfied with financial issues. The expected superiority of large companies exists concerning some of the factors (especially material ones); however, in other respects the difference is small, and interestingly, in human resources there is hardly any difference between the size categories (although the standard deviation of answers is greater for smaller companies). Thus, this factor is clearly not perceived by small companies to be the bottleneck concerning environmental innovation.

Figure 51: Perceived availability of resources and capabilities for environmental innovation according to company size (averages, on a scale of 0 to 5)[5]

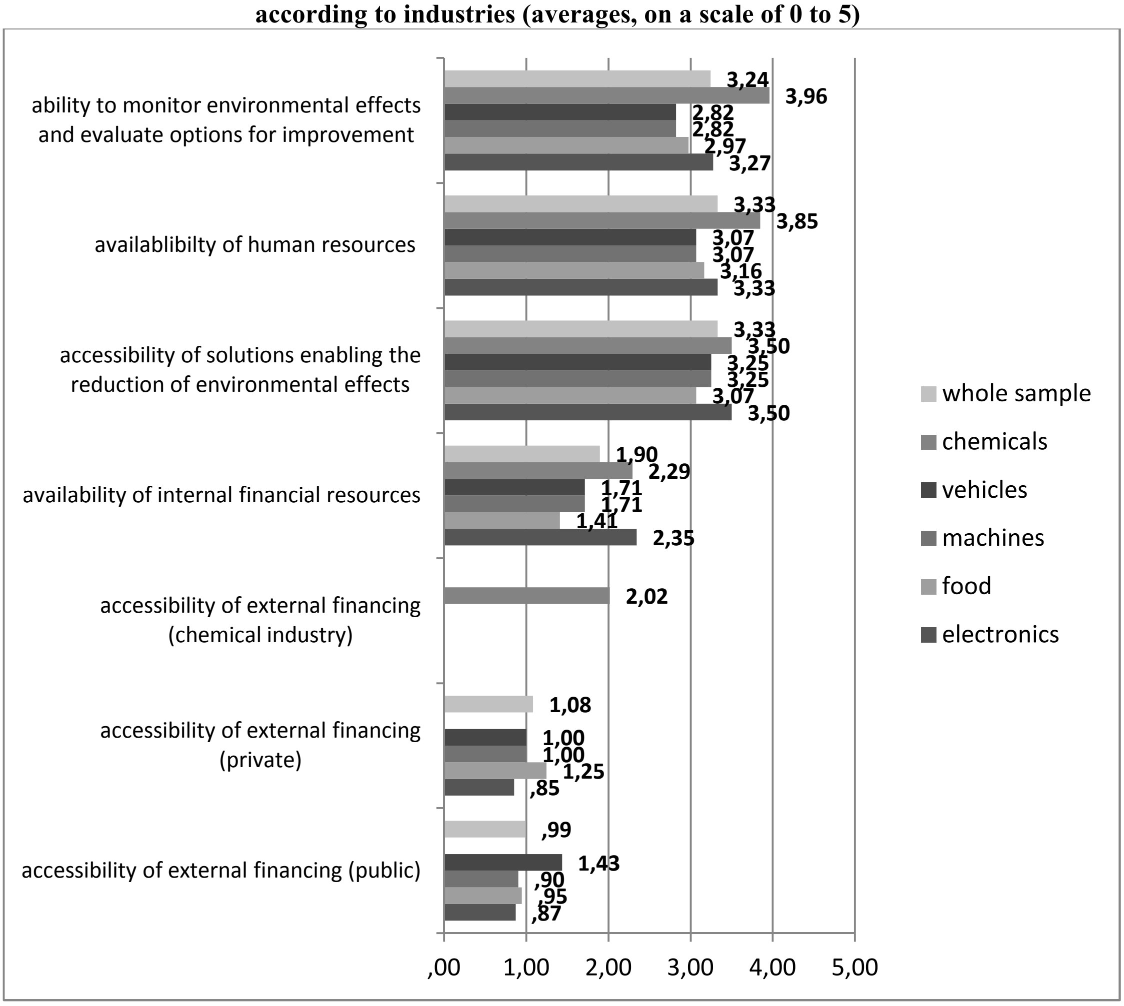


When comparing industries, it is noticeable that respondents from the chemical – and to a somewhat less extent electronics – industry report higher values (the size of chemical industry companies exceeds the average of the sample a little, but the

[5] In the chemical industry survey there was only one question which concerned outside financing. For the rest of the industries the opinion of the respondents was elicited separately for the availability of private and public funding (credits and subsidies).

differences hold within the single size categories too). This again can be explained by the fact that environmental protection is a more sensitive area for chemical industry companies in general, and they traditionally devote more attention to this issue than those industries where there are less hazardous materials and emissions. For chemical industry activities it is normally compulsory to have an environmental protection deputy, which ensures that more human resources are dedicated to this topic.

Figure 52: Perceived availability of resources and capabilities for environmental innovation according to industries (averages, on a scale of 0 to 5)



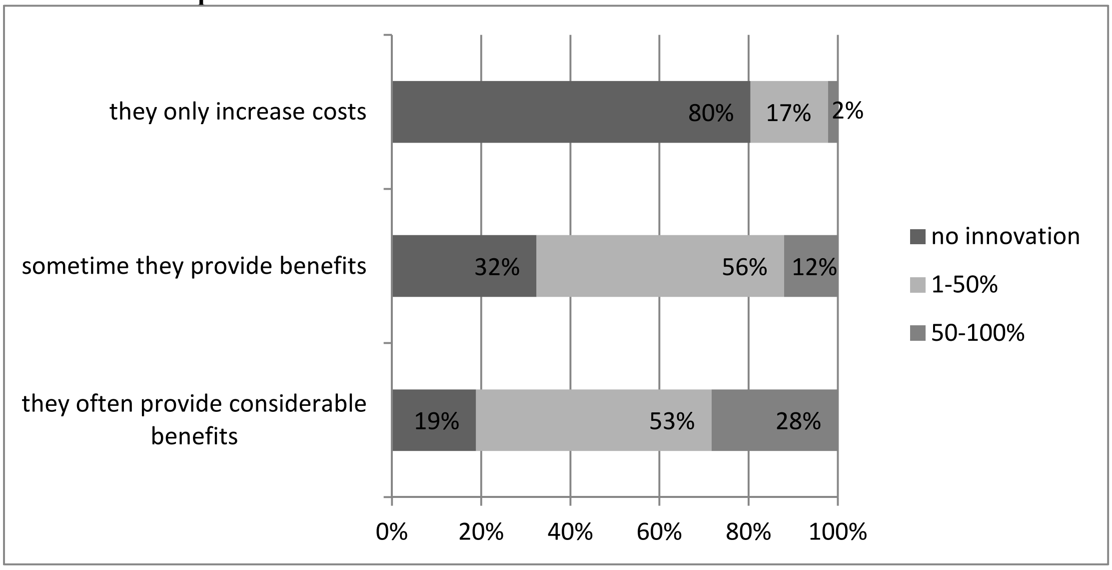
A cluster analysis was carried out on the variables related to resources and capabilities for environmental innovation in order to see which factors were suitable for creating a contracted variable. The results show that material and non-material factors may be identified as being separate clusters; therefore two contacted variables were created from these and used in the examination of the connection to the intensity of environmental innovation. The connections proved to be significant at a 95% level. In the case of the material variable the Pearson correlation coefficient was 0.278, and after controlling for company size, 0.175. For the non-material variable Pearson-r was 0.236, and after controlling for size 0,204. The result for all variables for resources and capabilities together was a Pearson-r of 0.32, and after controlling for size 0.24 (for the cluster analysis calculations, see Appendix 10; for the correlation calculations, see Appendix 11).

3.4.2 Opinions about the economic effects of environmental innovations

As was seen in the literature concerning environmental strategies, the decision-makers' affinity towards environmental protection measures strongly depends on whether they see these as additional expenses or rather opportunities for saving money and making a profit. In the sample, half of all respondents reported to having neutral views about the economic effects of environmental innovations – 51.4% said that "sometimes they provide benefits" – the rest of the respondents see influences of environmental innovations on profitability as being either positive or negative in about the same proportions 23.5% say that environmental innovations "only increase costs", while 25.2% say they "often provide considerable benefits for the company".

The proportion of positive opinions rises together with company size. Opinions about economic effects are significantly related to environmental innovation activity: we can see (Figure 53) that those who attribute positive economic effects to the utilization of environmentally friendly technologies typically introduced more of these kinds of innovations in the past (the figure shows this relation in respect of process innovations, but there is also a very similar tendency concerning products – for detailed tables and statistical calculations see Appendix 12). At the same time, the direction of causation cannot be determined, i.e. we do not know if positive opinions lead to the introduction of innovations, or rather if positive opinions are due to experiences with the introduced innovations.

Figure 53: Occurrence of environmental process innovations (as a % of company's processes) and opinions about the economic effects of environmental innovations



3.4.3 Pressure from stakeholders

As we have seen in the theoretical summary, the various stakeholders may have a significant role in encouraging the company to improve its environmental performance.

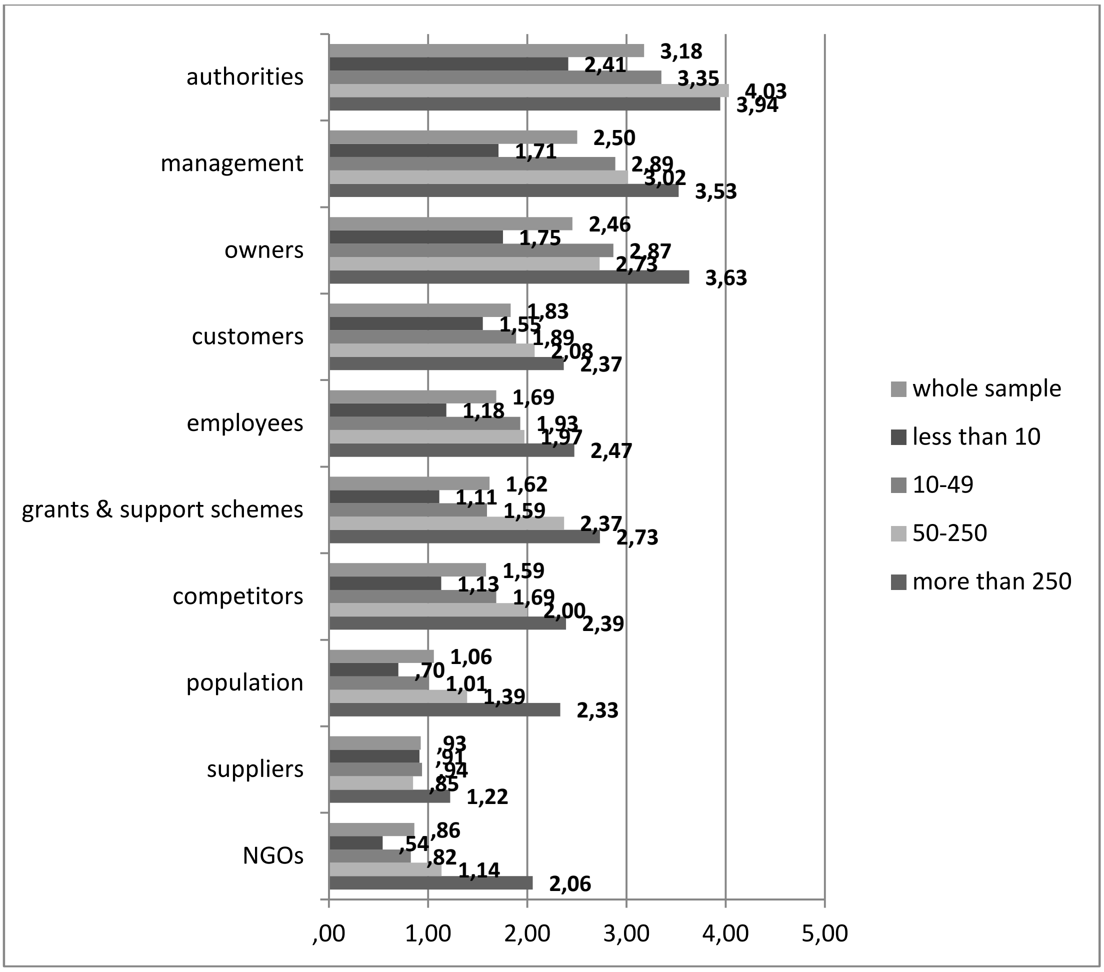
We asked our respondents to evaluate perceived pressure from stakeholders on a scale of 0 to 5. The strongest influence is exerted by the authorities (average 3.18), this is followed by the role of the management and owners (average 2.5 and 2.46). The next ones are the customers (1.83) and the employees (1.69), grants and subsidies (1.62)[8], then the competitors (1.59). The weakest pressure is perceived from the population (1.06), the suppliers (0.93) and the NGOs (0.86), as shown on Figure 54.

Thus, if we consider the groups of stakeholders, on the whole the role of the authorities is relatively strong, the pressure from the internal stakeholders is medium, the market stakeholders' role is weak and the civil society's role is negligible. It is also

[8] The first survey, which was conducted in the chemical industry, did not include this factor. However, partly because of the lessons learned from this survey and partly on the basis of a more thorough theoretical review, it seemed logical to examine the role of the state not only in terms of regulation, but also from the aspect of positive incentives (supply side measures).

shown on Figure 54 that the perceived pressure from stakeholders is the strongest in the case of large companies. This is hardly surprising, except for the encouraging force of grants and subsidies, as smaller enterprises would be in a greater need of those.

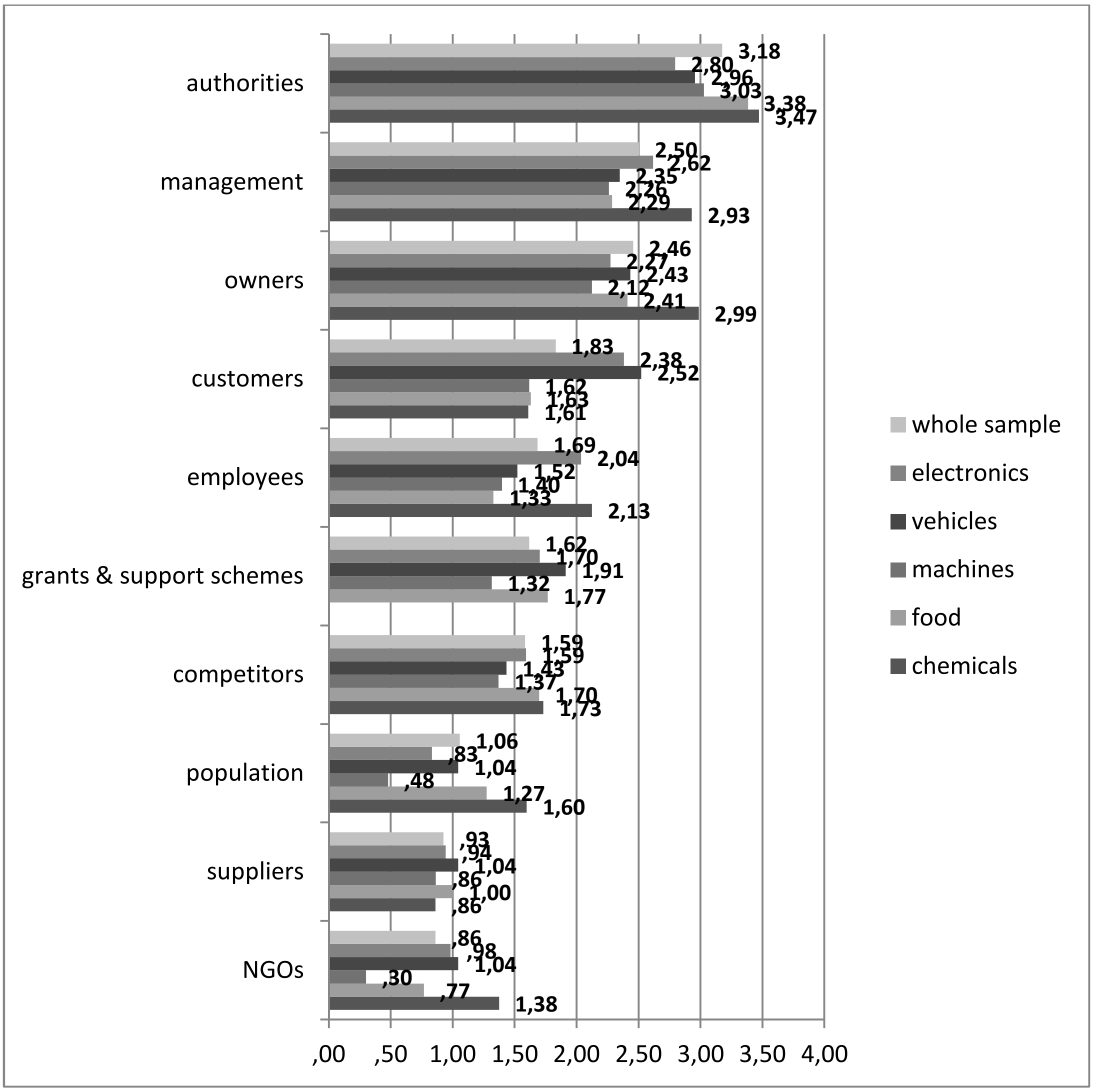
Figure 54 Perceived stakeholder pressure for improved environmental performance by company size (averages, where 0 = no pressure 6 = very strong pressure)



The comparison between the roles of the various stakeholders in the different industries shows an interesting picture (Figure 55). It can be seen that many factors proved to be the strongest in the chemical industry, which can be partly explained by the slightly larger average size of chemical companies in the sample. On the other hand, the increased environmental risks that are connected with the chemical industry obviously result in a higher perceived pressure from the NGOs and the population, the increased importance of health protection among the employees, as well as more attention to these questions from the owners and management.

It is also interesting that the pressure from customers is considerably larger in the electronics and vehicle industries. According to my interviewees, in these industries a high level of customer orientation is a precondition of becoming a supplier, and this is often supported by certified quality assurance systems. If we examine who the main customers of companies are in the different industries (see appendix 13 for the detailed table), we can see that in the electronics industry 60%, and in the vehicle industry 70% of businesses sells to other companies – this ratio is only 10% in the food industry, and 23% in the chemical industry (in these industries the ratio of retailers and wholesalers is much higher, as well as the ratio of companies who sell directly to the end consumers). The pressure perceived from customers is higher when the customers are other companies than in the rest of cases (2.18 and 1.61 on average – the difference is significant, see appendix 13 for the statistical test). At the same time, it is interesting that in the machine industry, where the ratio of sellers to corporate buyers is also high (62%), the role of customers is still weak – therefore it seems that customers of machine industry companies have less environmental expectations towards their suppliers than it is customary in the electronics or vehicle industries. The number of corporate buyers (a few significant customers or a great number of customers) does not result in significant change in the role of customer demands.

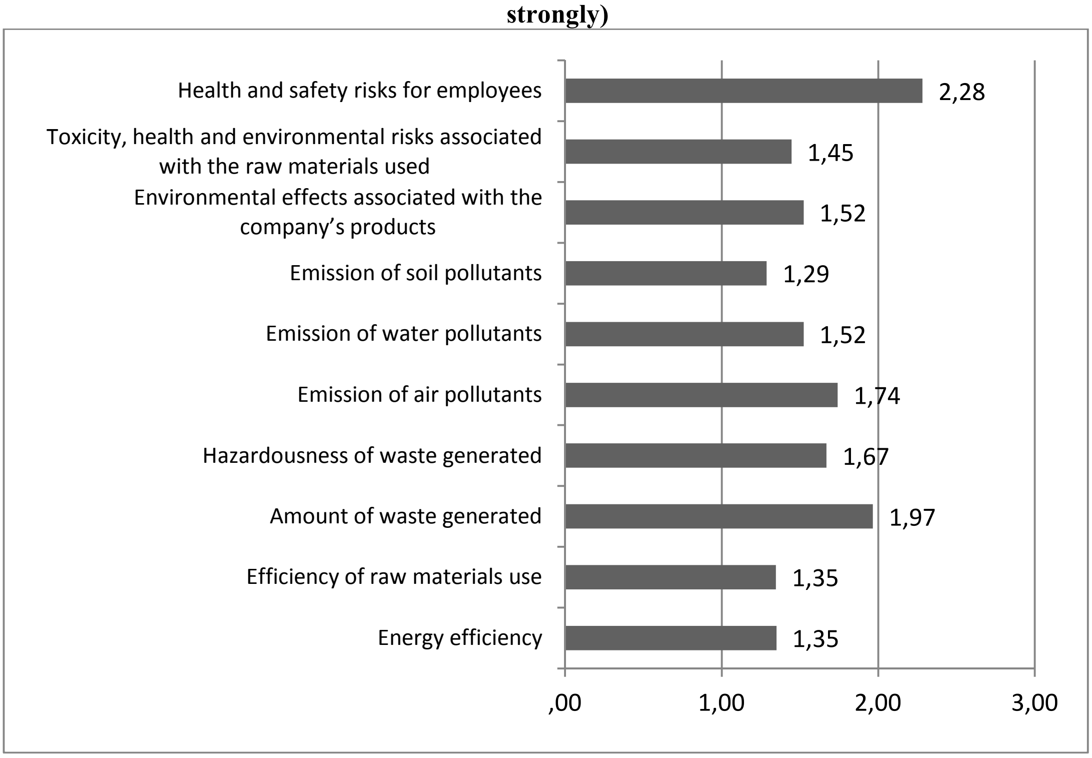
Figure 55: Perceived stakeholder pressure for improved environmental performance by industry (averages, where 0 = no pressure 6 = very strong pressure)



I also examined whether the nationality of buyers has an influence on the perceived environmental pressure. I found that companies which (also) sell to the markets of the European Union encounter stronger environmental demands than businesses which deal with mainly domestic customers, though the difference is significant only at the 90% level (see appendix 13).

