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Title: Determinants of eco-innovations. The evidence from Poland

Key-words: Environmental innovations (eco-innovation), environmental performance, drivers of innovation, environmentally sound technologies

Abstract

Given the challenges that arise due to climate change and global warming there is a need to ensure the widest possible diffusion and adoption of eco-innovations in both, developed and developing countries. The aim of this paper is to analyze and discuss the actions undertaken by Polish enterprises operating in the field of environmentally sound technologies to create and implement environmentally friendly products (eco-innovations). The study examines the impact of the determinants, such as technology, market, regulation and firm specific factors, on the development of eco-innovative solutions of analyzed companies. It also aims to examine whether the sources of innovations differ from the sources of eco-innovations. Based on the interviews conducted with the selected companies, it is possible to specify the determinants and sources of eco-innovative activity and the motivation for creating eco-innovations in Poland. They are mainly market- and technology-related factors. This conclusion is in line with the studies emphasizing the role of market, technology and firm specific factors as the determinants of eco-innovations, but in opposition to the results supporting the thesis that regulatory aspect is highly important for the companies that create and develop environmentally friendly novelties.

Introduction

Sustainable and permanent development is one of the strategic goals of the European Union and the environmental policy is listed as the tool to achieve it. Such goal has been first set in 1972 in the Environmental Action Programme. Over the years, the European environmental policy is being constantly updated taking into account the fact that Earths' natural resources are not unlimited. In one of the European Commission reports it is stated that the guidelines of the environmental policy should be assessed on the basis of costs, while the effects of environmental improvements and society's well-being additionally should be aimed at supporting eco-innovativeness (Oosterhuis, 2006). Given the challenges that arise due to climate change and global warming there is a need to ensure the widest possible diffusion and adoption of environmentally sound technologies in both, developed and developing countries (Correa, 2013, pp. 54-61).

In the last few years the issues of environmental responsibility and sustainable development have been arising in various debates amongst academic institutions, businesses and policy makers (Banerjee, Iyer, Kashyap, 2003; Triguero, Moreno-Mondéjar, Davia, 2013). With respect to the problem of environment pollution and high costs of its clearance, natural degradation prevention actions put forward the need for creating and widely implementing new practices for everyday life. Academics developed the idea of eco-efficiency (Kevin, Patrice, 1999), eco-labeling (Frieder, Dirk, Fabio, 2008), eco-effectiveness (Giancarlo, 2007), eco-design (Pinar, Jorg, 2005) and eco-innovation (Carrillo, Río, Könnölä, 2010; Horbach, Rammer, Rennings, 2012), while enterprises discovered the need to adapt to the new trends (Aragon-Correa, Sharma, 2003; Jänicke, 2012).

The aim of this paper is to analyze and discuss the actions undertaken by Polish enterprises operating in the field of environmentally sound technologies to create and implement environmentally friendly products (eco-innovations). The study examines the impact of the determinants, such as technology, market, regulation and firm specific factors, on the development of eco-innovative solutions of analyzed companies. The second issue worth examining is whether the sources of innovations differ from the sources of eco-innovations. Moreover, the research aims to describe country specific characteristics concerning the analyzed topic. The research questions are the following:

1. What are the sources of eco-innovative activity undertaken by Polish companies-suppliers of environmentally sound technologies?
2. To what extent the sources of eco-innovations differ from the sources of traditional innovation that are indentified in the literature?
3. What are the country specific characteristics of the determinants of eco-innovations?
4. What are the companies' motivations in the process of developing environmentally sound technology?

Theoretical framework

Research on innovation seen from firms' perspective is grounded in theories of organization and management. The concept of innovation has been introduced by Joseph Schumpeter (1939), who appreciate its important role in the economy. He believed that revolutionary business ideas, that break down the current state of economic equilibrium by introducing a new combination of factors, are the driving forces of the economy. He named such phenomenon innovation, and he explained it using the approach of creative destruction (Schumpeter, 1939; Schumpeter, 1960, pp. 89-150). There are five types of novelties distinguished by Schumpeter: the introduction of a new goods, the introduction of new methods of production, the opening of new markets, new sources of supply of raw materials and the introduction of new organizational structures of any industry (Schumpeter, 1960, p. 104).

There are many approaches that focus on the topic of innovations and provide its definitions and typology (Whitfield, 1979, p. 26; Kotler, 2000, p. 355; Rogers, 2003, p. 12; Freeman, 1982, p. 57; Drucker, 2004; Griffin, 1996; Porter, 2008). The variety of ways of describing innovation caused the need to introduce a clear definition of this phenomenon. Therefore, the Organization for Economic Co-operation and Development (OECD) proposed guidelines published in *Oslo Manual* that built a common understanding of innovation, its measuring and diffusion. According to the *Manual*, an innovation refers to the implementation of new or notably upgraded products, processes, goods, services, marketing methods or external relations. In order to help classifying novelty, four main types of innovations have been listed: product innovations, process innovations, marketing innovations, organizational innovations (OECD, 2005).

The topic of eco-innovation is not yet well-established in within the framework of economics and management. Although there are studies describing this issue, the research of this subject is still in early phase and there are not many researchers working on environmental innovations (Andersen, 2008, p. 2). The phenomenon of eco-innovation is situated at the interface of two different sub-disciplines, environmental economics and innovation management (Rennings, 2000, p. 324). In order to fully analyze it, multidisciplinary research would be very helpful.

Eco-innovation is a relatively new concept, therefore, before examining this phenomenon in Poland, it is necessary to define it. One of the first definitions of this issue has been proposed by Claude Fussler and Peter James in 1996. According to them it is an outstanding implementation of radical ideas, which will meet future needs (Fussler, James, 1996, p. 303). This concept has been later developed and clarified by one of its authors, Peter James, who describes it as new product and process that significantly decrease environmental impact and at the same time provide value for business and customers. (James, 1997, p. 53). In its broadest form, ecological innovation is any novelty that reduces environmental harm (Kanerva, Arundel, Kemp, 2009, p. 7). The most widely know and cited definition of eco-innovation is the one developed within the project Measuring Eco-Innovation on the basis of the definition of innovation proposed by OECD in Oslo Manual. It is the "production,

assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp, Pearson, 2007, p. 7). The authors' aim was to move away from the assumption that eco-innovation must be fundamentally aimed at reducing damage of the environment. Rene Kemp and Peter Pearson believe that a sufficient criterion for distinguishing eco-innovation from other types of innovation is, that as a result of an implementation of such solution, the harm of natural environment is smaller than in the case of the use of alternative technologies. Authors also developed the typology of eco-innovations, which distinguished four categories of novelties: environmental technologies, organizational innovation, product and service innovation, and green system innovations (Kemp, Pearson, 2007, pp. 10-11).

There are many factors that influence companies' eco-innovative activity. They are not only environmental motivations, but also characteristics of the sector that company operates in, or its technological and development opportunities (Carrillo-Hermosilla, Del Río, Könnölä, 2009, p. 9). Changes introduced within the company can result in the creation of eco-innovative solutions, especially when they are focused on product development, business strategy and marketing (Aragon-Correa, Sharma, 2003; Pujari, Wright, Peattie, 2003; Sharma, 2000). According to J. Elkington (1998), the company needs to make rational decisions in terms of balancing its financial, social and ecological performance, in order to introduce and operate in line with sustainable development philosophy.

The driving force behind the business willingness to invest in innovative activity facing the environment is, among others, the trend that promotes sustainable development (Cuerva, Triguero-Cano, Córcoles, 2013, p. 1). It has become clear that sustainability means environmental-friendly business, as well as long-lasting and significant changes in technology, infrastructure, lifestyles and existing institutions (Rennings, 2000, pp. 319-320). Until now it has been believed that technological innovation, together with the policy of sustainable development are key elements that are necessary to solve global environmental problems. Nowadays, however, the attention is drawn to the important role of customers, who through the implementation and widespread use of eco-innovative technological solutions, can contribute to a significant reduction of global pollution and the rational management and consumption of natural resources (Vergragt, Akenji, Dewick, 2013, pp. 3-5).