Because the role of the authorities and regulations appears as one of the most significant factors according to the literature, it was examined in more detail, looking at the various environmental issues separately. It is namely evident that for example if a company feels that the regulation concerning hazardous waste is very strict, this does not mean that they evaluate the situation in the same way in the area of air pollution or energy efficiency. It can be seen from the answers (Figure 56) that regulation provides the strongest pressure for improved performance in terms of the health and safety risks of employees and the amount of waste generated, and the weakest in terms of the efficiency of energy and raw materials use (it should be noted that the standard deviation of answers is quite significant, it is between 1.7-2 in every dimension). It holds here as well that the larger the company is, the stronger they feel the influence of regulations in all dimensions. It can also be noticed that environmental regulation is an important factor mostly in the operation of chemical industry companies (the difference is the strongest considering the toxicity of raw materials and products, while it is negligible in the dimensions of efficiency)[2] (For the detailed charts see appendix 14)

Figure 56: To what extent do regulations encourage the company to improve its environmental performance in the areas below? (averages on a scale of 0 to 5, where 0 = not at all and 5 = very strongly)



I carried out a cluster analysis to examine the connections between the variables that represent pressure from various stakeholder groups. I found that the variables which are the most closely linked in the sample are also those which form one group logically, so it may be a good solution to sum up these variables (for the detailed

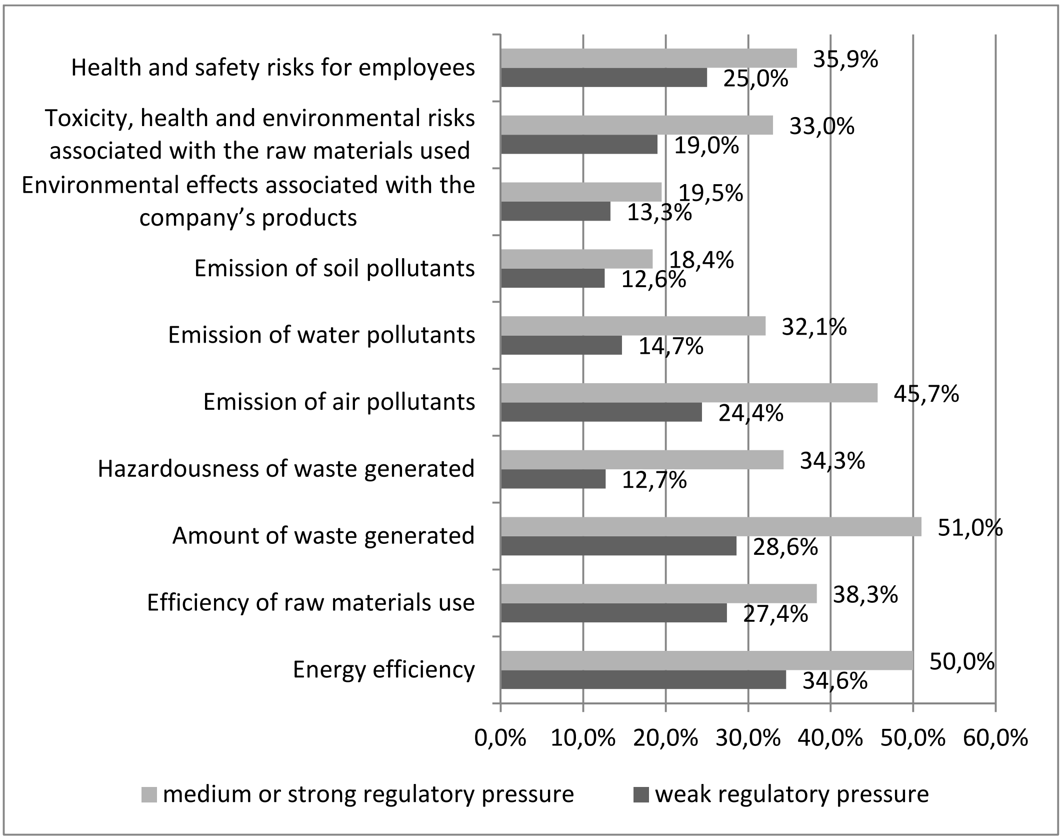
2 It also has to be noted that the chemical industry survey did not include regulatory pressure concerning the health and safety risks of employees and the hazardousness of generated waste (therefore for these two factors the average on figure 56 only reflects the answers of the other industries)

results of the cluster analysis see appendix 15). Therefore the internal stakeholders of a company make up one group: the owners, management and employees; so do the market stakeholders, i.e. the suppliers, customers and competitors; and, lastly, the NGOs and the population – I created contracted variables out of these groups. The perceived pressure from the authorities is not in close correlation with any others, so I examined its effect individually, forming a contracted variable from the values of the different areas of regulation (I did not include the role of grants and subsidies in the cluster analysis, as there is no information of these in the case of chemicals companies).

Examining the relationship between stakeholder pressure and environmental innovation activity, I found a connection on a similar scale in the case of the internal stakeholders (Pearson-r = 0.379, after controlling for company size 0.313), regulations (Pearson-r = 0.339, after controlling for company size 0.267), and market stakeholders (Pearson-r = 0.305, and 0.27). The relation is the weakest in terms of the NGOs and the population (Pearson-r = 0.258, and 0.184) but it is still significant on a 99% level. Considering the collective influence of all stakeholder groups Pearson-r = 0.394, after controlling for company size 0.315 (see appendix 16).

I also examined the influence of regulations on innovation separately in terms of the single environmental problems. As it can be seen in Figure 57, in every area, the companies who felt moderate or strong regulatory pressure introduced innovations to deal with the given problem in a higher proportion than the companies who reported weak pressure. Looking at the proportions it appears that state pressure is an important incentive of the introduction of environmentally friendly technologies mainly in the areas of hazardous waste, water and air pollution, amount of waste generated and the environmental effects of raw materials. The differences – with minimal exceptions – are of a similar direction and scale within the single size categories (although here a difference of the same size which in the whole sample qualifies as significant, does not qualify as significant because of the lower number of observations in one size category), thus the connection is real and not merely an effect of company size.

Figure 57: The connections between regulatory pressure and innovation activity for the different environmental issues
(The proportion of companies which carried out an innovation dealing with the given environmental problem during the examined period of time)



3.4.4 The company's environmental effects

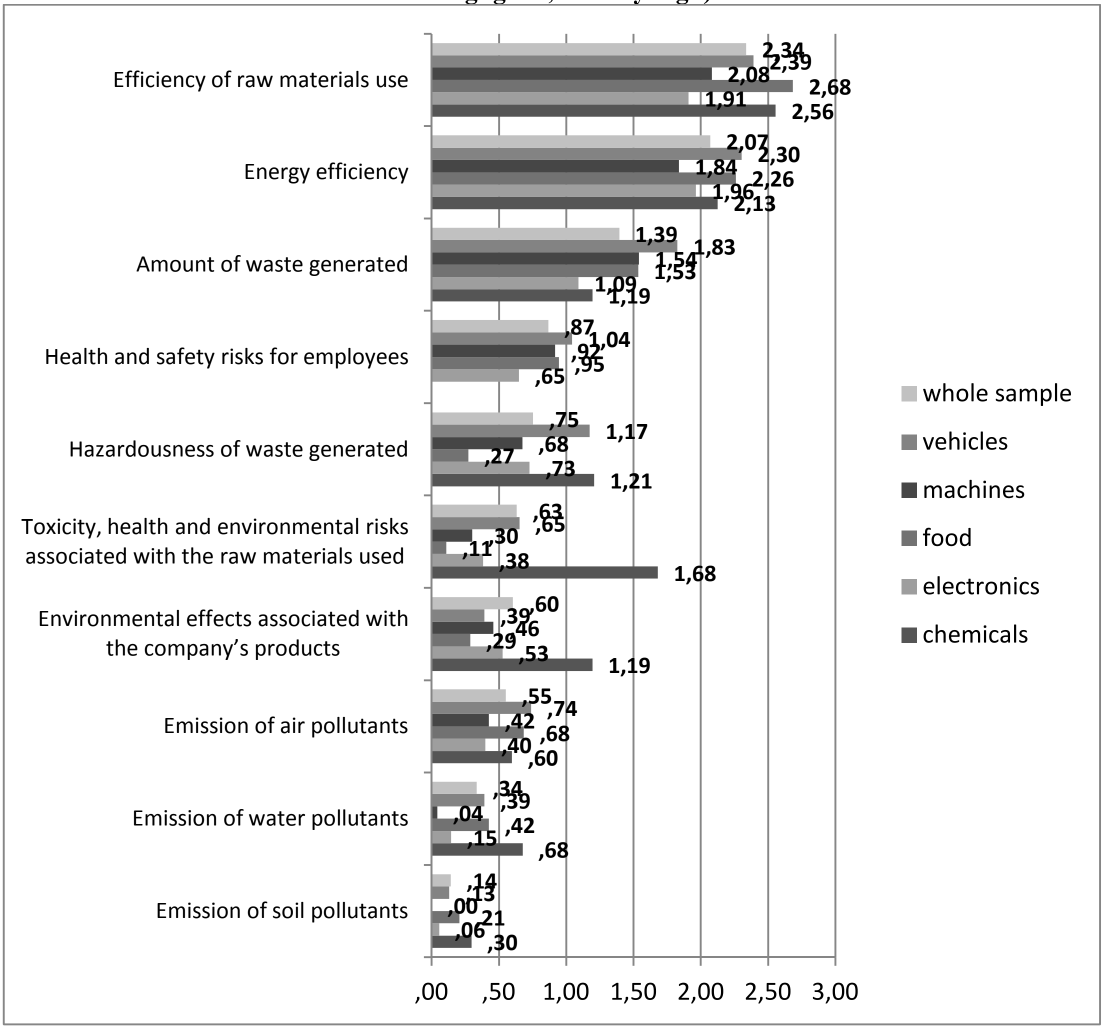
According to Montalvo (2002), the motivation for reducing environmental impacts partly depends on what the company's decision makers think about their severity. To be able to study the effects of these opinions on innovation activity, the pre-innovation conditions should be considered instead of the present ones as the level of environmental impact at the time of the survey already contains the pollution-reducing effects of the innovations themselves. (The first questionnaire, administered to chemical industry companies, did not take this into consideration, therefore, the influence of the perceived level of environmental effects can only be examined for the other industries, as they were specifically asked about environmental impacts from three years earlier).

Figure 58 shows the average reported levels of environmental impact in the sample (with regard to chemical industry companies the present effects are included in the figure). This representation is not based on exact measurement data but much rather subjective estimations by respondents. However, in the given situation this is exactly what is needed, as environmental innovation may be encouraged if the company's decision makers *feel* that environmental effects are too great (and therefore should be reduced). Judgement about environmental effects – not surprisingly – heavily depends on company size and there are considerable differences between industries too. On the whole, it can be said that most respondents think that their company's emissions are negligible (averages measured using a scale of 0 to 5 do not reach 1.5, even in the categories of highest impact)[9]. Considering the reported environmental effects of raw materials and products, chemical industry companies increase the averages a little[10]. Our respondents considered somewhat more significant only raw the amount of materials and energy utilised and, to a lesser degree, the quantity of waste generated. One possible reason for is that these are the effects which companies mostly need to manage as financial expenses.

[9] This is despite the fact that when enquiring about the environmental effects the use of the word "pollution" was avoided as the industry experts interviewed warned that in the vocabulary of a production company it typically refers only to emissions that exceed regulatory limits

[10] The chemical industry survey did not examine the health hazards faced by employees

Figure 58: The perceived environmental effects of companies (averages on a scale of 0 to 5 where 0= negligible, 5= very high)



Concerning the changes in environmental impacts that took place during the past three years, the majority of companies reported a reduction in every factor examined (increases mostly occurred with respect to the quantity of energy and raw materials consumed at those companies which increased their production during this period of time). The average reduction was between 0.1-0.2 on a scale of 0 to 5. Respondents reported the largest reductions in the areas of quantity of generated waste (0.27) and the health hazards of employees (0.255) (for a detailed chart, see Appendix 17).

Similarly as with stakeholders, a cluster analysis of variables was carried out regarding environmental effects, in order to examine the connections and to support the creation of contracted variables (this analysis referred to responses concerning the environmental load from three years ago, as this is what may have influenced innovation activity). The cluster analysis here also led to logically predictable results –

the data for water and soil pollution are very similar to each other, as are the hazards of waste and raw materials. The environmental effect of products is also found close to this group, with air pollution also not far. In the other group there is a close relation between the consumption of raw materials and energy, as well as the quantity of generated waste (health risks to employees from this analysis was also omitted because it was not included in the chemical industry survey. For detailed results of the cluster analysis, see Appendix 18).

The connection with innovation activity regarding these two groups of factors was examined. The first indicator, containing emissions and risks related to hazardous waste, raw materials and products shows a relatively weak but significant positive connection to intensity of innovation activity (Pearson-r = 0.269, or 0.16 after controlling for size). The variable containing consumption of energy and raw materials as well as the quantity of generated waste does not show a significant relationship to frequency of environmental innovations (see Appendix 19).

3.4.5 Examination of the combined effect of determinants using logistic regression

As can be seen above, several factors could be identified which display connections to the intensity of the environmental innovation activity of companies. In the following the *combined* effect of these factors is examined with the help of (binary) logistic regression. The dependent variable is the innovation activity of companies, while the independent variables are the company's basic characteristics and environmental effects, the pressure from stakeholders and the perceived availability of the resources and capabilities for environmental innovation.

Concerning environmental innovation activity, companies can be divided into two groups: into those who introduced some kind of environmental innovation in the examined period and those who did not. The question is, to what extent are the explanatory variables able to separate the two groups from each other– or in this case, how successfully can it be predicted from the determinants' values if a given company belongs to the innovative group (thus the logistic regression function estimates a probability for every company on the basis of the determinants; the probability of whether the company implemented any environmental innovation in the given time period. It can be also seen from the final result how single explanatory variables influence the probability of belonging to the innovative group).

The dependent variable was formed from the indicators for innovation activity (for what percentage of products and processes the company used an innovative solution): the non-innovative group is made up of those who responded (both in terms of processes and products) that they did not implement any kind of environmental innovation during the last three years The innovative group is made up of those who gave a positive answer in at least one respect. Before the analysis a control was made for contradictory answers (namely those respondents who reported more environmental innovations than the total number of innovations, and for those who provided a positive answer to the question concerning percentages but did not report on any specific innovations (or vice versa)).

Concerning the determinants it was a problem with company environmental impacts that the chemical industry survey did not include environmental effects from three years ago – because of this, answers concerning the present effects for these companies were used. Although it is the earlier effects which may have encouraged the environmental innovations, it can be seen from the example of the other industries that environmental effects have changed to a relatively small extent during the last three years. Because of this, I considered using the present effects in case of the chemical industry a better solution than omitting an important group of companies or the role of environmental effects from the analysis. On the other hand, perceptions about the economic influences of environmental innovations were omitted from the analysis because, as we have seen, although these show a close connection to the intensity of environmental innovation activity, the cause-effect direction is hardly evident.

The "forward" method was used to create the regression model; the point of this being that from the previously described variables this model only incorporates those which significantly improve its explanatory strength. In the table below (Table 4) are listed the factors which were included in the study as independent variables. The ones which were included in the final model are highlighted (Appendix 20 contains detailed calculations on the regression analysis).

Table 4: Factors examined in the logistic regression analysis

	GENERAL COMPANY CHARACTERICS	RESOURCES AND CAPABILITIES	PRESSURE FROM STAKEHOLDERS	ENVIRONMENTAL EFFECTS OF THE COMPANY
Factors included in the model	**Change in financial performance after taxes in the studied time period**	**Human resources Financial resources**	**Owners**	**Effect of products Emissions to air Hazardousness of waste**
Factors not included in the model	Industry Main customers of company	Ability to measure and evaluate environmental effects Availability of technologies suitable for improving environmental performance	Management Employees Customers Suppliers Competitors Environmental regulations NGOs Local population	Use of energy Use of raw materials Quantity of waste Emissions to water Emissions to the soil Hazardousness of raw materials

The first factor is the change in the company's financial performance after taxes: the companies which reported increases in their performance after taxes in the last three years had a significantly greater chance of belonging to the innovative category than those whose performance had stagnated or deteriorated. Concerning human and financial resources three categories were compared: those who perceived the availability of these to be not at all, moderately or completely adequate. While in the case of human resources only a strongly positive answer increased the chances of belonging to the innovative category, for financial resources an average answer was already enough (this is most probably due to the fact that very few companies considered their human resources to be inadequate, so from an innovation point of view there is a more significant difference between the moderately and maximally satisfied). Regarding the strength of encouragement of owners, three categories were compared: weak, moderate and powerful encouragement, and here too the effect of the strongest category of encouragement proved to be significant.

In the case of environmental effects, as here most of the companies reported having a negligible environmental load, only two categories were compared: those who judged their given environmental load to be absolutely negligible (0 value on the 0 to 5 scale of the original variable), and those who indicated a different value (concerning raw material and energy use and generation of waste, where the distribution of answers was not so extreme, I differentiated between three categories but these did not prove to be significant in the model). From the environmental effects, those concerning products, hazardous waste and emissions to air were finally featured in the model.

If a variable is not featured in the model, it does not necessarily mean that its influence is not significant on the presence of innovation; it only shows that the variable does not further increase the explanatory power of the model compared to the already included variables. For example, the influence of the management is at the starting point not much weaker than the influence of the owners, but these two factors – as described during the clustering of variables – are closely related, so after incorporation of the owners into the model, doing the same with the management would not provide any significantly new information. The situation is the same concerning the availability of human resources and the ability to perceive and evaluate environmental effects – where the earlier one was featured in the model. The effect of environmental regulations falls under the significance level in the fourth step after the inclusion of emissions to air.

The model described above, on the whole, explains 42% of the variance of the dependent variable and is able to predict correctly the presence or absence of environmental innovations for 75% of the companies in the sample[10]. The explanatory power of the model can be further improved if company size is included (i.e. the collective variable created on the basis of the number of employees and revenue). The explained variance then grows to 47% and the proportion of correctly classified companies reaches 80%. It is important to remark that in this case only emissions to air were removed from the model out of the variables featured in the first version, so the rest of the determinants have significant explanatory power irrespective of (and additionally to) company size (see Appendix 21). On the whole it can be said that the main groups of studied determinants are all important from the point of view of environmental innovation activity, while at the same time, even together they can only partly explain the presence or absence of innovations – for identification of the missing links the study of the incentives behind specific innovations offers interesting insights. This takes place in the next chapter.

[10] The regression calculation was made based on data from 192 companies in total because of contradictions and missing values.

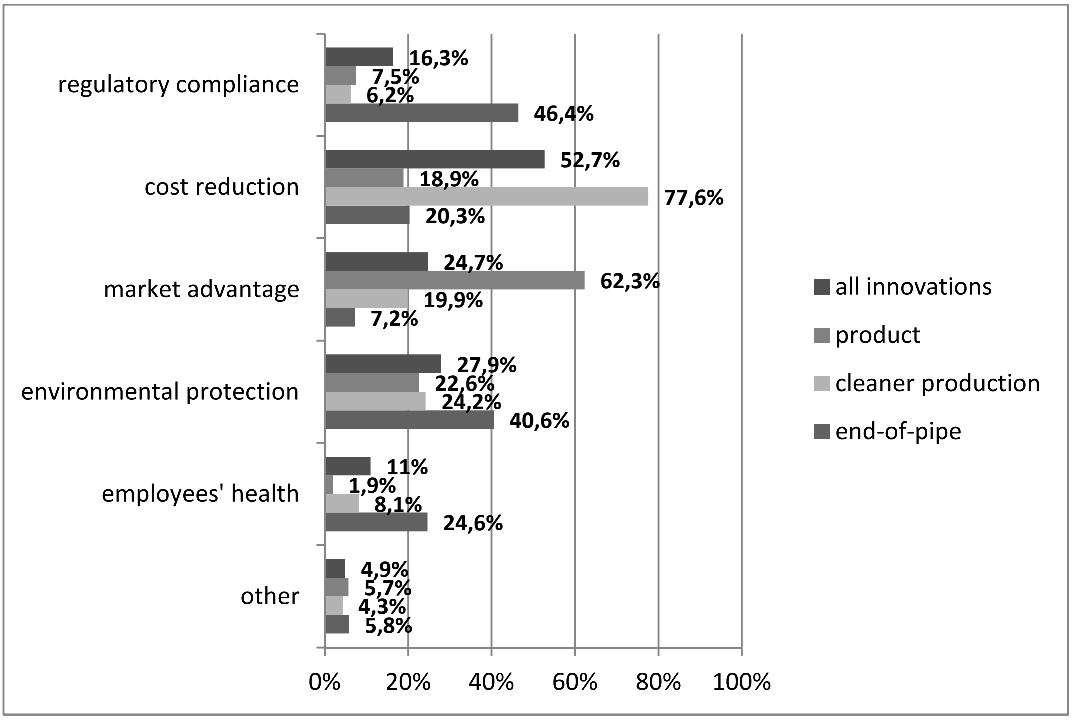
3.5 Incentives for specific environmental innovations

Figure 59 shows the motivations behind specific environmental innovations. (This was elicited through asking respondents about the reasons for the implementation of innovations in an open-ended question; answers were later coded. This way, respondents had the opportunity to mention several motivating factors concerning one innovation.) It can be seen that the most frequent reason behind the innovations was cost reduction (mentioned concerning more than half of the innovations); this answer was followed – after a large gap – by environmental protection considerations; the gaining of market advantage by meeting the demands of customers; then, regulatory compliance; and finally, the protection of the health of employees (additionally, several reasons occurred only once or twice and are featured in the "other" category). At the same time, it should be noted that (although we did not ask respondents to rank the motivations by importance), from the cases where environmental protection was mentioned, it was mentioned as the sole reason for the innovation only in every fourth case (it usually came up paired with cost reduction). The health of employees was mentioned alone in only 6.5% of mentions, while cost reduction, market considerations and regulatory compliance were mentioned alone in more than half of all cases.

The primary role of cost reduction as a motivating factor helps explain the incomplete explanatory power of the regression model that was introduced in the previous chapter: namely, if cost reduction is the most frequent reason for the introduction of environmental innovations, then environmental innovation activity (besides the factors examined so far) also greatly depends on whether or not the company encountered any solutions with a potential to reduce costs in the examined period of time.

The differential study of the basic types of environmental innovation highlights significant differences considering reasons for introduction (see Figure 59). (The differences – except for the "other" category – are all significant at the 99% level; for environmental protection at the 95% level – see Appendix 22 for the statistical details). Concerning end-of-pipe innovations respondents, as expected, mentioned meeting the requirements of environmental regulations the most often, while for product innovations it was customer demands and the possibility to gain markets that were primarily cited. Environmental protection appears as a motivating factor mostly in the case of end-of-pipe innovations, as does protection of the health of employees. The reason for this is probably that end-of-pipe innovations are generally used for treating more hazardous types of pollution, as well as the fact that reductions in cost cannot be expected from most of them (as already referred to concerning innovation payback; among end-of-pipe innovations, those connected to waste treatment were most often linked to a reduction in expenses). It can also be said about specific problem areas that environmental regulations play the largest part in the encouragement of water-related innovation. Environmental protection, while appearing most often in relation to water and air pollution and measures connected to waste, was also mentioned a few times connected to all other areas.