The research of eco-innovation concerns, above all, its definition (Rennings, 2000), drivers and determinants (Demirel, Kesidou, 2012), variety (Carrillo-Hermosilla, Del Río, Könnölä, 2010), characteristics (Horbach, 2013), classification according to its impact on the environment (Horbach, Rammer, Rennings, 2012), and their link with business performance (Cheng, Yang, Sheu, 2014). Some have described the development of eco-innovative products (Pujari, Wright, Peattie, 2003; Prothero, McDonagh, 1992). In this context, this topic, described from the perspective of the determinants of eco-innovations and companies' motivation for their creation seems to be an interesting research problem.

Summing up, eco-innovations are seen as one of the types of innovations. Because of this reason, their sources and determinants can be traced on the basis of the models of innovations, which have evolved over the past years, starting from the linear model introduced by Schumpeter (1939), through demand-push model (Schmookler, 1966; Rothwell, Gardiner, 1983), chain-linked model (Kline, Rosenberg, 1986), coupling model (Rothwell, Zegveld, 1985), network model, to the systemic perspective on innovations (Freeman, 1982). The analysis of these models lead to the conclusion that there are two crucial groups of innovation sources: 1) internal, i.e. determinants that are located inside the company, and 2) external, i.e. factors that come from its organizational environment (Janasz, Kozioł, 2007, p. 20). R&D companies' activities and knowledge resources accumulated in the enterprise are the most important amongst internal sources of innovation (Janasz, Leśkiewicz, 1995; Białoń, 2010). In the midst of external sources, the role of competitors and customers can be distinguished (Sosnowska, 2000) and also research carried out by universities, research and development centers and other research institutions (Penc, 1999, pp. 160-163). The approach of dividing the sources of innovations into two sets has been also applied by Peter Drucker (1992). As internal ones he lists: the unexpected, incongruities and process need. The next three sources are associated with changes in the business environment: changes in industry and market structure, demographics, changes in perception, and new knowledge (Drucker, 1992, p. 44) (see: Table 1).

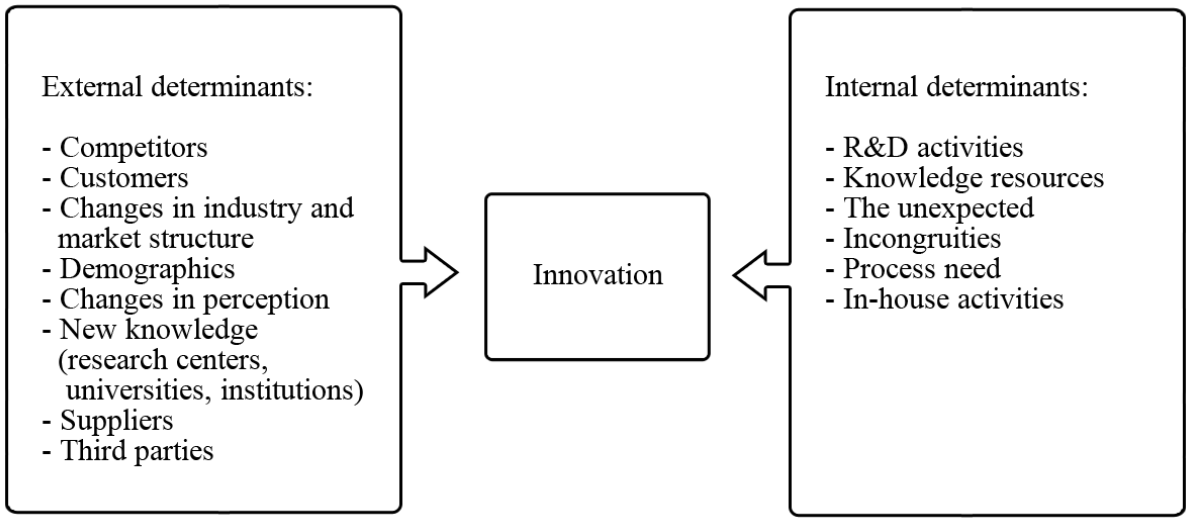
Table 1. The sources of innovations. Peter Ducker's approach

Source	**Description**
The unexpected	An unexpected success, failure or event, which can be a symptom of a unique opportunity.
Incongruities	A discrepancy between reality and perception, or between what is and what should be, can create an opportunity to innovate.
Process need	Existence of a weak link in a particular process, can be the source of innovation for the company that will supply the "missing link".
Changes in industry and market structure	Lack of stability on the market or in the industry can be seen as the opportunity to develop novelties.
Demographics	Changes in the population's size, structure or characteristics can be a symptom of a new opportunities.
Changes in perception	Changes in society's beliefs and attitudes can create innovative opportunities.
New knowledge	New discoveries, knowledge, both scientific and nonscientific knowledge can create new opportunities to develop products and new markets.

Source: Own elaboration based on Drucker, 1992, p. 44.

Amongst other classifications of determinants of innovations, there is a concept introduced by Von Hippel (Von Hippel, 1988), according to which the three main sources of innovations are: the customers, suppliers and third parties, such as research centers, universities. The similar approach has been proposed by Tidd, Bessant and Pavitt. These researchers listed suppliers, customers, in-house activities and basic research as the sources of developing the novelties (Tidd, Bessant, Pavitt, 2005, p. 171).

Figure 1. Determinants of innovations



Source: Own elaboration based on Tidd, Bessant, Pavitt, 2005; Drucker 1992; Von Hippel 1988; Janasz, Leśkiewicz, 1995; Białoń, 2010; Penc, 1999.

The researchers, who focus on environmental innovativeness, have developed industry specific classifications of determinants of innovations (Horbach, 2008; Belin, Horbach, Oltra, 2009; Cuerva, Triguero-Cano, Córcoles, 2013; Oltra, 2008; Cleff, Rennings, 1999; Del Val Segarra-Oña, Peiró-Signes, 2013). Although, the overview of the literature shows that similar set of drivers applies to general innovations and eco-innovations, but in the case of environmental innovations the precise influence of each driver on the emergence of environmental friendly solutions is difficult to evaluate. Therefore some researchers argue that the analysis of environmental innovations should concentrate on the interactions between different drivers of innovativeness and at the same time on the relationships between competitiveness, companies' characteristics and environmental performances of firms (Oltra, 2008 p. 7).

In the study conducted by Klaus Rennings (2000, p. 326), the sources of eco-innovations are divided into three categories: technology push, regulatory pull and market pull. The first source consists of such factors as product quality, energy efficiency, product palette and material efficiency. The later one, should be associated with existing environmental law, expected regulations and Occupational Safety and Health standards. The market pull determinants listed by Rennings are, among others, competition, labor costs, customer demand, image, market share and new markets.

Jens Horbach distinguished and described three categories of sources of eco-innovation, on the basis of their origin. There are eco-innovations stimulated by demand, supply, and policy and institutional factors. Detailed classification of these categories is described in table 2.

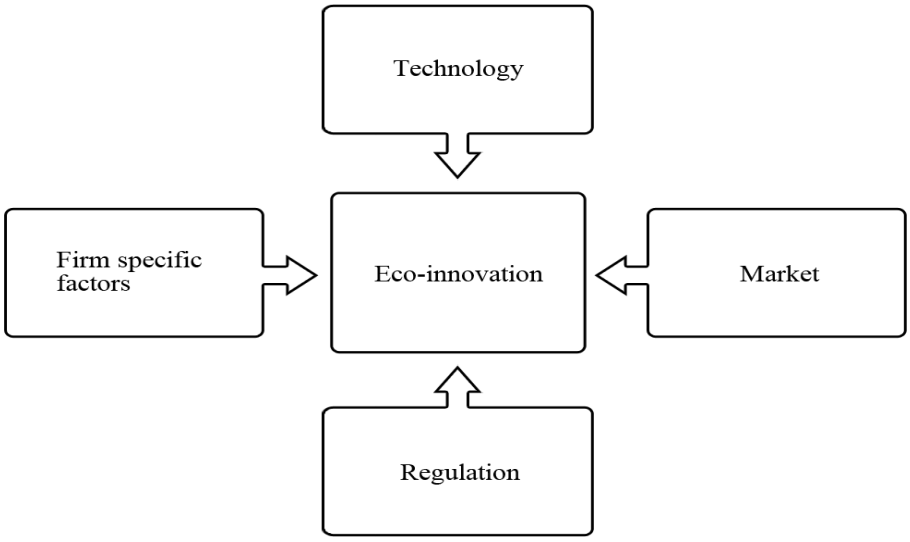
Table 2. Determinants of eco-innovation divided into categories