Figure 59: Factors motivating different types of environmental innovations (% of references)



Some interesting differences appear between the motivating factors for novel and adopted innovations (Appendix 23 contains detailed tables and statistical results). Environmental regulations were mentioned more often in relation to widespread innovations (16.4% of all innovations and 22.6% of widespread technologies), similar to protecting employees' health (for completely new innovations this reason was mentioned only once). Cost reduction, meanwhile, was mentioned as motivation in more than half of all innovations (53.2%) but only for a third of completely new solutions (34.5%). This is understandable, as a new technological solution always means more risk - those who make changes in order to reduce expenses are likely to choose a trusted piece of technology. On the other hand, gaining a market advantage – not surprisingly – occurs in greatest proportion for new solutions, as widespread methods are obviously less suitable for that purpose (24.6% for the former and 12.3% for the latter).

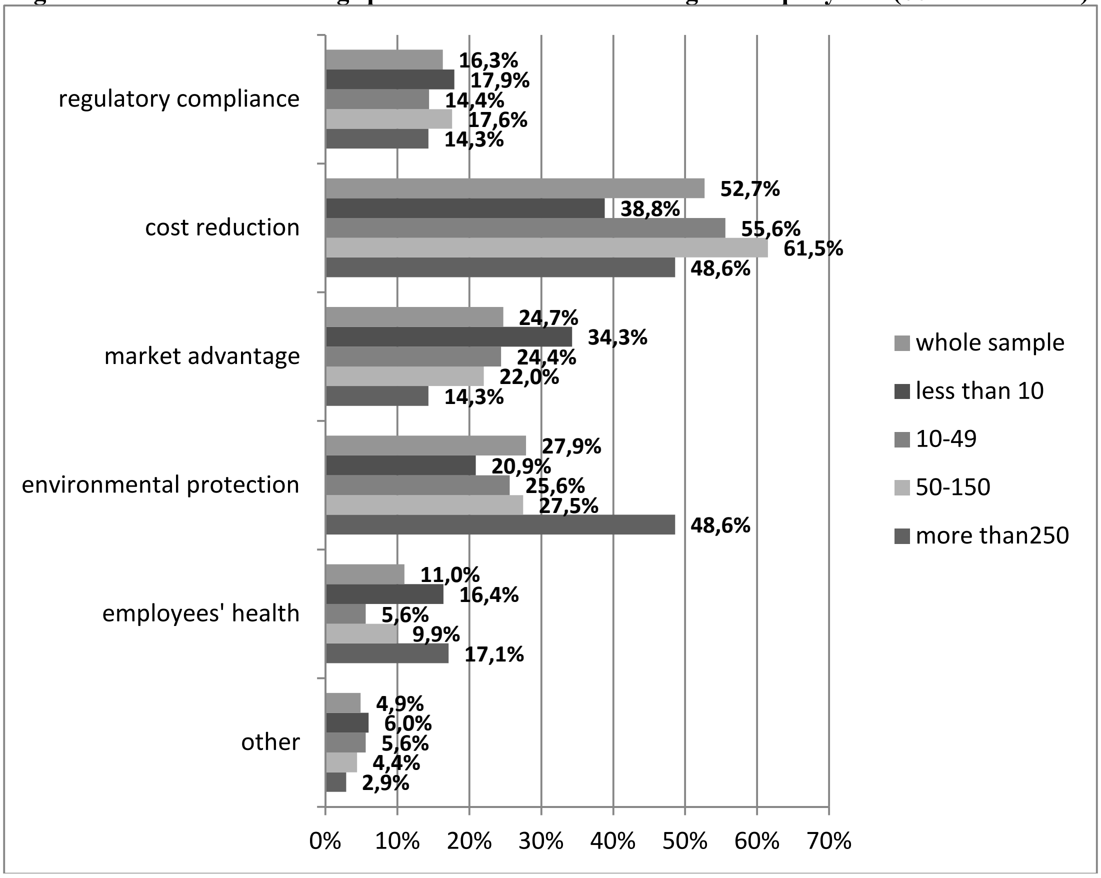
In the case of environmental protection considerations no significant connection was found overall with the novelty of the innovation; however, for preventive innovations this was mentioned as a motivating factor significantly more often for new (37.5%) and less widespread (30.8%) innovations than for established technologies (16.5%). This can also be explained when considering that a company which really holds environmental issues close to its heart probably is probably more willing to innovate in this area and is not among the last to adopt environmentally friendly technologies. The adoption of widespread technological solutions in the case of preventive innovations mostly means general modernization and the replacement of old appliances where environmental protection is typically not the primary motivation.

I also compared companies that belong to different size categories and industries in terms of drivers for realized innovations. It can be seen (Figure 60) that environmental regulations motivated the innovations introduced by companies of different sizes nearly in the same proportions, but the occurrence of other reasons varies in number. Cost reduction, for example, is most common at small and medium-sized companies. It is hypothesized that micro enterprises have less money for making efficiency improvement investments or cannot assess very well the opportunities for these. At the same time, market considerations were mentioned most often as driving the innovations of the smallest companies (as seen earlier, the number of product innovations is also the largest in this category). This is also proves that these smaller companies make the greatest efforts to be flexible about the demands of customers; something which appears less important for large companies (at least from an environmental point of view).

At the same time we can see in every size category that the proportion of environmental innovations motivated by the market is lower at companies which sell to end consumers and to retailers than when the main customers are other companies. However, the geographical location of these customers (i.e. if they are based in Hungary or in other countries of the European Union) has no influence on the share of environmental innovations motivated by the market. It may be concluded that there no longer appear to be significant differences between the environmental expectations on the Hungarian and the EU market.

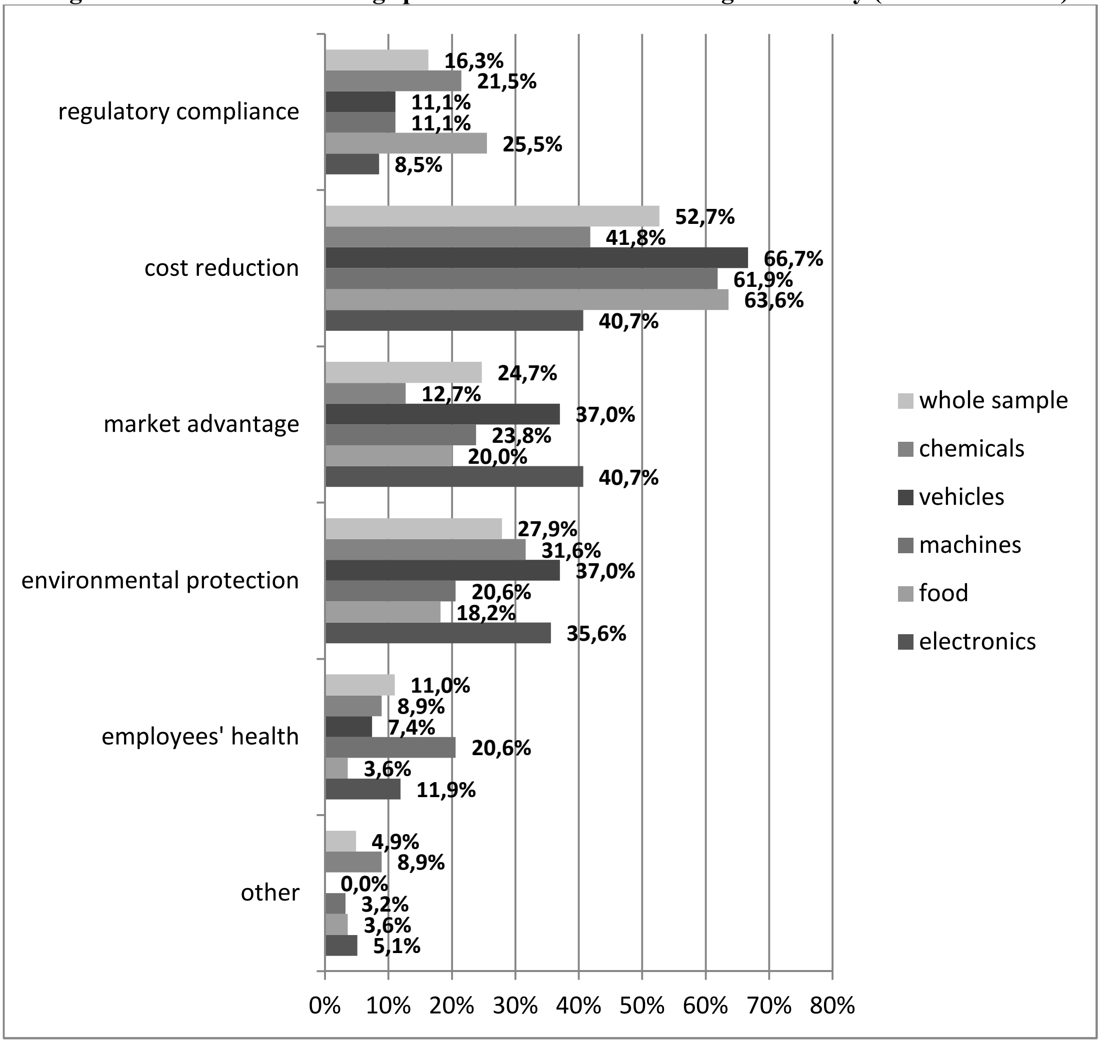
It can also be observed that large companies most often mentioned that explicit environmental considerations were behind their innovations. On the one hand we can suppose that these companies are the ones that can best afford environmental investments, but it is important to note that the reasons for introducing these innovations are mostly not “purely” for environmental protection. Thus, the difference may also be caused by the fact that environmental considerations are more strongly present the daily practices of (the representatives of) large companies, which also shows in their choice of vocabulary. Interestingly, micro-enterprises and large companies mentioned most often the health of employees. At micro-enterprises a close, personal relationship with employees is clearly the reason for this, while large companies simply cannot afford to neglect these considerations, and the large number of employees also means that absences due to unhealthy working conditions can be a significant cost factor (n.b. great care should be taken with interpreting the results for large companies, as in their case 17,1% means only a small number of mentions).

Figure 60: Factors motivating specific innovations according to company size (% of references)



Considering industrial sector it can be seen (Figure 61) that environmental regulations are important determinants of environmental innovation mostly in the chemical and food industry, while market considerations are important in the vehicle and electronics industry – this is the same picture which emerges from the examination of the role of stakeholders, concerning pressures from regulatory authorities and customers (Figure 55).

Figure 61: Factors motivating specific innovations according to industry (% of references)



3.6 The influence of environmental innovations on environmental performance

In the section on specific innovations in the survey we asked respondents to mark (on a 5 level scale) how the given innovation had influenced the company's environmental performance from a variety of perspectives (use of energy and raw material per unit, quantity and hazardousness of generated waste, emissions to air, water and soil, the environmental effects of raw materials and products and the health and safety risks of employees). Although the picture received is far vaguer than actual emissions data, it still makes possible a comparison of the different types of innovation.

Figure 62 shows the overall environmental effects of the different types of innovations (adding up the effects in every studied dimension[11]). It can be seen that, on the whole, preventive and product innovations resulted in a greater improvements in environmental performance than end-of-pipe innovations. Besides the type of innovations the degree of novelty has an even greater influence on the improvement in performance – on the whole, completely new solutions resulted in the biggest improvements, while the adoption of already widespread solutions yielded the smallest results (see Appendix 24 for the statistical details). It should be remarked at the same time that the evaluation by respondents of the change in environmental performance is obviously subjective – respondents may possibly care more for innovations developed within the company and evaluate improvements more positively.

Figure 62: The effects of different types of innovations on environmental performance (% of the achievable maximum improvement in terms of environmental effects. The value is 100% if an innovation resulted in considerable improvement in every studied dimension)

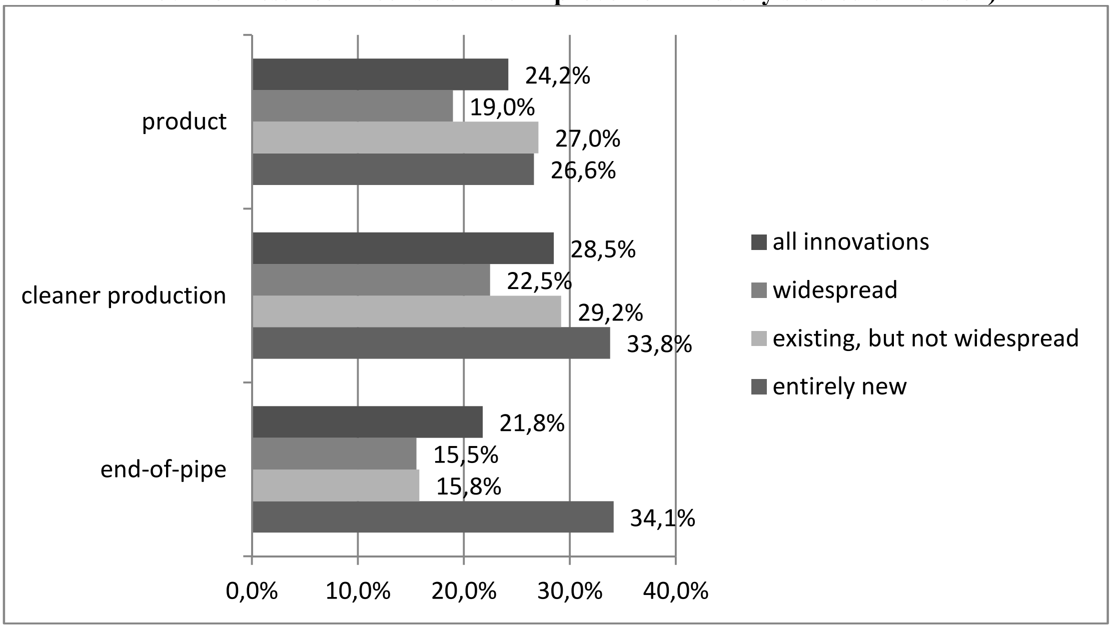
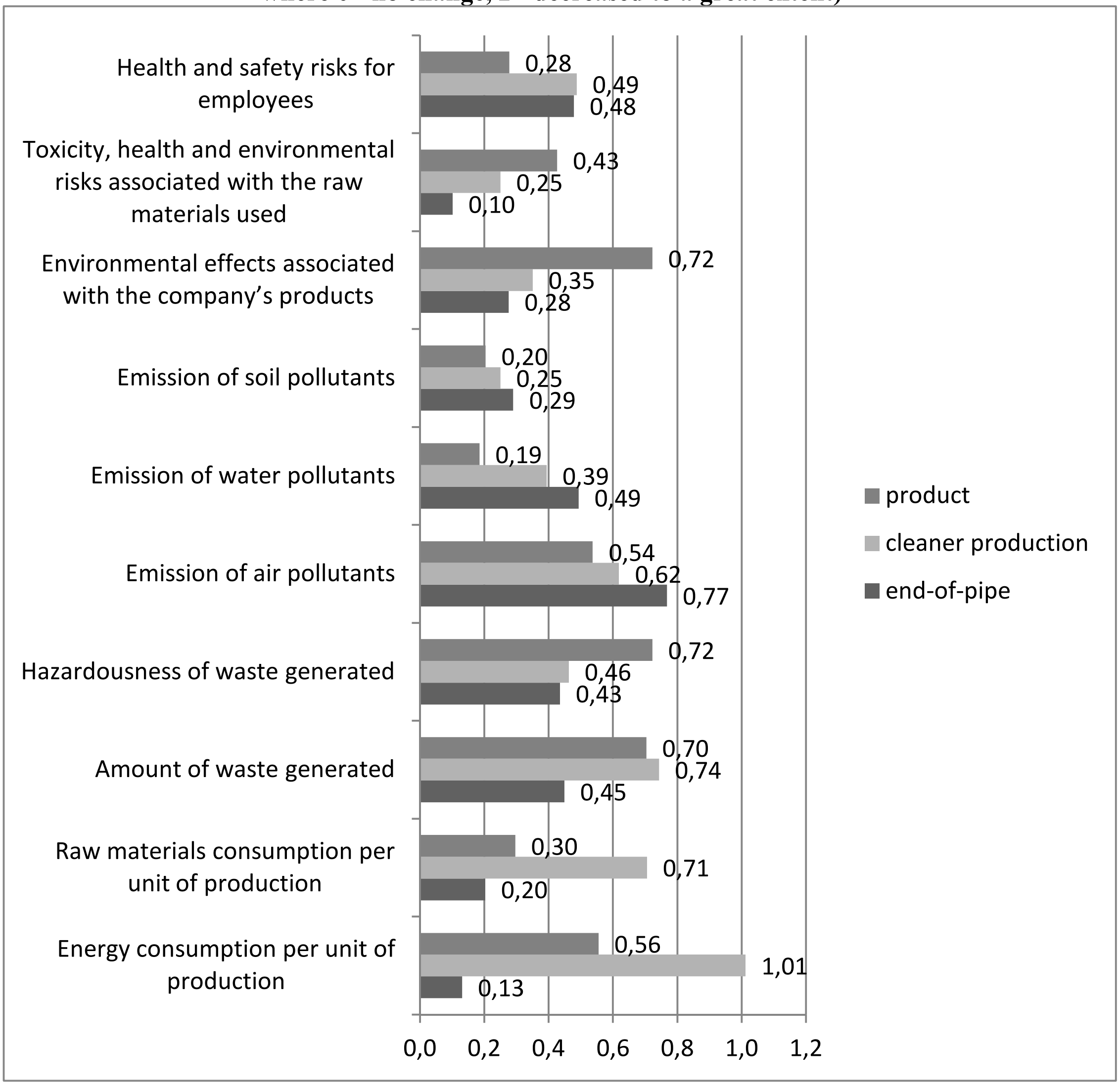


Figure 63 shows the performance of the basic types of innovative technologies separately for the different environmental effects. It can be seen that end-of-pipe innovations resulted in the biggest improvement concerning reduction of various harmful emissions, and – obviously in relation to this – reduction of the risks and health effects that employees are exposed to. The toxicity and environmental effects of raw materials and products are certainly most likely to be improved through product

[11] The combined indicator does not contain data on the effects of innovations on the health and safety risks of employees as the first survey – carried out in the chemical industry – did not collect information on this.

innovations, as is the hazardousness of generated waste. Regarding the quantity of waste generated, the companies in the sample made similar improvements with product and preventive innovations, but the efficiency of raw material and energy use stands out as being most improvable through the use of preventive innovation (see Appendix 25 for details of the statistical tests which refer to the differences described). It can also be seen on the figure why end-of-pipe innovations fall behind on an aggregate level nonetheless – i.e. while preventive technologies often result in some amount of improvement in several respects, end-of-pipe technologies are mostly suitable for dealing with only one problem, and they may even result in deterioration in other respects.

Figure 63: The effects of various types of innovation on environmental effects (average values where 0= no change, 2= decreased to a great extent)



Interesting connections were also made between the environmental effects of innovations and the reasons for their introduction. Those innovations where environmental protection was among the reported motivations reduced environmental load more, on average, in every respect (other than energy and raw material use) than those ones which were not introduced due to reasons of environmental protection. The difference is the greatest in the case of the environmental effects of raw materials and emissions to air, while the smallest in case of waste and the health of employees. As opposed to this, innovations motivated by environmental regulations performed significantly better than other innovations only in reducing water pollution. Regarding energy and raw material use, not surprisingly innovations introduced to reduce costs resulted in the biggest decrease. Market motivations, though they resulted in a decrease that is larger than average in terms of effects related to products, this is still smaller than the average of the innovations introduced due to environmental protection concerns. Innovations aimed at protecting the health of employees also had a higher than average effect on decreasing the toxicity of raw materials and air pollution, in addition to effects on the health of employees[12] (see Appendix 26 for the statistical details).