Category of determinants	**Determinant of eco-innovations**
Supply side	Technological capabilities
	Appropriation problem and market characteristics
Demand side	(Expected) market demand (demand-pull hypothesis)
	Social awareness of the need for clean production; environmental consciousness and preference for environmentally friendly products
Institutional and political influenced	Environmental policy (incentive based instruments and regulatory approaches)
	Institutional structure: e.g. political opportunities of environmentally oriented groups, organization of information flow, existence of innovation networks

Source: Horbach, 2008, p. 164.

In many recent studies the key concept of the determinants of environmental innovations consists of four main driving forces: technology, market, regulation and firm specific factors (Horbach, Rammer, Rennings, 2012).

Figure 2. Determinants of eco-innovations



Source: Horbach, Rammer, Rennings, 2012, p. 113.

As it has been already mentioned, it is difficult to assess, which of these factors are the most important in the development of eco-innovations. Empirical research provides various points of view on this topic.

Technology push factors are essential drivers of eco-innovations. The evidence of this is presented in the research based on German panel data that revels that R&D activities that result in the improvement of firms' technological performance influence eco-innovativeness (Horbach, 2008).

Companies access to significant, preferably limited resources can help to develop environmentally friendly solutions (Hart, 1995, pp. 994-995). The study of Demirel and Kesidou (2012), in line with the previous empirical findings, reveals that firm specific factors, such as organizational capabilities related to environmental management systems are important in eco-innovations creation. What is more, these determinants affect environmental solutions development decisions and the level of firms' resources allocated to eco-innovation activities.

This study provides also evidence, that market demand factors, amongst which corporate social responsibility (CSR) and consumer needs and requirements, do not influence the level of investments in environmentally friendly products to large extent. These factors are seen as important and companies are willing to respond to social needs with some minimum investment. However, these factors do not commit the companies to undertake outstanding actions in order to develop new solutions (Demirel, Kesidou, 2012). Such approach of companies is, in general, confirmed by some studies (Rehfeld, Rennings, Ziegler, 2007), but it is possible to find the evidence that customers can be very important in the process of developing eco-innovations. Such situation can take place only if the solution is perceived as adding value by customers (Kammerer, 2009).

The determinant of eco-innovations, that is the most difficult to assess, is the regulatory aspect. Some studies reveal that regulatory framework has a strong impact on firms' eco-innovative activity (Brunnermeier, Cohen, 2003; Rennings 2000) and is necessary in order to support market pull and technology push factors since these two do not seem to be strong enough to drive eco-innovativeness (Cleff, Rennings, 1999, p. 192). However, some researches claim that it should not be treated as a the only factor that directly influences the development of eco-innovations (Oltra, 2008). It has been also found that existing regulations, in contrary to expected ones, shape to some extent product and organizational eco-innovations. Future regulations have no significant impact on European companies' decisions to develop environmentally friendly solutions (Triguero, Moreno-Mondéjar, Davia, 2013).

To conclude the literature review, it should be pointed out that depending on geographical region and the type of environmental innovation, its origin can be assessed analyzing the technological compromises between various drivers and objectives of innovativeness (Oltra, 2008, p. 7). Such approach is used here in the research on eco-innovations in Poland.

Research methods

The empirical part of this research is based on in-depth, semi-structured interviews[1] conducted with the representatives of selected 40 Polish companies operating in the field of environmentally sound technologies, within six areas: renewable energy sources (10 firms), waste management (9 firms), water and wastewater management (7 firms), air protection (2 firms), energy efficiency (9 firms) and biodiversity protection (3 firms). The companies distinguish themselves from other environmentally sound technologies industry market players in Poland, as suppliers of own, eco-innovative products and their interest in international markets. The companies from the sample were examined by independent experts in terms of the originality and ecological significance of their innovative products introduced to the market. Each interview was based on the same script, which contained a list of more than a hundred detailed, open questions. The interviewers were allowed to interact freely with the interviewees in order to gather information on both, facts and their interpretation, along with personal opinions of respondents. That is why, during the interviews it was possible to discuss additional, relevant topics. The respondents were guaranteed anonymity. The interviews were recorded, transcribed, divided into topic-based text segments and coded into 77 detailed codes collected in the codebook. The codebook was the basis for analysis and interpretation of the qualitative data which was made in accordance with the grounded theory approach (Corbin, Strauss, 1990; Glaser, Strauss, 2006).

Results

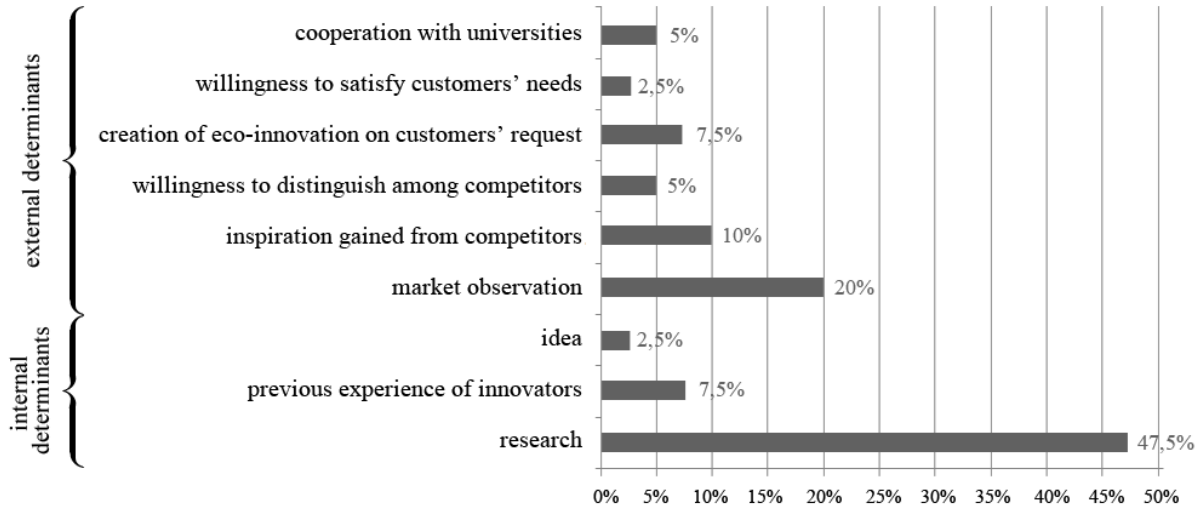
The interview confirmed that the process of developing eco-innovative solutions is often long and complex. New technologies are usually the result of long-term work of many experts from different fields. Each innovative idea is established in different circumstances, that is why, it is difficult to describe one, precise approach to this issue. For this reason, the respondents were not able to clearly indicate one factor that influenced the development of their technology. In their statements there were often pointed out several components. Moreover, the empirical research provides the evidence of motivations that led to the creation of eco-innovations. It is important to take into account, that determinants and motivations are not the same. Motivations are the inspirations to take the effort and develop environmental solution, while determinants specify the factors that directly influenced this development.

The determinants of eco-innovations distinguished by the interviewees can be divided into two groups, internal ones, related to the company and its potential, and external, such as its organizational environment, customers and competitors related. The former were considered more important, as 57,5% of respondents indicated that the development of eco-innovations depended on the knowledge and skills gathered within the company. However, external factors, such as inspiration from other market players, influence of the demand or cooperation with research centers, were indicated by 50% of respondents as the sources of eco-innovations. Since the research had been based on the semi-structured interviews with open-ended questions, the respondents were not provided sample answers that could affect their statements. For this reason, the drivers of eco-innovations recalled by interviewees were

[1] The interviews were conducted in person, in the period of October, November 2012.

not limited to any theoretical framework and closely describe the moment of their eco-innovative products creation. All the answers provided by the respondents are shown in figure 3.

Figure 3. What are the determinants of companies' eco-innovation development?



Source: Own elaboration based on the interviews.