3.7 The barriers to environmental innovation activity

Companies were asked, in the form of an open-ended question, what would be necessary to increase their environmental innovation activity (answers were coded afterwards; one respondent could mention several factors) It can be seen (Figure 64) that most respondents indicated an improvement in financial conditions – either in general ("we need more money", "if the company was better-off", etc.), or referring to need for subsidies and grants (here most of them would prefer non-refundable subsidies). Concerning application systems for grants, several disapproved of their overly severe conditions and their limited availability to smaller companies – which is in line with the fact, as seen earlier (Figure 54) that the innovation encouraging

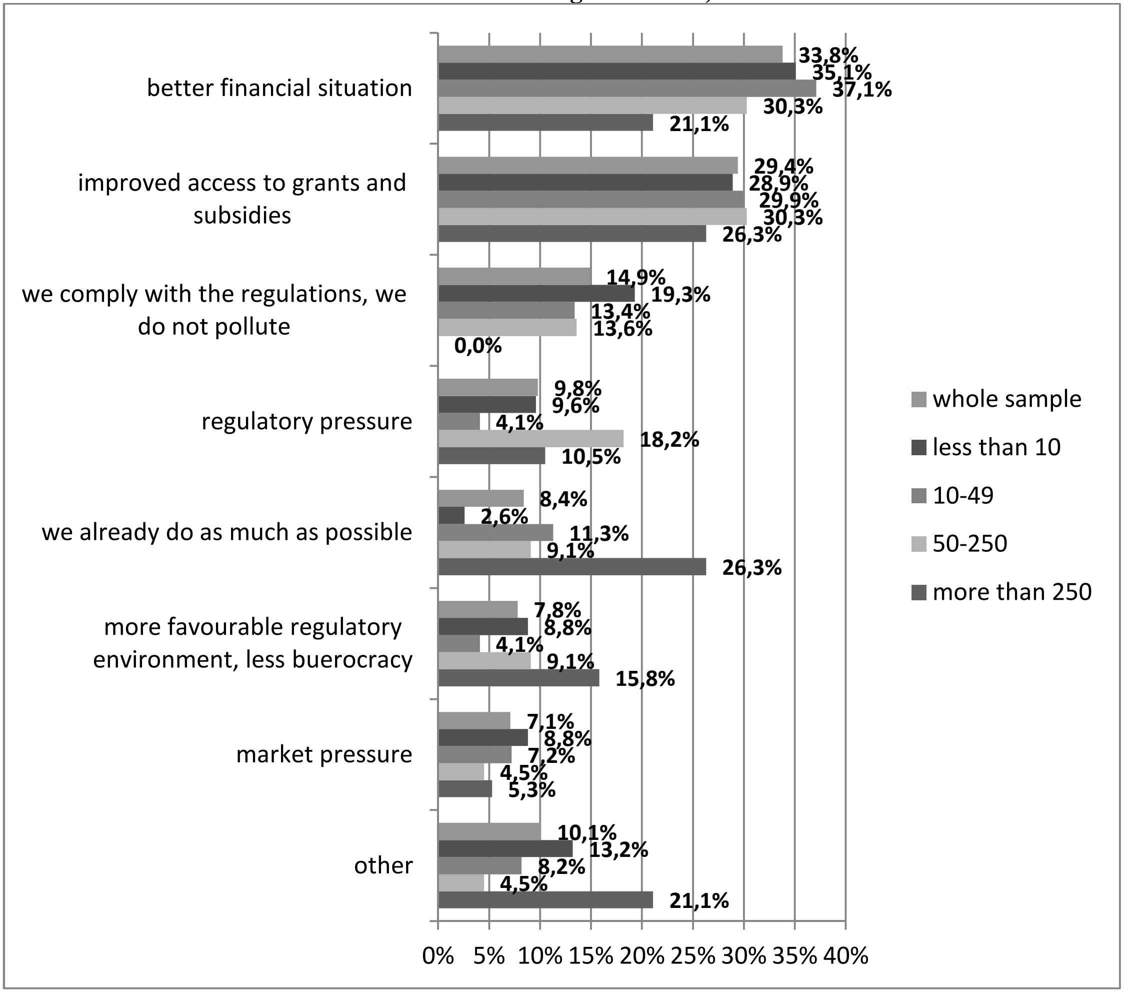
[12] To calculate average decreases I only included those innovations which are related to the given area (e.g. for an air filter, the respondent marked the toxicity of products or soil pollution as being irrelevant, so these were not included in the calculation of averages).

strength of grants and subsidies is much more significant at larger companies. Some (mainly larger firms) also mentioned the non-material dimension of state involvement, emphasizing the importance of more predictable regulations and a reduction in bureaucracy.

According to their own statements, about 15% of companies do not engage in the introduction of environmentally friendly technologies because their companies "do not pollute the environment". This is somewhat surprising at first hearing as it is hardly imaginable that any (let alone a production) company could operate without any environmental impacts – at the same time it is evident from the answers that many respondents understand the "absence of pollution" as compliance with legal emission standards; i.e. do not even consider any improvements beyond regulatory limits. This is again in harmony with the earlier observation (Figure 58) that the majority of companies consider their own emissions to be extremely low. It should be remarked at the same time that none of the large companies surveyed stated that they "do not pollute"– nevertheless, in the medium sized company category of 50-250 employees this answer was given. Another, somewhat smaller group of companies emphasized that they continuously strive to improve their environmental performance and to introduce the best available technologies.

About 10% of respondents would be willing to increase their environmental innovation activity chiefly under pressure from the regulatory authorities, and there were relatively few (7.1%) who see a possibility for progress in increased market demand and greater appreciation of environmental performance from customers. Among the 'other' reasons listed by 10% of respondents were an improvement in personnel and physical conditions (e.g. the need for a larger work site was also mentioned).

Figure 64: Conditions for increasing environmental innovation activity (% of companies who mentioned the given factor)

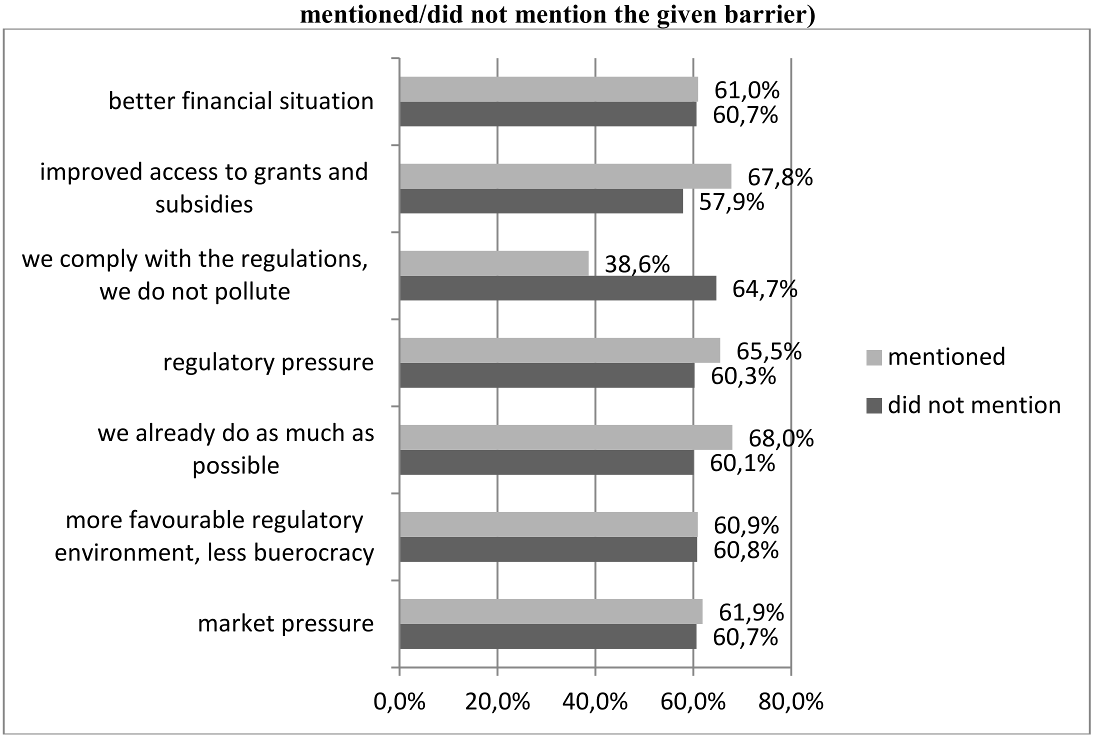


I also examined if there was a difference in the occurrence of environmental innovations between those companies who mentioned the individual barriers. As can be seen in Figure 65, innovative (i.e. those companies who introduced at least one environmental innovation during the last three years) and non-innovative companies mentioned several factors in about the same proportions. One of these factors is their financial situation – although there are more innovative companies among those who would like to see an improvement in grant opportunities (interestingly, the difference is only evident in the area of preventive innovations).

There is a striking difference in that companies who consider themselves to be non-polluters indeed introduced far fewer environmental innovations. Through separately examining the types of environmental innovation it also becomes clear that this difference emerges in the areas of preventive and product innovations as the "non-polluting" companies also introduced end-of-pipe innovations in a similar number to the average of the sample, which also shows their focus on emission standards. Looking at the other end of the spectrum it is interesting to see that, among those who according to their own account continuously make the maximum effort to protect the environment, we can also find non-innovative companies. At these companies the average age of production and environmental protection equipment was examined, supposing that the response had turned out this way because of innovations implemented before the examined period of time, but the data did not justify this assumption.

For market factors as drivers of innovation, although there does not seem to be a difference on the whole, yet after closer examination it becomes clear that we can find product innovation more often at those companies who mentioned this factor – but less preventive and end-of-pipe innovation. On the other hand, in the case of companies who mentioned environmental regulations, the frequency of end-of-pipe innovations is superior to the rest of the sample. On the basis of all these facts it seems that regarding increasing environmental innovation, most companies thought about those factors which are important for the types of innovation they already practice.

Figure 65: Innovative companies according to barriers to innovation (the proportion of companies who implemented at least one environmental innovation in the last 3 years among those who mentioned/did not mention the given barrier)



4. Examination of the research 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.

The research has shown that there are significant differences in the intensity of environmental innovation activity among Hungarian manufacturing firms. 37.4% of the companies in the sample did not introduce any environmental innovations in the past three years, but there were also several which have made changes to nearly all their products and processes over the same period. Among the determinants of environmental innovation behaviour I examined the availability of resources and capabilities, pressure from various stakeholders, the perceived severity of environmental effects as well as opinions about the economic effects of environmental innovations. I found significant relationships for all of the above factors with the intensity of environmental innovation activity, except for those environmental effects which do not belong to the „traditional" (highly damaging, hazardous) forms of pollution. However the connection is typically weak or medium strength, meaning that there is no single factor which is decisive on its own.

The size of the company has a significant effect on innovation activity: environmental innovations are more common among large firms (not only in terms of the number of innovations but also in the share of affected products and processes). I examined the effects of the economic and technological environment by comparing the various industries. It can be seen that electronics and chemical companies are more innovative in the environmental field while firms in the machines and food sectors have carried out fewer environmental innovations.

The regression model constructed from the examined determinants had medium explanatory power regarding the presence or absence of environmental innovations – examining the motivation factors behind the specific environmental innovations has shown that in addition to the above, the availability of technologies enabling cost reduction also plays a very important role.

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

Examining the relationship between general and environmental innovation activity, I found significant connections for products as well as processes.

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

The survey has examined the role of the various determinants mainly in relation to environmental innovations. From those factors which also influence innovation activity in general, I made comparisons for the role of firm size and industry. I found that company size has a closer connection to the prevalence of environmental innovations than innovations overall, meaning that innovation lag of small companies is greater in the field of the environment. The hypothesis has thus proven true for company size; on the other hand, comparison of the various industries did not show any significant differences.

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.

Examining the specific innovations presented by the respondents, I found clear connections between the type and degree of novelty of the innovations as well as their underlying motivations. In case of preventive technologies, cost reduction was almost always among the reasons for introduction, while two thirds of product innovations were driven by customer demands and potential market advantages. However, answers to the open-ended questions have shown that these customer demands are not necessarily environmental in nature; they may also be directed at, for example, quality improvements and have improved environmental performance as a side effect. The most common reason behind end-of-pipe innovations is indeed regulatory compliance, but protecting the environment or employees' health was also present in a fairly large share of the cases. However, unlike other reasons, the latter factors were rarely mentioned on their own. There are also significant differences in the motivation factors of novel and adopted innovations. Regulatory compliance and cost reduction are more often behind the adoption of existing technologies while market demand was usually mentioned in connection with innovations developed by the companies themselves. Among preventive innovations, protection of the environment was mentioned significantly more often for novel solutions.

Company size and industry also has an important effect on the types of innovation. We have seen that the share of process innovations and adopted solutions is the highest for small and medium-sized companies, while in the two extreme size categories product innovations and novel technologies are somewhat more common. There are also pronounced differences among the industries: in the chemical industry, for example, there are many end-of-pipe solutions to treat problematic emissions, in the vehicles industry there are mainly preventive solutions, while in the electronics sector the share of product innovations is much higher. Novel innovations are also the most common in the electronics industry, while in the food sector, for example, they are almost non-existent.

The relationship between the type and degree of novelty of innovations has also proven significant. While nearly half of product innovations are new solutions, this proportion is only 10 and 15% for end-of-pipe and cleaner production solutions respectively. A further difference between cleaner production and end-of-pipe technologies is that 71% of the latter were adopted as already widespread solutions; this was only true for 52% of the preventive solutions.

Overall this means that points a) and b) of the hypothesis could be verified, while point c) has also proven true regarding the tendencies, although for the specific proportions it has to be noted that the dominance of adopted innovations in the sample can also be observed among the preventive solutions, and their share is slightly above 50% even for the product innovations.

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

The findings of the survey support the hypothesis insofar as that the average improvement in environmental performance reported by the respondents is larger for novel innovations than adopted (especially widespread) technologies. Of course there are huge differences between end-of-pipe, cleaner production and product innovations in the types of environmental effects that they are the most effective in addressing. For the entirety of environmental effects, end-of-pipe solutions lag behind cleaner production and product innovations. However it has to be added that the information provided by the questionnaire about the environmental effects of innovations is rather vague and subjective, therefore testing of this hypothesis would be more reliable knowing the actual emissions data.

In connection to the examination of the hypotheses it is useful to mention the *limitations of the research*. Most important is the survey nature of the study, which means that we must entirely rely on the veracity of the information provided by the respondents. This is largely unavoidable as there is no available statistical information on the majority of the factors examined. Regarding environmental innovation activity I attempted to improve the reliability of the information by collecting data on the prevalence of innovations as well as on specific innovations and excluding contradictory replies from the analysis. In case of the former, it may occur that the respondent attempts to paint a more favourable picture of the company than the actual situation, but it is extremely unlikely that he or she would describe an „imaginary" innovation in detail.

On the other hand, the results are likely to be biased by the voluntary nature of the survey – it is likely that companies with no environmental innovations and little interest in environmental issues were less willing to participate. In order to obtain a sufficiently large amount of data from all industries and size categories, statistical representativity was not respected during the sampling procedure. All this means that the results from the survey should be treated with caution when it comes to, for example, the prevalence of environmental innovations in the whole of the Hungarian manufacturing industry. However, this was not the main goal of the research, rather, I focused on examining the *connections* between the types and determinants of innovations and this is also what most of the hypotheses were aimed at.

5. Conclusions, recommendations

The aim of my dissertation was to map the environmental innovation activity of Hungarian manufacturing companies, identify their determinants and to analyse these separately for the different types of environmental innovations (end-of-pipe/cleaner production/product; novel/adopted).

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, emissions to air and the generation 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 emissions to air) remained significant in the model. This means that they also affect environmental innovation activity on their own, not only through firm size. Identifying the factors not explained by the model was made possible by the analysis of specific environmental innovation examples.

Mapping actual environmental innovations in the Hungarian manufacturing industry is one of the important results of the thesis. 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 these 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*.

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 vague – that those innovations which were 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 shows 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).

Among the determinants of environmental innovation, many believe **environmental regulations** to be the most important, at least this is the issue which receives the most attention in the literature. The research also provides additional insights in this area, it has namely turned out that while regulations are indeed the most important source of pressure to *improve environmental performance*, only a relatively small part of specific innovations were motivated by regulatory compliance (the majority being innovations aimed at cost reduction, but market advantages and explicit environmental considerations were also mentioned more often). It could be seen that environmental regulations play the most important role in motivating measures to decrease water and air pollution as well as the creation of hazardous waste.

Environmental innovations introduced to gain **market advantages** however, do not necessarily indicate the presence of „green” consumers, as the customers themselves would often only like to save money, for example, through appliances with lower electricity consumption or products with reduced weight and therefore, lower price.
The research has also shown that, as yet, Hungarian manufacturing firms rarely encounter environmental demands from end consumers (or retailers); incentives from buyers are stronger where the buyers are other companies. It has also turned out that, with Hungary's EU integration the earlier importance of the geographic location of the market has largely disappeared, since the legal harmonisation process is complete and firms now face the same requirements at home as on the EU market.

In-depth analysis of the role of firm size in environmental innovation activity is another important result of the dissertation. 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 perceived 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.

Results of the survey have also highlighted the importance 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. Because of the relatively small number of vehicles companies in the sample, it is difficult to draw general conclusions about this sector – respondents have indicated strong customer orientation, however, the majority of innovations are aimed at improving energy efficiency.

Examination of the **barriers to environmental innovation** has yielded interesting results. 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.

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 subsidies 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.

In light of the findings from the dissertation it is also possible to make some **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.

Appendix

Appendix 1: Research questionnaire[11]

Dear Sir/Madam!

The Department of Environmental Economics and Technology of the Corvinus University of Budapest has been conducting research related to the environmental protection activities of companies regularly for the past 20 years. During this time, large changes have taken place in the economy and the society; while instead of improving, the state of our environment has deteriorated further. This happened despite the fact that many new solutions and practices have emerged and become popular with the companies which were unknown 20 years ago.

Currently our Department is conducting research on environmental innovations with the support of TÁMOP. This questionnaire is a part of that research, and it aims at obtaining a reliable picture about domestic manufacturing firms' innovation activity, the motivation factors and barriers of introducing new solutions, and their environmental effects. Your answers are very important for us as they allow us to formulate suggestions which we hope will be able to positively impact domestic innovation and environmental policy.

The data provided in the questionnaire will be treated in a confidentional manner and will only be used in an aggregate form – we will not publish any information about to your company.

If you are interested in the results of the survey, we will of course be happy to share these with you.

Thank you for your help!

Sincerely,
The members of the Department of Environmental Economics and Technology

Projekt azonosító: TÁMOP-4.2.1/B-09/1/KMR-2010-0005
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A projekt az Európai Unió támogatásával, az Európai Szociális Alap társfinanszírozásával valósul meg.

[11] Questions which were not included in the chemical industry survey are marked with an aterisk.

Environmental innovations in the manufacturing industry

1. General characteristics of the company

1.1. Name of the company:

1.2. Position of the respondent within the company:

1.3. What is the company's main field of activity?

1.4. Please describe briefly the company's main products and processes *

1.5. How many employees does the company have?
- a) Less than 10
- b) 10-49
- c) 50-249
- d) 250-499
- e) More than 500

1.6. How much was the company's revenue in the past year?

- a) Less than 15 million HUF
- b) 15-30 million
- c) 30-60 million
- d) 60-100 million
- e) 100-200 million
- f) 200-500 million
- g) 500-1000 million
- h) 1-2,5 billion
- i) 2,5-5 billion
- j) 5-8 billion
- k) More than 8 billion HUF

1.7. What was the company's approximate net income (after taxes) in the last year? ………….

1.8. How did the company's net income change in the past few years?
- a) Increased
- b) Remained constant
- c) Decreased

What is the reason for this?............

1.9. What are your expectations regarding the company's performance and market position for the next few years?
- a) Considerable improvement
- b) Slight improvement
- c) Stagnation
- d) Slight deterioration

e) Considerable deterioration
f) The company will cease operation
What is the reason for your expectations? …………

1.10. Where are the company's main markets? Please divide 100% between the following:
a) Domestic market %
b) EU market %
c) Non-EU market %

1.11. Who are the company's main buyers?
a) Consumers
b) Retailers
c) Wholesalers/distributors
d) Other companies (one or few large buyers)
e) Other companies (several buyers)

1.12. Approximately how many types of products does the company manufacture?

1.13. How would you characterise the company's main production processes?

Difficult and expensive to modify	1 2 3 4 5 6	Can be modified easily and flexibly
Outdated	1 2 3 4 5 6	Up to modern standards
Inefficient	1 2 3 4 5 6	Efficient
Capital intensive	1 2 3 4 5 6	Not capital intensive
Labour intensive	1 2 3 4 5 6	Not labour intensive

1.14. What is the average age of the company's main production equipment?

1.15. What is the average age of the company's main environmental equipment?

2. Innovation activity

In the following, we are going to ask questions about the company's innovation activity. By innovation, we mean any new or significantly improved products (and services) or processes which are **new to the company**.

2.1 Please describe any important innovations introduced by the company over the past three years.*

2.1 What percentage of your ***processes*** has been affected by innovation in the past 3 years?
a) 76-100%
b) 51-75%
c) 26-50%
d) 1-25%
e) No process innovations were introduced in this period.

2.2 What percentage of your ***products*** has been affected by innovation in the past 3 years?

a) 76-100%
b) 51-75%
c) 26-50%
d) 1-25%
e) No product innovations were introduced in this period.

2.3 Approximately what percentage of the company's turnover is from products affected by innovation in the past three years?*

2.4 Has the company filed for any patents during the past 3 years?

2.5 If the company owns any patents, what percentage of these is put to practical use?

a) 76-100%
b) 51-75%
c) 26-50%
d) 1-25%
e) The company does not own any patents.

2.6 Has the company participated in any innovation cooperations in the past three years? *

a) Yes, with the following
    a. Other company within the enterprise group
    b. Suppliers
    c. Buyers
    d. Competitors
    e. Experts, research companies
    f. Public research institutes
    g. Higher education institutions
    h. Other, please specify:
b) no, because …

In the following, we are going to ask questions about the company's **environmental innovation activity**. By environmental innovation, we mean any changes that reduce the environmental burden caused by the company's products or processes (material or energy use, pollutant emissions, waste, use of toxic substances, etc.) – **regardless of whether or not this was the purpose of the innovation.**

2.7 What percentage of your ***processes*** has been affected by ***environmental innovations*** in the past 3 years?

f) 76-100%
g) 51-75%
h) 26-50%
i) 1-25%
j) No environmental process innovations were introduced in this period.

2.8 What percentage of your ***products*** has been affected by ***environmental innovation***s in the past 3 years?

f) 76-100%
g) 51-75%
h) 26-50%
i) 1-25%
j) No environmental product innovations were introduced in this period.

2.9 Approximately what percentage of the company's turnover is from products affected by environmental innovation in the past three years?*

In the following, we would like to ask you to choose and describe the 3 most important environmental innovations introduced by the company in the past 3 years. (If there were one or two such innovations, please describe these. If there were no environmental innovations – in the sense described above – at the company in the past 3 years, please jump to question 3.1)

Innovation 1.[12]

2.10 Please describe briefly the nature and the main effects of this innovation!

2.11 When was this innovation introduced?

2.12 What was the reason for introducing this innovation?

2.13 How did the idea of this innovation emerge?

2.14 How was this innovation realised?

a) Internal research & development
b) Research & development carried out by an external party
c) Purchase of new or significantly improved equipment, machinery, software
d) Purchase of a patent, invention, or know-how

2.15 If the innovation involved the replacement of equipment, how old was the piece of equipment replaced?*

[12] The following questions were asked separately for all specific innovations (up to 3), but they will not be repeated here.

2.16 What is the degree of novelty of this innovation?

a) Completely new solution not used by any other company
b) Already existing, but not widespread solution
c) Widespread solution new to the company

2.17 If it is a completely new solution, has it been patented?

a) Yes
b) No, because
   i. this innovation cannot be patented
   ii. the necessary funds/other resources for patenting were not available
   iii. the innovation was not important enough to justify patenting
   iv. the innovation is impossible or very difficult to copy
   v. its protection can be ensured as a trade secret
   vi. other reason (please specify):……..