Internal determinants of eco-innovations

The main stimulus that falls to this category is the research activity, based on the work and skills of companies' employees and conducted within it. Although 67,5% of all respondents declared that the companies performed in-house research, 47,5% of them admitted that such activity was the determinant of their technology creation and development. At the moment of working on the eco-innovation, companies have been conducting research of various types. Most of them focused on the product testing and technology development in the laboratories and within the research teams inside the company and on previously gathered knowledge and experience of employees. Some of the companies received assistance from external entities, collaborated with them co-operating or subcontracting research tasks. Such cases were relatively few, only 5% of the interviewees followed this path of new solutions' development.

The biggest group amongst the companies engaged in R&D, was represented by both, former or present academics and members of university project teams. In a few cases, the technology is the result of research initiated during the higher education of its inventor.

According to the interviews, 30% of companies have developed eco-innovative technology without being influenced by, or engaged in any research. Most of them developed a new solution on the basis of observing the performance of the previously existing solutions, after its adoption by the client, confronting this performance with the original objectives and introducing continuous modifications and improvements.

Another important determinant, recalled by 7,5% of respondents, that influenced the development of eco-innovations by the Polish companies-suppliers of environmentally sound

technologies, was the result of past experiences of employees and firms' owners. Almost 50% of eco-innovation inventors previously worked in the environmental industry and advanced technology. More than one-third of them were employed in business and at the university at the same time. In addition, many employees have gained experience in multinational companies. For people employed in the research units of higher education, scientific research at companies' level was a logical complement to its academic activities and a basis for the creation of eco-innovative technologies.

The last internal driver of eco-innovation mentioned by 2,5% of interviewees was a completely new idea that appeared in their minds. These respondents also declare that the process of its creation was long and had been influenced by so many factors, and it is difficult to list all of them. The causes of such inspiration in these cases had not been revealed by the respondents.

In the opinion of respondents various types of their personal experience, not only related to education and business, contributed to the technology. However, 95% of interviewees confirmed that cooperation with universities or work in other companies had a positive impact on the performance and the speed of technology development, especially in terms of motivation.

External determinants of eco-innovations

Among the external determinants of eco-innovations, the most important, indicated by 20% of respondents, was the identification of market needs. On the basis of well-prepared market analysis, it was possible to identify easily, not only potential customers, but also competitors. The awareness of the market circumstances allowed to create and develop innovative technology, and new ideas were adapted to the companies' organizational conditions. Respondents admitted that both, domestic and international markets were a stimulus for the development of new technological solutions.

Interviewed firms admitted that there were also three main motivations for their eco-innovation activity: competitors, customers and the business environment in a broad sense.

60% of respondents declared that creation of new technologies was inspired by similar solutions developed by other companies. Such inspiration was usually drawn by examining existing technologies available on the market in order to identify their functional and technical deficiencies imperfections. According to some interviewees it is important to perform market observation to find imperfections and flaws in available technologies. They believe that the weakness of other market players are the best inspiration to create own eco-innovative solution.

Among companies that inspired interviews' respondents to their innovation activity, competitors are the most important external determinants of eco-innovations. 10% of Polish companies declare that they drew inspiration from competitors and this was the crucial factor in their technology development. Moreover, 5% of interviewees indicate that their firms developed innovative environmentally friendly solutions in order to distinguish themselves

from the competitors.

The creation of innovations can be motivated by customers, who, on the one hand, buy and use a product, and on the other, often share with suppliers their comments and valuable knowledge about its functionality and performance.

65% of respondents admitted that clients often prompt them an idea for a product, service, or technical improvement, and with such behavior motivate them to seek for potential eco-innovative development opportunities. Information from customers has been done in many different ways. It is usually gathered during conversations with clients concerning their needs and expectations, as well as possibilities to satisfy such needs by the new, potential features of eco-innovations. Some respondents declared that their contact with customers was regulated in special agreements' clauses, which obliged users to provide information about technology performance.