2.18 What was the cost of introducing this innovation?

2.19 What source was this innovation financed from? Please divide 100% between the following:

a) Own resources: %

b) Credit: %

c) Grant, subsidy: %

d) Other (please specify): %

2.20 What is (was) the payback time of this innovation?

a) Immediate
b) 1-3 years
c) More than 3 years
d) Never

2.21 Please describe the environmental effects of this innovation:

	Decreased greatly	Decreased	Remained constant	Increa sed	Increased greatly	Don't know /we do not monitor this	Not relevant
a) energy efficiency of the affected process							
b) material efficiency of the affected process							
c) amount of waste generated							
d) hazardousness of the generated waste							

e) emissions to air							
f) emissions to water							
g) emissions to the soil							
h) environmental effects associated with the company's products							
i) toxicity, health and environmental risks associated with the raw materials used							

3 Motivation factors

3.1 How do you judge your company's environmental effects?

	negligible					very high
a) Energy consumption						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
b) Consumption of raw materials						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
c) Amount of waste generated						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
d) Hazardousness of waste generated						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
e) Emissions to air						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
f) Emissions to water						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
g) Emissions to the soil						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
h) Environmental effects associated with the company's products						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6
i) Toxicity, health and environmental risks associated with the raw materials used						
i. 3 years ago*	1	2	3	4	5	6
ii. Today	1	2	3	4	5	6

j) health and safety risks for employees*						
iii. 3 years ago	1	2	3	4	5	6
i. Today	1	2	3	4	5	6

 The above changes resulted from a significant change in the company's output*

3.2 How do you judge the economic effects of environmental innovations?

a) They only increase costs
b) Sometimes they provide benefits
c) They often provide considerable benefits

3.3 How much do the following groups encourage the company to improve its environmental performance?

	not at all					very strongly
a) Customers	1	2	3	4	5	6
b) Suppliers	1	2	3	4	5	6
c) Competitors	1	2	3	4	5	6
d) NGOs	1	2	3	4	5	6
e) Population	1	2	3	4	5	6
f) Authorities/ environmental regulations	1	2	3	4	5	6
g) Environmetal and innovation grants & subsidies*	1	2	3	4	5	6
h) Owners	1	2	3	4	5	6
i) Management	1	2	3	4	5	6
j) Employees	1	2	3	4	5	6

3.4 How much do the existing regulations encourage the company to improve its environmental performance in the following areas?

	not at all					very strongly
a) Energy efficiency	1	2	3	4	5	6
b) Efficiency of raw materials use	1	2	3	4	5	6
c) Amount of waste generated	1	2	3	4	5	6
d) Hazardousness of waste generated*	1	2	3	4	5	6
e) Emissions to air	1	2	3	4	5	6
f) Emissions to water	1	2	3	4	5	6
g) Emissions to the soil	1	2	3	4	5	6
h) Environmental effects associated with the company's products	1	2	3	4	5	6
i) Toxicity, health and environmental risks associated with the raw materials used	1	2	3	4	5	6
j) Health and safety risks for employees*	1	2	3	4	5	6

3.5 To what extent does the company possess the ability to evaluate its own raw materials and energy use and the associated environmental effects, as well as to identify and assess possibilities for improvement?

not at all — completely

1 2 3 4 5 6

3.6 To what extent does the company possess the necessary human resources to introduce environmentally friendly products and processes?

not at all — completely

1 2 3 4 5 6

3.7 To what extent are solutions and information available on the market that would enable the improvement of the company's environmental performance?

not at all — completely

1 2 3 4 5 6

3.8 To what extent does the company possess the necessary financial means to implement environmental innovations?

not at all — completely

1 2 3 4 5 6

3.9 To what extent is the company able to access external (private) funds to finance the implementation of environmental innovations?

not at all — very easily

1 2 3 4 5 6

3.10 To what extent is the company able to access external (public) funds to finance the implementation of environmental innovations?

not at all — very easily

1 2 3 4 5 6

3.11 In your opinion, what conditions would be necessary for the company to engage in environmental innovation more intensively than it currently does?

3.12 Do you think it is likely that your company will increase its environmental innovation activity in the next few years? Why?

Thank you for answering our questions!

Name of respondent: e-mail:

☐ Wishes to receive the results of the survey

Appendix 2: Composition of the population and the sample by size and industry

	population	original sample	responses	response rate
micro	16877	543	114	21,0%
small	3044	351	97	27,6%
medium	833	192	67	34,9%
large	283	40	19	47,5%
total	21037	1126	297	26,4%

	population	original sample	responses	response rate
electonics	6809	259	55	21,2%
machines	5900	249	74	29,7%
vehicles	809	111	23	20,7%
food	6339	198	73	36,9%
chemicals	580	309	72	23,3%
total	20437	1126	297	26,4%

Appendix 3: Overview of the variables in the analysis

Content of the variable[13]	Name of variable	Measurement scale	Possible values
General company characteristics			
Position of the respondent at the company	pozkód	nominal	manager/director director of production environmental other
Industry	iparág	nominal	chemical food machines vehicles electronics
Number of employees	létszámkat2	ordinal	less than10 10-49 50-249 more than 250
Annual turnover	árbevkat	ordinal	less than 15 million HUF 15-30 million 30-60 million 60-100 million 100-200 million 200-500 million 500-1000 million 1-2,5 billion 2,5-5 billion 5-8 billion more than 8 billion

[13] Variables not included in the chemical industry survey are marked with an aterisk.

Content of the variable	Name of variable	Measurement scale	Possible values
Company size (variable derived combining number of employees and turnover)	méret	scale	0-100% (100%, if the company is in the top category regarding both the number of the employees and turnover)
Main market of the company's products • domestic • EU • external	hazaipiacra eupiacra külsőpiacra	scale	0-100% (total is 100%)
Who are the company's main buyers?	fővásárlók	nominal	end consumers retailers wholesalers/distributors other companies (one or few large buyers) other companies (many buyers)
Average age of the company's production equipment	termelőéves	scale	
Average age of the company's environmental protection equipment	kvéves	scale	
Variables related to innovation activity			
What percentage of your processes has been affected by innovation in the past 3 years?	eljárásinnov	ordinal	76-100% 51-75% 26-50% 1-25% No process innovations were introduced in this period.
What percentage of your products has been affected by innovation in the past 3 years?	termékinnov	ordinal	76-100% 51-75% 26-50% 1-25% No product innovations were introduced in this period.
What percentage of your processes has been affected by *environmental* innovation in the past 3 years?	ekvinnov	ordinal	76-100% 51-75% 26-50% 1-25% No environmental process innovations were introduced in this period.

Content of the variable	Name of variable	Measurement scale	Possible values
What percentage of your products has been affected by *environmental* innovation in the past 3 years?	tkvinnov	ordinal	76-100% 51-75% 26-50% 1-25% No environmental product innovations were introduced in this period.
Overall level of innovation activity (derived variable)	összinnov	ordinal	0-8 (value is 0, if no product or process innovations were introduced by the company, 8 if the answer in both respects is 76-100%)
Overall level of environmental innovation activity (derived variable)	összkvinnov	ordinal	0-8 (value is 0, if no environmental product or process innovations were introduced by the company, 8 if the answer in both respects is 76-100%)
Presence or absence of environmental innovations	összkvinnov3	nominal	0-1 (value is 0, if no environmental product or process innovations were introduced by the company, 1 in other cases)
Determinants of environmental innovation activity			
Perceived availability of resources and capabilities necessary for environmental innovation: • ability to assess environmental effects and points of intervention • human resources • accessibility of solutions enabling the improvement of environmental performance • financial resources • ability to access external (private) financing • ability to access external (public) financing*	vanmérés vanember vanmegoldás vansajátpénz vanhitelössz vantámogatás	ordinal	0 – 5; (where 0=not at all and 5=completely/very easily)
Overall availability of financial resources (internal and market combined) (derived variable)	vanpénz	scale	0-100%; value is100%, if both are fully available
Overall availability of non-financial resources (ability to assess environmental effects, human resources, accessibility of environmentally friendly solutions) (derived variable)	vanmindenmás	scale	0-100%; value is100%, if all three are fully available
Opinion about the economic effects of environmental innovations	kvinnovgazdhat	ordinal	They only increase costs Sometimes they provide benefits They often provide considerable benefits

Content of the variable	Name of variable	Measurement scale	Possible values
Pressure from various stakeholders to improve environmental performance: • Customers • Suppliers • Competitors • Owners • Management • Employees • NGOs • Population • Authorities/environmental regulations • environmental and innovation grants & subsidies*	ösztvevő ösztbeszállító ösztversenytárs össztulaj ösztmenedzs ösztalkalm ösztcilvil ösztlakos öszthatóság ösztámogat	ordinal	0 – 5; where 0=not at all, 5=very strongly (for the crosstabulations I used a reduced scale in order to increase the expected count of the cells when necessary)
Combined pressure from internal stakeholders (managers, owners, employees) (derived variable)	ösztbelső	scale	0-100%; 100%, if all three factors have the maximum value
Combined pressure from market stakeholders (customers, suppliers, competitors) (derived variable)	ösztpiac	scale	0-100%; 100%, if all three factors have the maximum value
Combined pressure from NGOs and the population (derived variable)	ösztcivlak	scale	0-100%; 100%, if both factors have the maximum value
How much do the existing regulations encourage the company to improve its environmental performance in the following areas: • Energy efficiency • Efficiency of raw materials use • Amount of waste generated • Hazardousness of waste generated* • Emission of air pollutants • Emission of water pollutants • Emission of soil pollutants • Environmental effects associated with the company's products • Toxicity, health and environmental risks associated with the raw materials used • Health and safety risks for employees*	szabenergia szabnyersanyag szabhullmenny szabhullvesz szablevegő szabvíz szabtalaj szabtermék szabalapanyag szabalkalm	ordinal	0 – 5; where 0=not at all, 5=very strongly (for the crosstabulations I used a reduced scale in order to increase the expected count of the cells when necessary)
Overall regulatory pressure (derived variable)	szabössz	scale	0-100%; 100%,if perceived regulatory pressure is very strong in all areas

Content of the variable	Name of variable	Measurement scale	Possible values
How do you judge your company's environmental effects in the following areas (3 years ago* and today): • Energy efficiency • Efficiency of raw materials use • Amount of waste generated • Hazardousness of waste generated • Emissions to air • Emissions to water • Emissions to the soil • Environmental effects associated with the company's products • Toxicity, health and environmental risks associated with the raw materials used • Health and safety risks for employees*	khvoltenergia khmaenergia khvoltnyersanyag khmanyersanyag khvolthullmenny khmahullmenny khvolthullvesz khmahullvesz khvoltlevegő khmalevegő khvoltvíz khmavíz khvolttalajú khmatalaj khvolltermék khmatermék khvoltalapanyag khmaalapanyag khvoltalkalmazott khmaalkalmazott	ordinal	0 – 5; where 0=negligible, 5=very high (for the crosstabulations I used a reduced scale in order to increase the expected count of the cells when necessary)
The above changes resulted from a significant change in the company's output*	termelésvált	nominal	yes no
Overall environmental effects related to air, water, soil, products and raw materials (derived variable)	khterhelés	scale	0-100%; 100%, if the environmental effects of the company are very high in all aspects
Overall environmental effects related to energy, raw materials use and amount of waste generated (derived variable)	khméret	scale	0-100%; 100%, if the environmental effects of the company are very high in all aspects
In your opinion, what conditions would be necessary for the company to engage in environmental innovation more intensively than it currently does? (answers coded from open-ended questions) • we already do as much as possible • we comply with the regulations, we do not pollute • better financial situation • improved access to grants and subsidies • more favourable regulatory environment, less buerocracy • regulatory pressure • market pressure • other	kellmostis kellnemszennyez kellpénz kelltámogatás kelljobbszab kellkényszer kellpiac kellother	nominal	factor was mentioned factor was not mentioned

Content of the variable	Name of variable	Measurement scale	Possible values
Variables related to the specific innovations			
Basic type of the innovation	ialap	nominal	end-of-pipe cleaner production product
Detailed type of the innovation (answers coded from open-ended questions)	irészletes	nominal	end-of-pipe: reduction of water pollution, reduction of air pollution, selective collection of water, waste treatment, prevention of accidental pollution cleaner production: improvement of raw materials efficiency, improvement of energy efficiency, recycling of waste, switching to more environmentally friendly raw materials, general efficiency improvements, use of renewable energies
Motivation for introducing the specific innovations (answers coded from open-ended questions): • regulatory compliance • cost reduction • market advantages • environmental protection • protecting employees' health • other	imotivjogszab imotivköltség imotivpiac imotivkörny imotivmunkás imotivother	nominal	factor was mentioned factor was not mentioned
Degree of novelty of the innovation	iúj	nominal	Completely new solution not used by any other company Already existing, but not widespread solution Widespread solution new to the company
Sources of funding for the innovation: • internal sources • credit • public support • other	ifinbelső ifinhitel ifintám ifinother	scale	0-100%
Payback time of the innovation	imegtérül	nominal	Immediate 1-3 years More than 3 years Never

Content of the variable	Name of variable	Measurement scale	Possible values
Effect of the innovation on the company's environmental performance in the following dimensions: • Energy efficiency • Efficiency of raw materials use • Amount of waste generated • Hazardousness of waste generated • Emission of air pollutants • Emission of water pollutants • Emission of soil pollutants • Environmental effects associated • with the company's products • Toxicity, health and environmental risks associated with the raw materials used • Health and safety risks for employees*	ikvenergia ikvnyersanyag ikvhullmenny ikvhullvesz ikvlevegő ikvvíz ikvtalaj ikvtermtox ikvalaptox ikvalkalm	ordinal	significant decrease decrease no change increase significant increase not relevant do not know/effect not monitored by the company (during the analysis the last two answers were coded as missing variables, and for energy and raw materials use the values of the scale were reversed)

Appendix 4: Relationship between the intensity of overall and environmental innovation activity

eljárásinnov3 * ekvinnov3 Crosstabulation

			ekvinnov3			Total
			nem volt ilyen	1-50%	50-100	
eljárásinnov3	nem volt ilyen	Count	34	6	0	40
		% within eljárásinnov3	85,0%	15,0%	,0%	100,0%
	1-50%	Count	36	87	5	128
		% within eljárásinnov3	28,1%	68,0%	3,9%	100,0%
	50-100	Count	14	27	36	77
		% within eljárásinnov3	18,2%	35,1%	46,8%	100,0%
Total		Count	84	120	41	245
		% within eljárásinnov3	34,3%	49,0%	16,7%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	119,887[a]	4	,000
Likelihood Ratio	113,904	4	,000
Linear-by-Linear Association	72,823	1	,000
N of Valid Cases	245		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,69.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	,700	,000
	Cramer's V	,495	,000
N of Valid Cases		245	

termékinnov3 * tkvinnov3 Crosstabulation

			tkvinnov3			Total
			nem volt ilyen	1-50%	50-100	
termékinnov3	nem volt ilyen	Count	47	4	0	51
		% within termékinnov3	92,2%	7,8%	,0%	100,0%
	1-50%	Count	51	56	1	108
		% within termékinnov3	47,2%	51,9%	,9%	100,0%
	50-100	Count	22	20	44	86
		% within termékinnov3	25,6%	23,3%	51,2%	100,0%
Total		Count	120	80	45	245
		% within termékinnov3	49,0%	32,7%	18,4%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	130,837[a]	4	,000
Likelihood Ratio	138,094	4	,000
Linear-by-Linear Association	82,694	1	,000
N of Valid Cases	245		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 9,37.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	,731	,000
	Cramer's V	,517	,000
N of Valid Cases		245	

Report

deltainnov

létszámkat2	Mean	N	Std. Deviation
10 alatt	2,0353	85	2,34240
10-49	1,8615	65	1,80171
50-250	1,1837	49	1,42410
250 felett	,7778	9	1,09291
Total	1,7260	208	1,97494

Appendix 5: The impact of company size on the difference between overall and environmental innovation activity

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
deltainnov * létszámkat2	Between Groups	(Combined)	31,829	3	10,610	2,791	,042
	Within Groups		775,550	204	3,802		
	Total		807,380	207			

Appendix 6: Payback time of environmental innovations by type

i1részletes * i1megtérül Crosstabulation

			i1megtérül					
			azonnal megtérül(t)	1-3 év alatt térül(t) meg	hosszabb távon térül(t) meg	várhatóan nem térül meg	nem tudom	Total
i1részletes	vízszennyezés csökkentése	Count	1	6	6	6	0	19
		% within i1részletes	5,3%	31,6%	31,6%	31,6%	,0%	100,0%
	levegőszennyezés csökkentése	Count	1	4	13	5	0	23
		% within i1részletes	4,3%	17,4%	56,5%	21,7%	,0%	100,0%
	szelektív hulladékgyűjtés, hulladék ártalmatlanítás	Count	5	2	3	4	0	14
		% within i1részletes	35,7%	14,3%	21,4%	28,6%	,0%	100,0%
	rendkívüli szennyezések elkerülése	Count	0	1	2	2	0	5
		% within i1részletes	,0%	20,0%	40,0%	40,0%	,0%	100,0%
	zajszennyezés csökkentése	Count	1	1	1	1	0	4
		% within i1részletes	25,0%	25,0%	25,0%	25,0%	,0%	100,0%
	hatékonyabb nyersanyagfelhasználás	Count	7	6	5	0	1	19
		% within i1részletes	36,8%	31,6%	26,3%	,0%	5,3%	100,0%
	hatékonyabb energiafelhasználás	Count	9	16	28	0	0	53
		% within i1részletes	17,0%	30,2%	52,8%	,0%	,0%	100,0%
	hulladékok újrahasznosítása	Count	5	5	4	1	0	15
		% within i1részletes	33,3%	33,3%	26,7%	6,7%	,0%	100,0%
	környezetbarátabb anyagok használata	Count	10	5	2	3	1	21
		% within i1részletes	47,6%	23,8%	9,5%	14,3%	4,8%	100,0%
	általános hatékonyságjavítás	Count	5	21	20	0	0	46
		% within i1részletes	10,9%	45,7%	43,5%	,0%	,0%	100,0%
	megújuló energia használata	Count	0	0	3	0	0	3
		% within i1részletes	,0%	,0%	100,0%	,0%	,0%	100,0%
	új, környezetbarát termék bevezetése	Count	5	15	7	0	2	29
		% within i1részletes	17,2%	51,7%	24,1%	,0%	6,9%	100,0%
	meglévő termék környezeti hatásainak csökkentése	Count	4	10	4	0	3	21
		% within i1részletes	19,0%	47,6%	19,0%	,0%	14,3%	100,0%
Total		Count	53	92	98	22	7	272
		% within i1részletes	19,5%	33,8%	36,0%	8,1%	2,6%	100,0%

Appendix 7: Type and degree of novelty of environmental innovations

i1alap * i1új Crosstabulation

			i1új			
			teljesen új, más vállalat által még nem használt megoldás	a piacon már megjelent, de még nem széles körben elterjedt újítás	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	Total
i1alap	csővégi	Count	7	13	49	69
		% within i1alap	10,1%	18,8%	71,0%	100,0%
	megelőző	Count	24	51	85	160
		% within i1alap	15,0%	31,9%	53,1%	100,0%
	termékinnováció	Count	24	15	12	51
		% within i1alap	47,1%	29,4%	23,5%	100,0%
Total		Count	55	79	146	280
		% within i1alap	19,6%	28,2%	52,1%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	40,125[a]	4	,000
Likelihood Ratio	37,280	4	,000
Linear-by-Linear Association	31,750	1	,000
N of Valid Cases	280		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 10,02.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	,379	,000
	Cramer's V	,268	,000
N of Valid Cases		280	

Appendix 8: Type of environmental innovations by company size and industry

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
létszámkat2	10 alatt	Count	16	28	23	67
		% within létszámkat2	23,9%	41,8%	34,3%	100,0%
	10-49	Count	22	56	12	90
		% within létszámkat2	24,4%	62,2%	13,3%	100,0%
	50-250	Count	24	56	11	91
		% within létszámkat2	26,4%	61,5%	12,1%	100,0%
	250 felett	Count	7	20	8	35
		% within létszámkat2	20,0%	57,1%	22,9%	100,0%
Total		Count	69	160	54	283
		% within létszámkat2	24,4%	56,5%	19,1%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16,242[a]	6	,013
Likelihood Ratio	15,430	6	,017
Linear-by-Linear Association	1,466	1	,226
N of Valid Cases	283		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,68.

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
iparág	elektronika	Count	7	27	25	59
		% within iparág	11,9%	45,8%	42,4%	100,0%
	élelmiszer	Count	15	35	5	55
		% within iparág	27,3%	63,6%	9,1%	100,0%
	gép	Count	15	37	11	63
		% within iparág	23,8%	58,7%	17,5%	100,0%
	jármű	Count	3	21	3	27
		% within iparág	11,1%	77,8%	11,1%	100,0%
	vegyipar	Count	29	40	10	79
		% within iparág	36,7%	50,6%	12,7%	100,0%
Total		Count	69	160	54	283
		% within iparág	24,4%	56,5%	19,1%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	37,604[a]	8	,000
Likelihood Ratio	34,905	8	,000
N of Valid Cases	283		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 5,15.

Appendix 9: Degree of novelty of environmental innovations by company size and industry

Crosstab

			i1új			
			teljesen új, más vállalat által még nem használt megoldás	a piacon már megjelent, de még nem széles körben elterjedt újítás	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	Total
létszámkat2	10 alatt	Count	16	24	25	65
		% within létszámkat2	24,6%	36,9%	38,5%	100,0%
	10-49	Count	16	19	55	90
		% within létszámkat2	17,8%	21,1%	61,1%	100,0%
	50-250	Count	12	26	52	90
		% within létszámkat2	13,3%	28,9%	57,8%	100,0%
	250 felett	Count	11	10	14	35
		% within létszámkat2	31,4%	28,6%	40,0%	100,0%
Total		Count	55	79	146	280
		% within létszámkat2	19,6%	28,2%	52,1%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13,909[a]	6	,031
Likelihood Ratio	13,932	6	,030
Linear-by-Linear Association	,232	1	,630
N of Valid Cases	280		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,88.

Crosstab

			i1új			Total
			teljesen új, más vállalat által még nem használt megoldás	a piacon már megjelent, de még nem széles körben elterjedt újítás	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	
iparág	elektronika	Count	23	14	19	56
		% within iparág	41,1%	25,0%	33,9%	100,0%
	élelmiszer	Count	5	16	34	55
		% within iparág	9,1%	29,1%	61,8%	100,0%
	gép	Count	10	20	33	63
		% within iparág	15,9%	31,7%	52,4%	100,0%
	jármű	Count	2	13	12	27
		% within iparág	7,4%	48,1%	44,4%	100,0%
	vegyipar	Count	15	16	48	79
		% within iparág	19,0%	20,3%	60,8%	100,0%
Total		Count	55	79	146	280
		% within iparág	19,6%	28,2%	52,1%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	30,798[a]	8	,000
Likelihood Ratio	29,035	8	,000
N of Valid Cases	280		

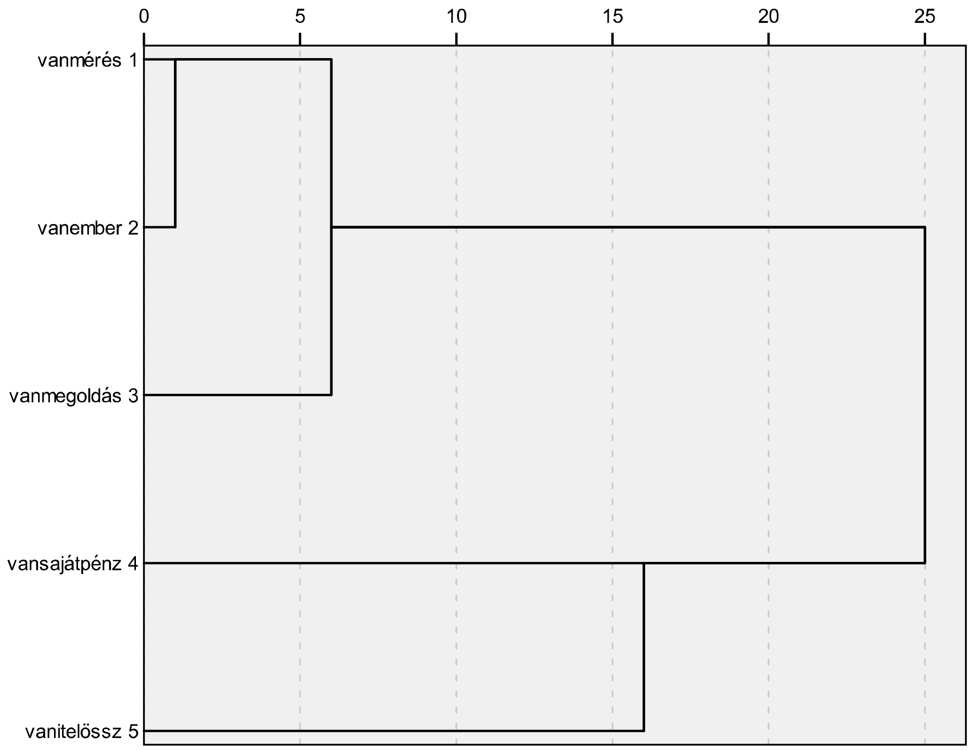
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 5,30.

Appendix 10: Cluster analysis of the variables related to resources and capabilities necessary for environmental innovation

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	1	2	12,536	0	0	2
2	1	3	13,592	1	0	4
3	4	5	15,361	0	0	4
4	1	4	16,961	2	3	0

Dendrogram using Average Linkage (Between Groups)



Appendix 11: Relationship between resources and capabilities and environmental innovation activity (simply and controlling for company size)

Correlations

		összkvinnov	vanpénz	vanmindenmás	vanössz
összkvinnov	Pearson Correlation	1	,278**	,236**	,320**
	Sig. (1-tailed)		,000	,000	,000
	N	289	281	282	276
vanpénz	Pearson Correlation	,278**	1	,300**	,730**
	Sig. (1-tailed)	,000		,000	,000
	N	281	288	283	283
vanmindenmás	Pearson Correlation	,236**	,300**	1	,871**
	Sig. (1-tailed)	,000	,000		,000
	N	282	283	290	283
vanössz	Pearson Correlation	,320**	,730**	,871**	1
	Sig. (1-tailed)	,000	,000	,000	
	N	276	283	283	283

**. Correlation is significant at the 0.01 level (1-tailed).

Correlations

Control Variables			összkvinnov	vanpénz	vanmindenmás	vanössz
méret	összkvinnov	Correlation	1,000	,175	,204	,240
		Significance (1-tailed)	.	,002	,000	,000
		df	0	269	269	269
	vanpénz	Correlation	,175	1,000	,250	,689
		Significance (1-tailed)	,002	.	,000	,000
		df	269	0	269	269
	vanmindenmás	Correlation	,204	,250	1,000	,874
		Significance (1-tailed)	,000	,000	.	,000
		df	269	269	0	269
	vanössz	Correlation	,240	,689	,874	1,000
		Significance (1-tailed)	,000	,000	,000	.
		df	269	269	269	0

Appendix 12: Relationship between the opinion on the economic effects of environmental innovations and environmental innovation activity

Crosstab

			ekvinnov3			Total
			nem volt ilyen	1-50%	50-100	
kvinnovgazdhat	csak a költségeket növelik	Count	37	8	1	46
		% within kvinnovgazdhat	80,4%	17,4%	2,2%	100,0%
	előfordul, hogy hasznot is hoznak	Count	35	60	13	108
		% within kvinnovgazdhat	32,4%	55,6%	12,0%	100,0%
	gyakran jelentős hasznot hoznak a vállalatnak	Count	10	28	15	53
		% within kvinnovgazdhat	18,9%	52,8%	28,3%	100,0%
Total		Count	82	96	29	207
		% within kvinnovgazdhat	39,6%	46,4%	14,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	49,923[a]	4	,000
Likelihood Ratio	50,219	4	,000
Linear-by-Linear Association	39,202	1	,000
N of Valid Cases	207		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,44.

Crosstab

			tkvinnov3			Total
			nem volt ilyen	1-50%	50-100	
kvinnovgazdhat	csak a költségeket növelik	Count	37	8	1	46
		% within kvinnovgazdhat	80,4%	17,4%	2,2%	100,0%
	előfordul, hogy hasznot is hoznak	Count	57	38	14	109
		% within kvinnovgazdhat	52,3%	34,9%	12,8%	100,0%
	gyakran jelentős hasznot hoznak a vállalatnak	Count	18	16	18	52
		% within kvinnovgazdhat	34,6%	30,8%	34,6%	100,0%
Total		Count	112	62	33	207
		% within kvinnovgazdhat	54,1%	30,0%	15,9%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	30,422[a]	4	,000
Likelihood Ratio	30,956	4	,000
Linear-by-Linear Association	26,881	1	,000
N of Valid Cases	207		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 7,33.

Appendix 13: Main buyers of the companies by industry and effect on the srength of customer pressure

iparág * fővásárlók Crosstabulation

			fővásárlók					
			végső fogyasztók	kiskereskedők	nagykereskedők, disztribútorok	más vállalatok (egy vagy néhány nagy vevő)	más vállalatok (nagyszámú vevő)	Total
iparág	elektronika	Count	10	1	11	25	8	55
		% within iparág	18,2%	1,8%	20,0%	45,5%	14,5%	100,0%
	élelmiszer	Count	23	17	26	3	4	73
		% within iparág	31,5%	23,3%	35,6%	4,1%	5,5%	100,0%
	gép	Count	17	2	9	31	15	74
		% within iparág	23,0%	2,7%	12,2%	41,9%	20,3%	100,0%
	jármű	Count	3	1	3	12	4	23
		% within iparág	13,0%	4,3%	13,0%	52,2%	17,4%	100,0%
	vegyipar	Count	19	3	33	16	0	71
		% within iparág	26,8%	4,2%	46,5%	22,5%	,0%	100,0%
Total		Count	72	24	82	87	31	296
		% within iparág	24,3%	8,1%	27,7%	29,4%	10,5%	100,0%

Report

ösztvevő

fővásárlók	Mean	N	Std. Deviation
végső fogyasztók	1,57	72	1,806
kiskereskedők	1,50	24	1,978
nagykereskedők, disztribútorok	1,68	82	1,798
más vállalatok (egy vagy néhány nagy vevő)	2,21	86	1,898
más vállalatok (nagyszámú vevő)	2,10	31	2,103
Total	1,84	295	1,886

Group Statistics

	fővásárlók	N	Mean	Std. Deviation	Std. Error Mean
ösztvevő	>= 4	117	2,18	1,946	,180
	< 4	178	1,61	1,817	,136

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
ösztvevő	Equal variances assumed	2,326	,128	2,550	293	,011	,567	,222	,129	1,005
	Equal variances not assumed			2,514	236,199	,013	,567	,226	,123	1,012

piac * ösztvevő3 Crosstabulation

			ösztvevő3			
			0-1	2-3	4-5	Total
piac	csak hazai	Count	63	20	21	104
		% within piac	60,6%	19,2%	20,2%	100,0%
	főként hazai	Count	45	20	24	89
		% within piac	50,6%	22,5%	27,0%	100,0%
	főként EU	Count	34	13	23	70
		% within piac	48,6%	18,6%	32,9%	100,0%
	főként külső	Count	4	5	0	9
		% within piac	44,4%	55,6%	,0%	100,0%
	vegyes	Count	9	6	9	24
		% within piac	37,5%	25,0%	37,5%	100,0%
Total		Count	155	64	77	296
		% within piac	52,4%	21,6%	26,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14,438[a]	8	,071
Likelihood Ratio	15,261	8	,054
Linear-by-Linear Association	4,788	1	,029
N of Valid Cases	296		

a. 3 cells (20,0%) have expected count less than 5. The minimum expected count is 1,95.

Appendix 14: Perceived regulatory pressure in various areas by company size and industry

Report

iparág		szabenergia	szabnyersanyag	szabhullmenny	szabhullvesz	szablevegő	szabvíz	szabtalaj	szabtermék	szabalapanyag	szabalkalm
elektronika	Mean	1,07	1,02	1,64	1,74	1,45	,98	,81	1,14	1,07	1,86
	N	42	42	42	42	42	42	42	42	42	42
	Std. Deviation	1,568	1,522	1,805	1,875	1,837	1,615	1,418	1,458	1,351	1,719
élelmiszer	Mean	1,51	1,41	1,82	1,33	1,43	1,43	1,06	1,53	1,14	2,43
	N	49	49	49	49	49	49	49	49	49	49
	Std. Deviation	1,839	1,731	1,799	1,807	1,791	1,969	1,663	1,733	1,768	1,744
gép	Mean	1,12	1,13	1,70	1,90	1,60	,97	,80	1,22	1,12	2,65
	N	60	60	60	60	60	60	60	60	60	60
	Std. Deviation	1,585	1,620	1,629	1,848	1,924	1,677	1,560	1,668	1,678	1,725
jármű	Mean	1,39	1,33	1,56	1,33	1,17	1,00	,78	,83	1,28	1,89
	N	18	18	18	18	18	18	18	18	18	18
	Std. Deviation	1,685	1,715	1,756	1,645	1,978	1,940	1,801	1,339	1,965	1,844
vegyipar	Mean	1,30	1,43	2,23	1,00	2,04	2,04	1,76	2,21	2,13	1,00
	N	47	47	47	5	47	46	46	47	47	5
	Std. Deviation	1,531	1,729	1,936	1,414	2,105	2,108	2,068	2,116	1,952	1,732
Total	Mean	1,26	1,25	1,82	1,61	1,59	1,31	1,07	1,46	1,35	2,27
	N	216	216	216	174	216	215	215	216	216	174
	Std. Deviation	1,633	1,652	1,781	1,814	1,924	1,887	1,725	1,770	1,764	1,767

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
szabenergia * iparág	Between Groups	(Combined)	6,160	4	1,540	,573	,683
	Within Groups		567,322	211	2,689		
	Total		573,481	215			
szabnyersanyag * iparág	Between Groups	(Combined)	5,760	4	1,440	,523	,719
	Within Groups		581,236	211	2,755		
	Total		586,995	215			
szabhullmenny * iparág	Between Groups	(Combined)	11,499	4	2,875	,905	,462
	Within Groups		670,460	211	3,178		
	Total		681,958	215			
szabhullvesz * iparág	Between Groups	(Combined)	12,907	4	3,227	,980	,420
	Within Groups		556,295	169	3,292		
	Total		569,201	173			
szablevegő * iparág	Between Groups	(Combined)	14,928	4	3,732	1,008	,404
	Within Groups		781,220	211	3,702		
	Total		796,148	215			
szabvíz * iparág	Between Groups	(Combined)	38,917	4	9,729	2,827	,026
	Within Groups		722,823	210	3,442		
	Total		761,740	214			
szabtalaj * iparág	Between Groups	(Combined)	30,715	4	7,679	2,659	,034
	Within Groups		606,373	210	2,887		
	Total		637,088	214			
szabtermék * iparág	Between Groups	(Combined)	41,722	4	10,431	3,483	,009
	Within Groups		631,903	211	2,995		
	Total		673,625	215			
szabalapanyag * iparág	Between Groups	(Combined)	37,144	4	9,286	3,101	,017
	Within Groups		631,814	211	2,994		
	Total		668,958	215			
szabalkalm * iparág	Between Groups	(Combined)	27,734	4	6,933	2,286	,062
	Within Groups		512,571	169	3,033		
	Total		540,305	173			

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létszámkat2		szabenergia	szabnyersanyag	szabhullmenny	szabhullvesz	szablevegő	szabvíz	szabtalaj	szabtermék	szabalapanyag	szabalkalm
10 alatt	Mean	,84	,99	1,41	1,41	1,03	,74	,72	,99	,94	1,85
	N	88	88	88	79	88	88	88	88	88	79
	Std. Deviation	1,461	1,505	1,699	1,780	1,718	1,497	1,485	1,497	1,504	1,747
10-49	Mean	1,39	1,23	2,00	1,54	1,45	1,26	,96	1,75	1,49	2,19
	N	69	69	69	52	69	69	69	69	69	52
	Std. Deviation	1,717	1,733	1,823	1,720	1,843	1,899	1,675	1,913	1,828	1,692
50-250	Mean	1,65	1,55	2,16	1,91	2,59	2,17	1,65	1,67	1,55	3,14
	N	49	49	49	35	49	48	48	49	49	35
	Std. Deviation	1,653	1,696	1,688	1,915	1,892	2,046	1,885	1,784	1,838	1,537
250 felett	Mean	2,10	2,30	2,50	2,87	2,60	2,50	2,10	2,50	2,90	3,13
	N	10	10	10	8	10	10	10	10	10	8
	Std. Deviation	1,663	1,703	2,121	1,959	2,319	2,273	2,331	2,068	2,132	2,031
Total	Mean	1,26	1,25	1,82	1,61	1,59	1,31	1,07	1,46	1,35	2,27
	N	216	216	216	174	216	215	215	216	216	174
	Std. Deviation	1,633	1,652	1,781	1,814	1,924	1,887	1,725	1,770	1,764	1,767

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
szabenergia * létszámkat2	Between Groups	(Combined)	31,272	3	10,424	4,076	,008
	Within Groups		542,210	212	2,558		
	Total		573,481	215			
szabnyersanyag * létszámkat2	Between Groups	(Combined)	21,494	3	7,165	2,686	,048
	Within Groups		565,501	212	2,667		
	Total		586,995	215			
szabhullmenny * létszámkat2	Between Groups	(Combined)	27,492	3	9,164	2,968	,033
	Within Groups		654,467	212	3,087		
	Total		681,958	215			
szabhullvesz * létszámkat2	Between Groups	(Combined)	19,622	3	6,541	2,023	,113
	Within Groups		549,579	170	3,233		
	Total		569,201	173			
szablevegő * létszámkat2	Between Groups	(Combined)	87,941	3	29,314	8,775	,000
	Within Groups		708,207	212	3,341		
	Total		796,148	215			
szabvíz * létszámkat2	Between Groups	(Combined)	78,280	3	26,093	8,056	,000
	Within Groups		683,460	211	3,239		
	Total		761,740	214			
szabtalaj * létszámkat2	Between Groups	(Combined)	38,442	3	12,814	4,516	,004
	Within Groups		598,646	211	2,837		
	Total		637,088	214			
szabtermék * létszámkat2	Between Groups	(Combined)	38,549	3	12,850	4,289	,006
	Within Groups		635,076	212	2,996		
	Total		673,625	215			
szabalapanyag * létszámkat2	Between Groups	(Combined)	41,974	3	13,991	4,731	,003
	Within Groups		626,985	212	2,957		
	Total		668,958	215			
szabalkalm * létszámkat2	Between Groups	(Combined)	46,890	3	15,630	5,385	,001
	Within Groups		493,415	170	2,902		
	Total		540,305	173			

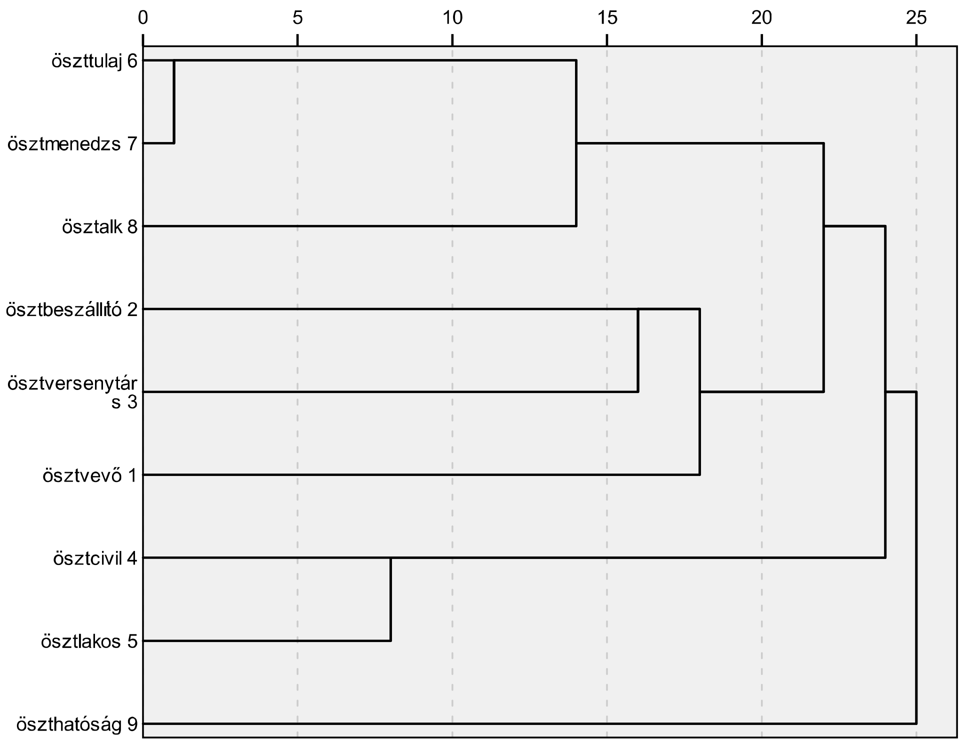
Appendix 15: Cluster analysis of the variables related to stakeholder pressure

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	6	7	8,984	0	0	3
2	4	5	11,653	0	0	7
3	6	8	13,631	1	0	6
4	2	3	14,395	0	0	5
5	1	2	15,348	0	4	6
6	1	6	16,805	5	3	7
7	1	4	17,214	6	2	8
8	1	9	17,878	7	0	0

Dendrogram using Average Linkage (Between Groups)

Rescaled Distance Cluster Combine



Appendix 16: Relationship between pressure from various stakeholder groups and environmental innovation activity (simply and controlling for company size)

Correlations

		összkvinnov	ösztpiac	ösztbelső	ösztcivlak	szabössz	ösztössz
összkvinnov	Pearson Correlation	1	,305**	,379**	,258**	,339**	,394**
	Sig. (1-tailed)		,000	,000	,000	,000	,000
	N	289	286	288	287	287	286
ösztpiac	Pearson Correlation	,305**	1	,549**	,374**	,378**	,814**
	Sig. (1-tailed)	,000		,000	,000	,000	,000
	N	286	294	294	294	292	294
ösztbelső	Pearson Correlation	,379**	,549**	1	,389**	,400**	,854**
	Sig. (1-tailed)	,000	,000		,000	,000	,000
	N	288	294	296	295	294	294
ösztcivlak	Pearson Correlation	,258**	,374**	,389**	1	,464**	,659**
	Sig. (1-tailed)	,000	,000	,000		,000	,000
	N	287	294	295	295	293	294
szabössz	Pearson Correlation	,339**	,378**	,400**	,464**	1	,542**
	Sig. (1-tailed)	,000	,000	,000	,000		,000
	N	287	292	294	293	295	292
ösztössz	Pearson Correlation	,394**	,814**	,854**	,659**	,542**	1
	Sig. (1-tailed)	,000	,000	,000	,000	,000	
	N	286	294	294	294	292	294

**. Correlation is significant at the 0.01 level (1-tailed).

Correlations

Control Variables			összkvinnov	ösztpiac	ösztbelső	ösztcivlak	szabössz	ösztössz
méret	összkvinnov	Correlation	1,000	,270	,302	,177	,267	,315
		Significance (1-tailed)	.	,000	,000	,001	,000	,000
		df	0	277	277	277	277	277
	ösztpiac	Correlation	,270	1,000	,534	,359	,349	,826
		Significance (1-tailed)	,000	.	,000	,000	,000	,000
		df	277	0	277	277	277	277
	ösztbelső	Correlation	,302	,534	1,000	,324	,335	,834
		Significance (1-tailed)	,000	,000	.	,000	,000	,000
		df	277	277	0	277	277	277
	ösztcivlak	Correlation	,177	,359	,324	1,000	,411	,622
		Significance (1-tailed)	,001	,000	,000	.	,000	,000
		df	277	277	277	0	277	277
	szabössz	Correlation	,267	,349	,335	,411	1,000	,487
		Significance (1-tailed)	,000	,000	,000	,000	.	,000
		df	277	277	277	277	0	277
	ösztössz	Correlation	,315	,826	,834	,622	,487	1,000
		Significance (1-tailed)	,000	,000	,000	,000	,000	.
		df	277	277	277	277	277	0

Appendix 17: Changes in the companies' environmental effects over the observed period

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termelésvált		váltenergia	váltnyersanyag	válthullmenny	válthullvesz	váltlevegő	váltvíz
0	Mean	-0,2	-0,129	-0,2774	-0,1742	-0,1883	-0,1753
	N	155	155	155	155	154	154
	Std. Deviation	0,77627	0,63153	0,69819	0,5483	0,65449	0,59555
igen	Mean	-0,0405	0	-0,2568	-0,1757	-0,2703	-0,1757
	N	74	74	74	74	74	74
	Std. Deviation	1,36932	1,58762	1,54442	0,86576	1,03761	0,53271
Total	Mean	-0,1485	-0,0873	-0,2707	-0,1747	-0,2149	-0,1754
	N	229	229	229	229	228	228
	Std. Deviation	1,00645	1,03926	1,04549	0,66561	0,79776	0,57473

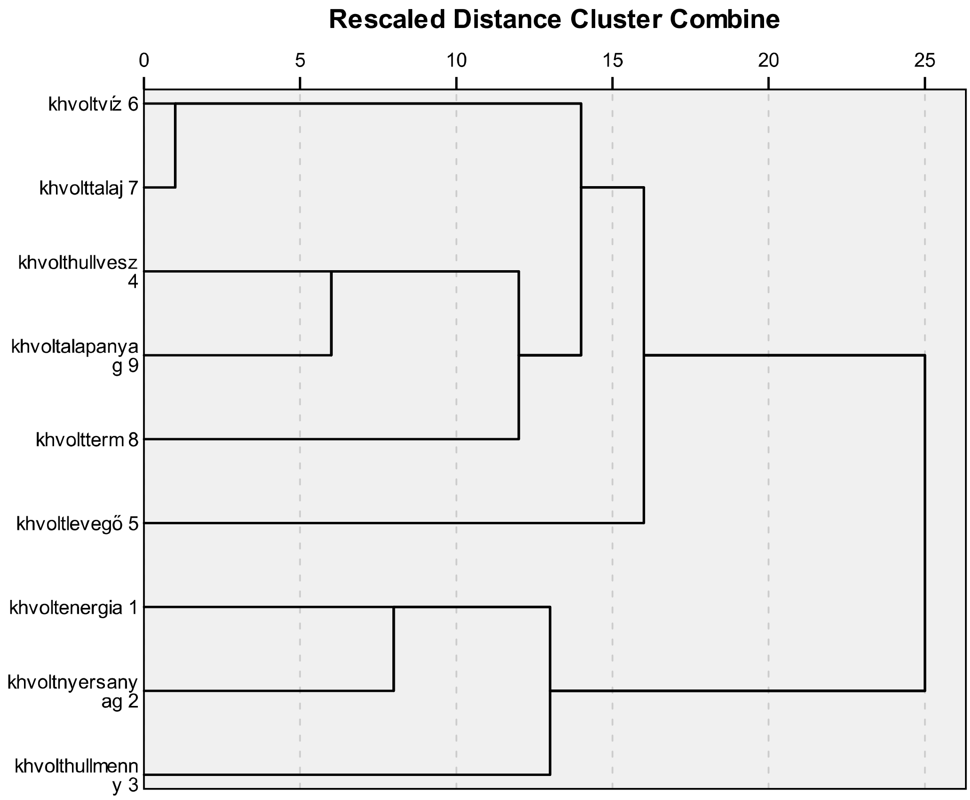
termelésvált		válttalaj	váltterm	váltalapanyag	válalkalmazott	khváltössz
0	Mean	-0,085	-0,1242	-0,0909	-0,2549	-1,6755
	N	153	153	154	153	151
	Std. Deviation	0,37954	0,40263	0,36807	0,6441	3,19906
igen	Mean	-0,1081	-0,0676	-0,1081	-0,2568	-1,4595
	N	74	74	74	74	74
	Std. Deviation	0,45534	0,6266	0,53807	0,64236	6,09331
Total	Mean	-0,0925	-0,1057	-0,0965	-0,2555	-1,6044
	N	227	227	228	227	225
	Std. Deviation	0,40493	0,48637	0,42951	0,64211	4,3547

Appendix 18: Cluster analysis of the variables related to the companies' environmental effects

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	6	7	6,583	0	0	6
2	4	9	8,308	0	0	4
3	1	2	9,046	0	0	5
4	4	8	10,210	2	0	6
5	1	3	10,402	3	0	8
6	4	6	10,984	4	1	7
7	4	5	11,458	6	0	8
8	1	4	14,459	5	7	0

Dendrogram using Average Linkage (Between Groups)



Appendix 19: Relationship between the company's perceived environmental effects and environmental innovation activity (simply and controlling for company size)

Correlations

		összkvinnov	khterhelés	khméret	khössz
összkvinnov	Pearson Correlation	1	,269**	,093	,224**
	Sig. (1-tailed)		,000	,083	,000
	N	289	220	223	220
khterhelés	Pearson Correlation	,269**	1	,432**	,874**
	Sig. (1-tailed)	,000		,000	,000
	N	220	226	226	226
khméret	Pearson Correlation	,093	,432**	1	,815**
	Sig. (1-tailed)	,083	,000		,000
	N	223	226	229	226
khössz	Pearson Correlation	,224**	,874**	,815**	1
	Sig. (1-tailed)	,000	,000	,000	
	N	220	226	226	226

**. Correlation is significant at the 0.01 level (1-tailed).

Correlations

Control Variables			összkvinnov	khméret	khterhelés	khössz
méret	összkvinnov	Correlation	1,000	-,040	,160	,084
		Significance (1-tailed)	.	,279	,009	,109
		df	0	213	213	213
	khméret	Correlation	-,040	1,000	,295	,769
		Significance (1-tailed)	,279	.	,000	,000
		df	213	0	213	213
	khterhelés	Correlation	,160	,295	1,000	,838
		Significance (1-tailed)	,009	,000	.	,000
		df	213	213	0	213
	khössz	Correlation	,084	,769	,838	1,000
		Significance (1-tailed)	,109	,000	,000	.
		df	213	213	213	0

Appendix 20: Results of the regression analysis

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	90% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	kompterm01(1)	1,643	,375	19,187	1	,000	5,173	2,791	9,589
	Constant	-,016	,179	,008	1	,929	,984		
Step 2[b]	vansajátpénz2			13,052	2	,001			
	vansajátpénz2(1)	1,359	,399	11,589	1	,001	3,892	2,018	7,503
	vansajátpénz2(2)	,904	,433	4,361	1	,037	2,469	1,212	5,031
	kompterm01(1)	1,501	,387	15,063	1	,000	4,484	2,374	8,470
	Constant	-,517	,233	4,924	1	,026	,597		
Step 3[c]	vansajátpénz2			10,727	2	,005			
	vansajátpénz2(1)	1,403	,431	10,593	1	,001	4,066	2,001	8,261
	vansajátpénz2(2)	,587	,466	1,588	1	,208	1,799	,836	3,874
	öszttulaj2			10,281	2	,006			
	öszttulaj2(1)	-,379	,418	,823	1	,364	,684	,344	1,361
	öszttulaj2(2)	1,049	,435	5,811	1	,016	2,854	1,395	5,837
	kompterm01(1)	1,647	,404	16,661	1	,000	5,193	2,674	10,086
	Constant	-,700	,294	5,662	1	,017	,497		
Step 4[d]	vansajátpénz2			10,079	2	,006			
	vansajátpénz2(1)	1,391	,442	9,908	1	,002	4,019	1,943	8,313
	vansajátpénz2(2)	,609	,470	1,681	1	,195	1,839	,849	3,986
	öszttulaj2			10,302	2	,006			
	öszttulaj2(1)	-,367	,427	,737	1	,391	,693	,343	1,399
	öszttulaj2(2)	1,081	,444	5,940	1	,015	2,948	1,421	6,116
	komplevegő01(1)	,878	,368	5,698	1	,017	2,407	1,314	4,408
	kompterm01(1)	1,533	,408	14,092	1	,000	4,630	2,366	9,063
	Constant	-,992	,328	9,174	1	,002	,371		
Step 5[e]	ervált2(1)	1,021	,470	4,716	1	,030	2,775	1,281	6,010
	vansajátpénz2			9,372	2	,009			
	vansajátpénz2(1)	1,342	,446	9,060	1	,003	3,826	1,838	7,964
	vansajátpénz2(2)	,110	,530	,043	1	,836	1,116	,467	2,667
	öszttulaj2			10,989	2	,004			
	öszttulaj2(1)	-,335	,431	,604	1	,437	,716	,352	1,453
	öszttulaj2(2)	1,180	,455	6,730	1	,009	3,254	1,540	6,877
	komplevegő01(1)	,843	,373	5,113	1	,024	2,322	1,258	4,286
	kompterm01(1)	1,481	,414	12,769	1	,000	4,397	2,224	8,693
	Constant	-1,138	,342	11,074	1	,001	,320		
Step 6[f]	ervált2(1)	1,232	,501	6,034	1	,014	3,427	1,502	7,819
	vanember2			8,267	2	,016			
	vanember2(1)	-,034	,560	,004	1	,952	,967	,385	2,427
	vanember2(2)	1,113	,565	3,889	1	,049	3,044	1,203	7,705
	vansajátpénz2			8,520	2	,014			
	vansajátpénz2(1)	1,239	,466	7,058	1	,008	3,453	1,603	7,438
	vansajátpénz2(2)	-,345	,573	,363	1	,547	,708	,276	1,818
	öszttulaj2			9,066	2	,011			
	öszttulaj2(1)	-,166	,447	,138	1	,710	,847	,406	1,767
	öszttulaj2(2)	1,201	,473	6,442	1	,011	3,324	1,526	7,242
	komplevegő01(1)	,978	,389	6,318	1	,012	2,659	1,402	5,044
	kompterm01(1)	1,705	,444	14,738	1	,000	5,503	2,650	11,426
	Constant	-1,715	,557	9,479	1	,002	,180		
Step 7[g]	ervált2(1)	1,319	,512	6,642	1	,010	3,738	1,611	8,673
	vanember2			9,443	2	,009			
	vanember2(1)	-,043	,567	,006	1	,940	,958	,377	2,436
	vanember2(2)	1,219	,574	4,516	1	,034	3,384	1,317	8,693
	vansajátpénz2			7,000	2	,030			
	vansajátpénz2(1)	1,091	,476	5,241	1	,022	2,976	1,359	6,516
	vansajátpénz2(2)	-,440	,582	,572	1	,449	,644	,247	1,677
	öszttulaj2			7,532	2	,023			
	öszttulaj2(1)	-,068	,458	,022	1	,881	,934	,440	1,984
	öszttulaj2(2)	1,148	,475	5,853	1	,016	3,153	1,444	6,883
	komphullvesz01(1)	,770	,422	3,327	1	,068	2,159	1,079	4,323
	komplevegő01(1)	,884	,398	4,931	1	,026	2,421	1,258	4,661
	kompterm01(1)	1,428	,471	9,201	1	,002	4,169	1,922	9,042
	Constant	-1,914	,578	10,958	1	,001	,147		

a. Variable(s) entered on step 1: kompterm01.
b. Variable(s) entered on step 2: vansajátpénz2.
c. Variable(s) entered on step 3: öszttulaj2.
d. Variable(s) entered on step 4: komplevegő01.
e. Variable(s) entered on step 5: ervált2.
f. Variable(s) entered on step 6: vanember2.
g. Variable(s) entered on step 7: komphullvesz01.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	233,115[a]	,112	,153
2	219,275[a]	,174	,236
3	208,139[b]	,221	,300
4	202,241[b]	,244	,332
5	197,254[b]	,264	,358
6	188,535[b]	,296	,402
7	185,174[b]	,308	,419

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than ,001.
b. Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

Classification Table[a]

	Observed		Predicted		
			összkvinnov3		Percentage Correct
			,00	1,00	
Step 1	összkvinnov3	,00	0	74	,0
		1,00	0	118	100,0
	Overall Percentage				61,5
Step 2	összkvinnov3	,00	44	30	59,5
		1,00	27	91	77,1
	Overall Percentage				70,3
Step 3	összkvinnov3	,00	40	34	54,1
		1,00	18	100	84,7
	Overall Percentage				72,9
Step 4	összkvinnov3	,00	35	39	47,3
		1,00	13	105	89,0
	Overall Percentage				72,9
Step 5	összkvinnov3	,00	33	41	44,6
		1,00	12	106	89,8
	Overall Percentage				72,4
Step 6	összkvinnov3	,00	42	32	56,8
		1,00	23	95	80,5
	Overall Percentage				71,4
Step 7	összkvinnov3	,00	42	32	56,8
		1,00	16	102	86,4
	Overall Percentage				75,0

a. The cut value is ,420

Appendix 21: Results of the regression analysis including company size in the model

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	90% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	méret	,046	,009	25,312	1	,000	1,047	1,032	1,063
	Constant	-1,335	,369	13,057	1	,000	,263		
Step 2[b]	kompterm01(1)	1,345	,396	11,543	1	,001	3,838	2,001	7,360
	méret	,041	,009	18,787	1	,000	1,042	1,026	1,058
	Constant	-1,524	,389	15,363	1	,000	,218		
Step 3[c]	vanember2			9,936	2	,007			
	vanember2(1)	,170	,544	,097	1	,755	1,185	,484	2,900
	vanember2(2)	1,257	,546	5,290	1	,021	3,514	1,431	8,633
	kompterm01(1)	1,579	,425	13,810	1	,000	4,849	2,411	9,752
	méret	,042	,010	17,789	1	,000	1,043	1,026	1,060
	Constant	-2,263	,596	14,427	1	,000	,104		
Step 4[d]	vanember2			10,843	2	,004			
	vanember2(1)	,159	,548	,084	1	,772	1,172	,476	2,888
	vanember2(2)	1,327	,551	5,807	1	,016	3,770	1,524	9,325
	komphullvesz01(1)	,948	,401	5,585	1	,018	2,581	1,334	4,993
	kompterm01(1)	1,211	,452	7,187	1	,007	3,358	1,597	7,061
	méret	,040	,010	15,562	1	,000	1,041	1,024	1,059
	Constant	-2,464	,613	16,160	1	,000	,085		
Step 5[e]	erváltl2(1)	,959	,452	4,494	1	,034	2,608	1,240	5,487
	vanember2			11,358	2	,003			
	vanember2(1)	,149	,555	,072	1	,789	1,161	,466	2,892
	vanember2(2)	1,382	,562	6,050	1	,014	3,982	1,580	10,031
	komphullvesz01(1)	1,029	,410	6,292	1	,012	2,800	1,425	5,499
	kompterm01(1)	1,144	,454	6,338	1	,012	3,140	1,487	6,629
	méret	,038	,010	13,365	1	,000	1,039	1,021	1,057
	Constant	-2,635	,636	17,154	1	,000	,072		
Step 6[f]	erváltl2(1)	1,371	,525	6,806	1	,009	3,938	1,659	9,347
	vanember2			12,452	2	,002			
	vanember2(1)	-,216	,593	,133	1	,715	,806	,304	2,136
	vanember2(2)	1,291	,584	4,892	1	,027	3,638	1,392	9,503
	vansajátpénz2			6,905	2	,032			
	vansajátpénz2(1)	,899	,461	3,795	1	,051	2,457	1,150	5,247
	vansajátpénz2(2)	-,782	,585	1,786	1	,181	,457	,175	1,198
	komphullvesz01(1)	,983	,418	5,531	1	,019	2,673	1,344	5,316
	kompterm01(1)	1,144	,467	5,988	1	,014	3,139	1,455	6,772
	méret	,042	,012	13,577	1	,000	1,043	1,024	1,063
	Constant	-2,752	,657	17,556	1	,000	,064		
Step 7[g]	erváltl2(1)	1,424	,544	6,860	1	,009	4,152	1,698	10,153
	vanember2			9,836	2	,007			
	vanember2(1)	-,216	,598	,130	1	,718	,806	,302	2,154
	vanember2(2)	1,164	,594	3,845	1	,050	3,203	1,206	8,504
	vansajátpénz2			8,124	2	,017			
	vansajátpénz2(1)	,974	,488	3,981	1	,046	2,649	1,187	5,914
	vansajátpénz2(2)	-,963	,616	2,445	1	,118	,382	,139	1,051
	öszttulaj2			6,588	2	,037			
	öszttulaj2(1)	-,449	,482	,867	1	,352	,638	,289	1,411
	öszttulaj2(2)	,833	,480	3,010	1	,083	2,301	1,044	5,069
	komphullvesz01(1)	,829	,426	3,778	1	,052	2,290	1,136	4,618
	kompterm01(1)	1,304	,487	7,172	1	,007	3,683	1,654	8,202
	méret	,043	,012	12,940	1	,000	1,044	1,023	1,064
	Constant	-2,803	,677	17,133	1	,000	,061		

a. Variable(s) entered on step 1: méret.
b. Variable(s) entered on step 2: kompterm01.
c. Variable(s) entered on step 3: vanember2.
d. Variable(s) entered on step 4: komphullvesz01.
e. Variable(s) entered on step 5: erváltl2.
f. Variable(s) entered on step 6: vansajátpénz2.
g. Variable(s) entered on step 7: öszttulaj2.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	223,464[a]	,156	,212
2	210,677[b]	,210	,286
3	200,083[b]	,253	,343
4	194,364[b]	,275	,373
5	189,587[b]	,292	,397
6	182,065[b]	,320	,434
7	175,134[c]	,344	,467

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than ,001.
b. Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.
c. Estimation terminated at iteration number 6 because parameter estimates changed by less than ,001.

Classification Table[a]

	Observed		Predicted		
			összkvinnov3		Percentage Correct
			,00	1,00	
Step 1	összkvinnov3	,00	36	38	48,6
		1,00	24	94	79,7
	Overall Percentage				67,7
Step 2	összkvinnov3	,00	47	27	63,5
		1,00	24	94	79,7
	Overall Percentage				73,4
Step 3	összkvinnov3	,00	40	34	54,1
		1,00	16	102	86,4
	Overall Percentage				74,0
Step 4	összkvinnov3	,00	46	28	62,2
		1,00	23	95	80,5
	Overall Percentage				73,4
Step 5	összkvinnov3	,00	45	29	60,8
		1,00	18	100	84,7
	Overall Percentage				75,5
Step 6	összkvinnov3	,00	48	26	64,9
		1,00	15	103	87,3
	Overall Percentage				78,6
Step 7	összkvinnov3	,00	51	23	68,9
		1,00	15	103	87,3
	Overall Percentage				80,2

a. The cut value is ,470

Appendix 22: Factors motivating the specific innovations by innovation type

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
i1motivköltség	nem említette	Count	55	36	43	134
		% within i1alap	79,7%	22,5%	79,6%	47,3%
	említette	Count	14	124	11	149
		% within i1alap	20,3%	77,5%	20,4%	52,7%
Total		Count	69	160	54	283
		% within i1alap	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	91,186[a]	2	,000
Likelihood Ratio	96,714	2	,000
Linear-by-Linear Association	,785	1	,376
N of Valid Cases	283		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 25,57.

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
i1motivkörny	nem említette	Count	41	121	42	204
		% within i1alap	59,4%	75,6%	77,8%	72,1%
	említette	Count	28	39	12	79
		% within i1alap	40,6%	24,4%	22,2%	27,9%
Total		Count	69	160	54	283
		% within i1alap	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7,366[a]	2	,025
Likelihood Ratio	7,042	2	,030
Linear-by-Linear Association	5,654	1	,017
N of Valid Cases	283		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 15,07.

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
i1motivpiac	nem említette	Count	64	129	20	213
		% within i1alap	92,8%	80,6%	37,0%	75,3%
	említette	Count	5	31	34	70
		% within i1alap	7,2%	19,4%	63,0%	24,7%
Total		Count	69	160	54	283
		% within i1alap	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	56,194[a]	2	,000
Likelihood Ratio	52,243	2	,000
Linear-by-Linear Association	46,864	1	,000
N of Valid Cases	283		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 13,36.

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
i1motivjogszab	nem említette	Count	37	151	49	237
		% within i1alap	53,6%	94,4%	90,7%	83,7%
	említette	Count	32	9	5	46
		% within i1alap	46,4%	5,6%	9,3%	16,3%
Total		Count	69	160	54	283
		% within i1alap	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	61,215[a]	2	,000
Likelihood Ratio	53,331	2	,000
Linear-by-Linear Association	36,138	1	,000
N of Valid Cases	283		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 8,78.

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
i1motivmunkás	nem említette	Count	52	147	53	252
		% within i1alap	75,4%	91,9%	98,1%	89,0%
	említette	Count	17	13	1	31
		% within i1alap	24,6%	8,1%	1,9%	11,0%
Total		Count	69	160	54	283
		% within i1alap	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19,145[a]	2	,000
Likelihood Ratio	18,396	2	,000
Linear-by-Linear Association	17,231	1	,000
N of Valid Cases	283		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 5,92.

Crosstab

			i1alap			Total
			csővégi	megelőző	termékinnováció	
i1motivegyéb	nem említette	Count	65	153	51	269
		% within i1alap	94,2%	95,6%	94,4%	95,1%
	említette	Count	4	7	3	14
		% within i1alap	5,8%	4,4%	5,6%	4,9%
Total		Count	69	160	54	283
		% within i1alap	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,260[a]	2	,878
Likelihood Ratio	,257	2	,879
Linear-by-Linear Association	,012	1	,914
N of Valid Cases	283		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 2,67.

Appendix 23: Factors motivating the specific innovations by degree of novelty of the innovation

Crosstab

			i1új			Total
			teljesen új, más vállalat által még nem használt megoldás	a piacon már megjelent, de még nem széles körben elterjedt újítás	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	
i1motivjogszab	nem említette	Count	49	72	113	234
		% within i1új	89,1%	91,1%	77,4%	83,6%
	említette	Count	6	7	33	46
		% within i1új	10,9%	8,9%	22,6%	16,4%
Total		Count	55	79	146	280
		% within i1új	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8,570[a]	2	,014
Likelihood Ratio	8,906	2	,012
Linear-by-Linear Association	6,147	1	,013
N of Valid Cases	280		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 9,04.

Crosstab

			i1új			Total
			teljesen új, más vállalat által még nem használt megoldás	a piacon már megjelent, de még nem széles körben elterjedt újítás	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	
i1motivmunkás	nem említette	Count	54	70	125	249
		% within i1új	98,2%	88,6%	85,6%	88,9%
	említette	Count	1	9	21	31
		% within i1új	1,8%	11,4%	14,4%	11,1%
Total		Count	55	79	146	280
		% within i1új	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6,418[a]	2	,040
Likelihood Ratio	8,589	2	,014
Linear-by-Linear Association	5,816	1	,016
N of Valid Cases	280		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,09.

Crosstab

			i1új			Total
			teljesen új, más vállalat által még nem használt megoldás	a piacon már megjelent, de még nem széles körben elterjedt újítás	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	
i1motivköltség	nem említette	Count	36	32	63	131
		% within i1új	65,5%	40,5%	43,2%	46,8%
	említette	Count	19	47	83	149
		% within i1új	34,5%	59,5%	56,8%	53,2%
Total		Count	55	79	146	280
		% within i1új	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9,725[a]	2	,008
Likelihood Ratio	9,797	2	,007
Linear-by-Linear Association	5,664	1	,017
N of Valid Cases	280		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 25,73.

Crosstab

			i1új			Total
			teljesen új, más vállalat által még nem használt megoldás	a piacon már megjelent, de még nem széles körben elterjedt újítás	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	
i1motivpiac	nem említette	Count	29	54	128	211
		% within i1új	52,7%	68,4%	87,7%	75,4%
	említette	Count	26	25	18	69
		% within i1új	47,3%	31,6%	12,3%	24,6%
Total		Count	55	79	146	280
		% within i1új	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	29,175[a]	2	,000
Likelihood Ratio	28,950	2	,000
Linear-by-Linear Association	28,975	1	,000
N of Valid Cases	280		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 13,55.

Crosstab

i1alap				i1új: teljesen új, más vállalat által még nem használt megoldás	i1új: a piacon már megjelent, de még nem széles körben elterjedt újítás	i1új: a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	Total
csővégi	i1motivkörny	nem említette	Count	5	7	29	41
			% within i1új	71,4%	53,8%	59,2%	59,4%
		említette	Count	2	6	20	28
			% within i1új	28,6%	46,2%	40,8%	40,6%
	Total		Count	7	13	49	69
			% within i1új	100,0%	100,0%	100,0%	100,0%
megelőző	i1motivkörny	nem említette	Count	15	35	71	121
			% within i1új	62,5%	68,6%	83,5%	75,6%
		említette	Count	9	16	14	39
			% within i1új	37,5%	31,4%	16,5%	24,4%
	Total		Count	24	51	85	160
			% within i1új	100,0%	100,0%	100,0%	100,0%
termékinnováció	i1motivkörny	nem említette	Count	19	13	7	39
			% within i1új	79,2%	86,7%	58,3%	76,5%
		említette	Count	5	2	5	12
			% within i1új	20,8%	13,3%	41,7%	23,5%
	Total		Count	24	15	12	51
			% within i1új	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests

i1alap		Value	df	Asymp. Sig. (2-sided)
csővégi	Pearson Chi-Square	,587[a]	2	,746
	Likelihood Ratio	,604	2	,739
	Linear-by-Linear Association	,123	1	,726
	N of Valid Cases	69		
megelőző	Pearson Chi-Square	6,479[b]	2	,039
	Likelihood Ratio	6,456	2	,040
	Linear-by-Linear Association	6,123	1	,013
	N of Valid Cases	160		
termékinnováció	Pearson Chi-Square	3,158[c]	2	,206
	Likelihood Ratio	3,006	2	,222
	Linear-by-Linear Association	1,309	1	,253
	N of Valid Cases	51		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 2,84.
b. 0 cells (,0%) have expected count less than 5. The minimum expected count is 5,85.
c. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 2,82.

Appendix 24: Effects of the innovations on environmental performance by type and degree of novelty

Report

ikvössz

i1alap	i1új	Mean	N	Std. Deviation
csővégi	teljesen új, más vállalat által még nem használt megoldás	34,1270	7	19,09166
	a piacon már megjelent, de még nem széles körben elterjedt újítás	15,8120	13	12,18136
	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	15,5329	49	12,92884
	Total	17,4718	69	14,42669
megelőző	teljesen új, más vállalat által még nem használt megoldás	35,4167	24	20,96776
	a piacon már megjelent, de még nem széles körben elterjedt újítás	29,1939	51	17,63285
	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	22,5490	85	14,58199
	Total	26,5972	160	17,21537
termékinnováció	teljesen új, más vállalat által még nem használt megoldás	26,6204	24	21,54644
	a piacon már megjelent, de még nem széles körben elterjedt újítás	27,0370	15	17,92433
	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	18,9815	12	13,07372
	Total	24,9455	51	18,76997
Total	teljesen új, más vállalat által még nem használt megoldás	31,4141	55	21,06607
	a piacon már megjelent, de még nem széles körben elterjedt újítás	26,5823	79	17,42507
	a piacon már elterjedt újítás, mely a vállalat szempontjából újszerű	19,9011	146	14,21655
	Total	24,0476	280	17,24335

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
ikvössz * i1alap	Between Groups	(Combined)	4064,834	2	2032,417	7,136	,001
	Within Groups		78891,075	277	284,805		
	Total		82955,908	279			

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
ikvössz * i1új	Between Groups	(Combined)	6002,457	2	3001,228	10,803	,000
	Within Groups		76953,452	277	277,810		
	Total		82955,908	279			

Appendix 25: Effects of the different types of environmental innovations in the various dimensions of environmental performance

Report

i1alap		energia3	nyersanyag3	hullmenny3	hullvesz3	levegő3	víz3	talaj3	termtox3	alaptox3	alkalm3
csővégi	Mean	-,1304	-,2029	-,4493	-,4348	-,7681	-,4928	-,2899	-,2754	-,1014	-,4783
	N	69	69	69	69	69	69	69	69	69	69
	Std. Deviation	,70530	,47216	,84950	,69617	,94160	,77882	,57141	,59121	,38900	,81545
megelőző	Mean	-1,0125	-,7062	-,7437	-,4625	-,6188	-,3938	-,2500	-,3500	-,2500	-,4875
	N	160	160	160	160	160	160	160	160	160	160
	Std. Deviation	,93154	,84375	,81067	,77612	,76784	,70127	,59347	,61634	,60397	,76057
termékinnováció	Mean	-,5556	-,2963	-,7037	-,7222	-,5370	-,1852	-,2037	-,7222	-,4259	-,2778
	N	54	54	54	54	54	54	54	54	54	54
	Std. Deviation	1,09315	,96406	,79217	,83365	,74512	,43758	,49065	,71154	,71643	,65637
Total	Mean	-,7102	-,5053	-,6643	-,5053	-,6396	-,3781	-,2509	-,4028	-,2473	-,4452
	N	283	283	283	283	283	283	283	283	283	283
	Std. Deviation	,98615	,82673	,82322	,77355	,81047	,68558	,56865	,64708	,59156	,75771

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
energia3 * i1alap	Between Groups	(Combined)	39,106	2	19,553	23,284	,000
	Within Groups		235,134	280	,840		
	Total		274,240	282			
nyersanyag3 * i1alap	Between Groups	(Combined)	15,130	2	7,565	11,926	,000
	Within Groups		177,612	280	,634		
	Total		192,742	282			
hullmenny3 * i1alap	Between Groups	(Combined)	4,284	2	2,142	3,210	,042
	Within Groups		186,825	280	,667		
	Total		191,110	282			
hullvesz3 * i1alap	Between Groups	(Combined)	3,177	2	1,589	2,687	,070
	Within Groups		165,565	280	,591		
	Total		168,742	282			
levegő3 * i1alap	Between Groups	(Combined)	1,777	2	,889	1,356	,259
	Within Groups		183,460	280	,655		
	Total		185,237	282			
víz3 * i1alap	Between Groups	(Combined)	2,956	2	1,478	3,193	,043
	Within Groups		129,588	280	,463		
	Total		132,544	282			
talaj3 * i1alap	Between Groups	(Combined)	,225	2	,113	,346	,707
	Within Groups		90,962	280	,325		
	Total		91,187	282			
termtox3 * i1alap	Between Groups	(Combined)	7,076	2	3,538	8,925	,000
	Within Groups		111,001	280	,396		
	Total		118,078	282			
alaptox3 * i1alap	Between Groups	(Combined)	3,192	2	1,596	4,680	,010
	Within Groups		95,494	280	,341		
	Total		98,686	282			
alkalm3 * i1alap	Between Groups	(Combined)	1,875	2	,938	1,641	,196
	Within Groups		160,026	280	,572		
	Total		161,901	282			

Appendix 26: Effects of innovations with different motivations on the various dimensions of environmental performance

Report

i1motivkörny		hullmenny2	hullvesz2	levegő2	víz2	talaj2	termtox2	alaptox2	alkalm2	energia2	nyersanyag2
nem említette	Mean	-,8301	-,7288	-,9576	-,8000	-,6479	-,6981	-,4242	-,8053	-,9879	-,6887
	N	153	118	118	90	71	106	99	113	165	151
	Std. Deviation	,77622	,80236	,77783	,75252	,71910	,73251	,70118	,84366	,99993	,87320
említette	Mean	-1,0517	-1,0179	-1,3878	-1,1667	-1,0000	-1,0811	-,9333	-1,1290	-,7600	-,7959
	N	58	56	49	30	25	37	30	31	50	49
	Std. Deviation	,98091	,90435	,75874	,91287	,86603	,59528	,90719	,92166	1,13497	,99957
Total	Mean	-,8910	-,8218	-1,0838	-,8917	-,7396	-,7972	-,5426	-,8750	-,9349	-,7150
	N	211	174	167	120	96	143	129	144	215	200
	Std. Deviation	,84090	,84483	,79466	,80748	,77112	,71758	,78070	,86804	1,03465	,90436

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
hullmenny2 * i1motivkörny	Between Groups	(Combined)	2,066	1	2,066	2,949	,087
	Within Groups		146,427	209	,701		
	Total		148,493	210			
hullvesz2 * i1motivkörny	Between Groups	(Combined)	3,173	1	3,173	4,536	,035
	Within Groups		120,304	172	,699		
	Total		123,477	173			
levegő2 * i1motivkörny	Between Groups	(Combined)	6,406	1	6,406	10,739	,001
	Within Groups		98,421	165	,596		
	Total		104,826	166			
víz2 * i1motivkörny	Between Groups	(Combined)	3,025	1	3,025	4,787	,031
	Within Groups		74,567	118	,632		
	Total		77,592	119			
talaj2 * i1motivkörny	Between Groups	(Combined)	2,292	1	2,292	3,976	,049
	Within Groups		54,197	94	,577		
	Total		56,490	95			
termtox2 * i1motivkörny	Between Groups	(Combined)	4,023	1	4,023	8,208	,005
	Within Groups		69,096	141	,490		
	Total		73,119	142			
alaptox2 * i1motivkörny	Between Groups	(Combined)	5,967	1	5,967	10,518	,002
	Within Groups		72,048	127	,567		
	Total		78,016	128			
alkalm2 * i1motivkörny	Between Groups	(Combined)	2,549	1	2,549	3,441	,066
	Within Groups		105,201	142	,741		
	Total		107,750	143			
energia2 * i1motivkörny	Between Groups	(Combined)	1,993	1	1,993	1,869	,173
	Within Groups		227,096	213	1,066		
	Total		229,088	214			
nyersanyag2 * i1motivkörny	Between Groups	(Combined)	,425	1	,425	,518	,472
	Within Groups		162,330	198	,820		
	Total		162,755	199			

Report

i1motivjogszab		hullmenny2	hullvesz2	levegő2	víz2	talaj2	termtox2	alaptox2	alkalm2	energia2	nyersanyag2
nem említette	Mean	-,9438	-,8125	-1,0876	-,8211	-,7215	-,7705	-,5364	-,8468	-1,0486	-,8070
	N	178	144	137	95	79	122	110	124	185	171
	Std. Deviation	,84184	,85255	,79033	,83766	,78343	,71335	,77433	,85582	1,00153	,90304
említette	Mean	-,6061	-,8667	-1,0667	-1,1600	-,8235	-,9524	-,5789	-1,0500	-,2333	-,1724
	N	33	30	30	25	17	21	19	20	30	29
	Std. Deviation	,78817	,81931	,82768	,62450	,72761	,74001	,83771	,94451	,97143	,71058
Total	Mean	-,8910	-,8218	-1,0838	-,8917	-,7396	-,7972	-,5426	-,8750	-,9349	-,7150
	N	211	174	167	120	96	143	129	144	215	200
	Std. Deviation	,84090	,84483	,79466	,80748	,77112	,71758	,78070	,86804	1,03465	,90436

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
hullmenny2 * i1motivjogszab	Between Groups	(Combined)	3,176	1	3,176	4,568	,034
	Within Groups		145,317	209	,695		
	Total		148,493	210			
hullvesz2 * i1motivjogszab	Between Groups	(Combined)	,073	1	,073	,102	,750
	Within Groups		123,404	172	,717		
	Total		123,477	173			
levegő2 * i1motivjogszab	Between Groups	(Combined)	,011	1	,011	,017	,897
	Within Groups		104,816	165	,635		
	Total		104,826	166			
víz2 * i1motivjogszab	Between Groups	(Combined)	2,274	1	2,274	3,562	,062
	Within Groups		75,318	118	,638		
	Total		77,592	119			
talaj2 * i1motivjogszab	Between Groups	(Combined)	,146	1	,146	,243	,623
	Within Groups		56,344	94	,599		
	Total		56,490	95			
termtox2 * i1motivjogszab	Between Groups	(Combined)	,593	1	,593	1,152	,285
	Within Groups		72,526	141	,514		
	Total		73,119	142			
alaptox2 * i1motivjogszab	Between Groups	(Combined)	,029	1	,029	,048	,827
	Within Groups		77,986	127	,614		
	Total		78,016	128			
alkalm2 * i1motivjogszab	Between Groups	(Combined)	,711	1	,711	,944	,333
	Within Groups		107,039	142	,754		
	Total		107,750	143			
energia2 * i1motivjogszab	Between Groups	(Combined)	17,160	1	17,160	17,246	,000
	Within Groups		211,929	213	,995		
	Total		229,088	214			
nyersanyag2 * i1motivjogszab	Between Groups	(Combined)	9,985	1	9,985	12,942	,000
	Within Groups		152,770	198	,772		
	Total		162,755	199			

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i1motivköltség		hullmenny2	hullvesz2	levegő2	víz2	talaj2	termtox2	alaptox2	alkalm2	energia2	nyersanyag2
nem említette	Mean	-,8788	-,9438	-1,1446	-,9184	-,8718	-1,0299	-,7143	-,8333	-,6304	-,5169
	N	99	89	83	49	39	67	63	60	92	89
	Std. Deviation	,79889	,83066	,82835	,78626	,76707	,65064	,81178	,90510	1,03475	,91840
említette	Mean	-,9018	-,6941	-1,0238	-,8732	-,6491	-,5921	-,3788	-,9048	-1,1626	-,8739
	N	112	85	84	71	57	76	66	84	123	111
	Std. Deviation	,87980	,84549	,76009	,82686	,76745	,71512	,71823	,84481	,97824	,86463
Total	Mean	-,8910	-,8218	-1,0838	-,8917	-,7396	-,7972	-,5426	-,8750	-,9349	-,7150
	N	211	174	167	120	96	143	129	144	215	200
	Std. Deviation	,84090	,84483	,79466	,80748	,77112	,71758	,78070	,86804	1,03465	,90436

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
hullmenny2 * i1motivköltség	Between Groups	(Combined)	,028	1	,028	,039	,843
	Within Groups		148,465	209	,710		
	Total		148,493	210			
hullvesz2 * i1motivköltség	Between Groups	(Combined)	2,711	1	2,711	3,861	,051
	Within Groups		120,766	172	,702		
	Total		123,477	173			
levegő2 * i1motivköltség	Between Groups	(Combined)	,609	1	,609	,964	,328
	Within Groups		104,217	165	,632		
	Total		104,826	166			
víz2 * i1motivköltség	Between Groups	(Combined)	,059	1	,059	,090	,765
	Within Groups		77,533	118	,657		
	Total		77,592	119			
talaj2 * i1motivköltség	Between Groups	(Combined)	1,148	1	1,148	1,950	,166
	Within Groups		55,341	94	,589		
	Total		56,490	95			
termtox2 * i1motivköltség	Between Groups	(Combined)	6,823	1	6,823	14,512	,000
	Within Groups		66,296	141	,470		
	Total		73,119	142			
alaptox2 * i1motivköltség	Between Groups	(Combined)	3,628	1	3,628	6,194	,014
	Within Groups		74,387	127	,586		
	Total		78,016	128			
alkalm2 * i1motivköltség	Between Groups	(Combined)	,179	1	,179	,236	,628
	Within Groups		107,571	142	,758		
	Total		107,750	143			
energia2 * i1motivköltség	Between Groups	(Combined)	14,906	1	14,906	14,823	,000
	Within Groups		214,183	213	1,006		
	Total		229,088	214			
nyersanyag2 * i1motivköltség	Between Groups	(Combined)	6,296	1	6,296	7,968	,005
	Within Groups		156,459	198	,790		
	Total		162,755	199			

Report

i1motivpiac		hullmenny2	hullvesz2	levegő2	víz2	talaj2	termtox2	alaptox2	alkalm2	energia2	nyersanyag2
nem említette	Mean	-,8896	-,8651	-1,1349	-,9579	-,7361	-,7283	-,5610	-,9897	-,9355	-,7914
	N	154	126	126	95	72	92	82	97	155	139
	Std. Deviation	,86743	,84241	,80352	,81104	,75046	,69698	,80274	,85993	1,02360	,82948
említette	Mean	-,8947	-,7083	-,9268	-,6400	-,7500	-,9216	-,5106	-,6383	-,9333	-,5410
	N	57	48	41	25	24	51	47	47	60	61
	Std. Deviation	,77192	,84949	,75466	,75719	,84699	,74413	,74811	,84508	1,07146	1,04201
Total	Mean	-,8910	-,8218	-1,0838	-,8917	-,7396	-,7972	-,5426	-,8750	-,9349	-,7150
	N	211	174	167	120	96	143	129	144	215	200
	Std. Deviation	,84090	,84483	,79466	,80748	,77112	,71758	,78070	,86804	1,03465	,90436

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
hullmenny2 * i1motivpiac	Between Groups	(Combined)	,001	1	,001	,002	,969
	Within Groups		148,492	209	,710		
	Total		148,493	210			
hullvesz2 * i1motivpiac	Between Groups	(Combined)	,854	1	,854	1,198	,275
	Within Groups		122,623	172	,713		
	Total		123,477	173			
levegő2 * i1motivpiac	Between Groups	(Combined)	1,340	1	1,340	2,136	,146
	Within Groups		103,487	165	,627		
	Total		104,826	166			
víz2 * i1motivpiac	Between Groups	(Combined)	2,000	1	2,000	3,122	,080
	Within Groups		75,592	118	,641		
	Total		77,592	119			
talaj2 * i1motivpiac	Between Groups	(Combined)	,003	1	,003	,006	,940
	Within Groups		56,486	94	,601		
	Total		56,490	95			
termtox2 * i1motivpiac	Between Groups	(Combined)	1,226	1	1,226	2,405	,123
	Within Groups		71,893	141	,510		
	Total		73,119	142			
alaptox2 * i1motivpiac	Between Groups	(Combined)	,076	1	,076	,123	,726
	Within Groups		77,940	127	,614		
	Total		78,016	128			
alkalm2 * i1motivpiac	Between Groups	(Combined)	3,909	1	3,909	5,346	,022
	Within Groups		103,841	142	,731		
	Total		107,750	143			
energia2 * i1motivpiac	Between Groups	(Combined)	,000	1	,000	,000	,989
	Within Groups		229,088	213	1,076		
	Total		229,088	214			
nyersanyag2 * i1motivpiac	Between Groups	(Combined)	2,658	1	2,658	3,287	,071
	Within Groups		160,097	198	,809		
	Total		162,755	199			

Report

i1motivmunkás		hullmenny2	hullvesz2	levegő2	víz2	talaj2	termtox2	alaptox2	alkalm2	energia2	nyersanyag2
nem említette	Mean	-,9251	-,8105	-,9856	-,9083	-,7349	-,8031	-,4732	-,7250	-1,0052	-,7363
	N	187	153	139	109	83	127	112	120	193	182
	Std. Deviation	,81962	,84099	,77071	,81128	,78218	,72418	,73472	,83979	,99214	,90224
említette	Mean	-,6250	-,9048	-1,5714	-,7273	-,7692	-,7500	-1,0000	-1,6250	-,3182	-,5000
	N	24	21	28	11	13	16	17	24	22	18
	Std. Deviation	,96965	,88909	,74180	,78625	,72501	,68313	,93541	,57578	1,21052	,92355
Total	Mean	-,8910	-,8218	-1,0838	-,8917	-,7396	-,7972	-,5426	-,8750	-,9349	-,7150
	N	211	174	167	120	96	143	129	144	215	200
	Std. Deviation	,84090	,84483	,79466	,80748	,77112	,71758	,78070	,86804	1,03465	,90436

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
hullmenny2 * i1motivmunkás	Between Groups	(Combined)	1,916	1	1,916	2,732	,100
	Within Groups		146,577	209	,701		
	Total		148,493	210			
hullvesz2 * i1motivmunkás	Between Groups	(Combined)	,164	1	,164	,229	,633
	Within Groups		123,313	172	,717		
	Total		123,477	173			
levegő2 * i1motivmunkás	Between Groups	(Combined)	7,998	1	7,998	13,629	,000
	Within Groups		96,828	165	,587		
	Total		104,826	166			
víz2 * i1motivmunkás	Between Groups	(Combined)	,327	1	,327	,500	,481
	Within Groups		77,264	118	,655		
	Total		77,592	119			
talaj2 * i1motivmunkás	Between Groups	(Combined)	,013	1	,013	,022	,882
	Within Groups		56,476	94	,601		
	Total		56,490	95			
termtox2 * i1motivmunkás	Between Groups	(Combined)	,040	1	,040	,077	,781
	Within Groups		73,079	141	,518		
	Total		73,119	142			
alaptox2 * i1motivmunkás	Between Groups	(Combined)	4,096	1	4,096	7,037	,009
	Within Groups		73,920	127	,582		
	Total		78,016	128			
alkalm2 * i1motivmunkás	Between Groups	(Combined)	16,200	1	16,200	25,127	,000
	Within Groups		91,550	142	,645		
	Total		107,750	143			
energia2 * i1motivmunkás	Between Groups	(Combined)	9,321	1	9,321	9,034	,003
	Within Groups		219,768	213	1,032		
	Total		229,088	214			
nyersanyag2 * i1motivmunkás	Between Groups	(Combined)	,914	1	,914	1,119	,292
	Within Groups		161,841	198	,817		
	Total		162,755	199			

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