7,5% of respondents reported that customers' behavior had a direct influence on the development of their technology and can be seen as the determinant of companies' eco-innovative activity. This influence occurred, when potential users asked the companies to develop a technology with special features that would better satisfy their needs. Enterprises were willing to work on such solution, and customers were happy to help in developing its functionality and features. The cases of such companies justify their fruitful and successful cooperation with the users. Within the researched companies, the information from clients usually contributed to the modernization and faster development of previously existing technologies. In some cases, customers were the direct inspiration for the development of new solutions, which were developed to better satisfy their needs. Such situation took place in 2,5% of analyzed enterprises.

A number of innovations appeared as a result of effective collaboration between external research institutions and businesses. However, such cooperation had not been not frequently established. Only 5% of companies declared that the universities can be classified as a source of their new environmentally friendly technologies. Nevertheless, if such cooperation took place, it was positively evaluated by entrepreneurs.

75% of respondents believe that the motivation for the creation of technologies can be drawn not only from the industry but also from the wider business environment, including media, trade shows and textbooks. They find mass media and socially available resources very inspiring. The information from the Internet, television and newspapers can guarantee companies' knowledge of technology available among different industries and global technological innovations. It often happens that these information influence functionality and improvements of eco-innovation among companies-suppliers of environmentally sound technologies in Poland.

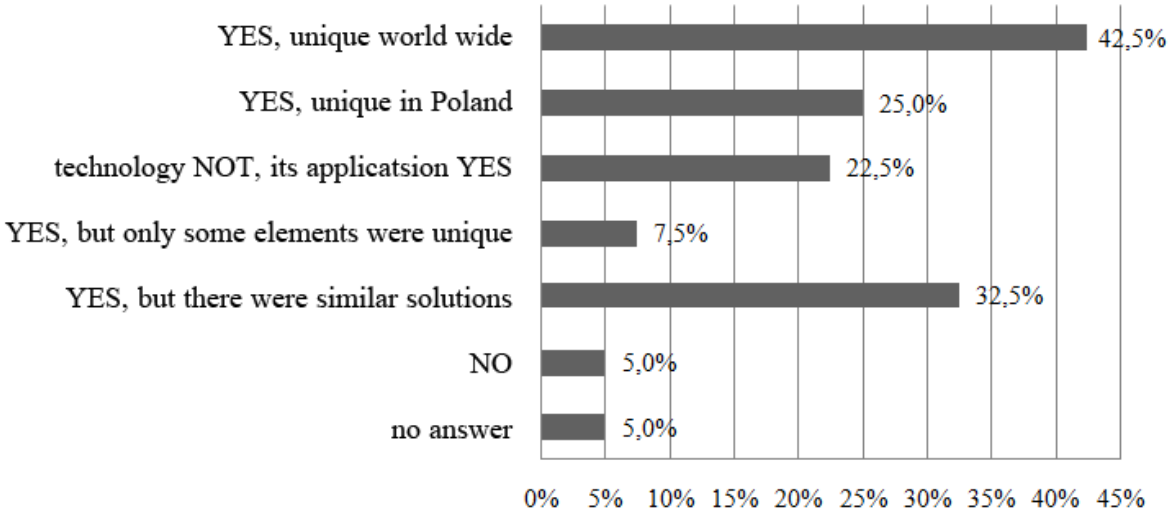
Eco-innovations characteristics

Determinants of eco-innovations and different sources of inspiration resulted in the development of various types of eco-innovative solutions. The interviews show that 90% of

the created products have the characteristics typical for novelties. 42,5% of the interviewed companies' claimed that their eco-innovation, at the moment of the creation, was undoubtedly an innovation on a global scale (see: Figure 4). 25% of respondents described the technology as new on the Polish market. Among the technologies that have been described as unique in the Polish market, there are also those, which were developed parallel to the global solutions. In rare cases, it happened that the engineers have been working on a solution with no awareness that another group of researchers in other countries came up earlier with the similar idea.

Among eco-innovations that have been created by the companies-suppliers of environmentally sound technologies in Poland, 5% are the ones that were not unique, at the world or the country level. The reason why such situation occurred, according to interviewees, is that there are some technological areas and industries in which, based on the present state of knowledge, there is no more space and possibility for creating innovation.

Figure 4. Was the technology eco-innovation unique at the moment of its development?



Source: Own elaboration based on the interviews.

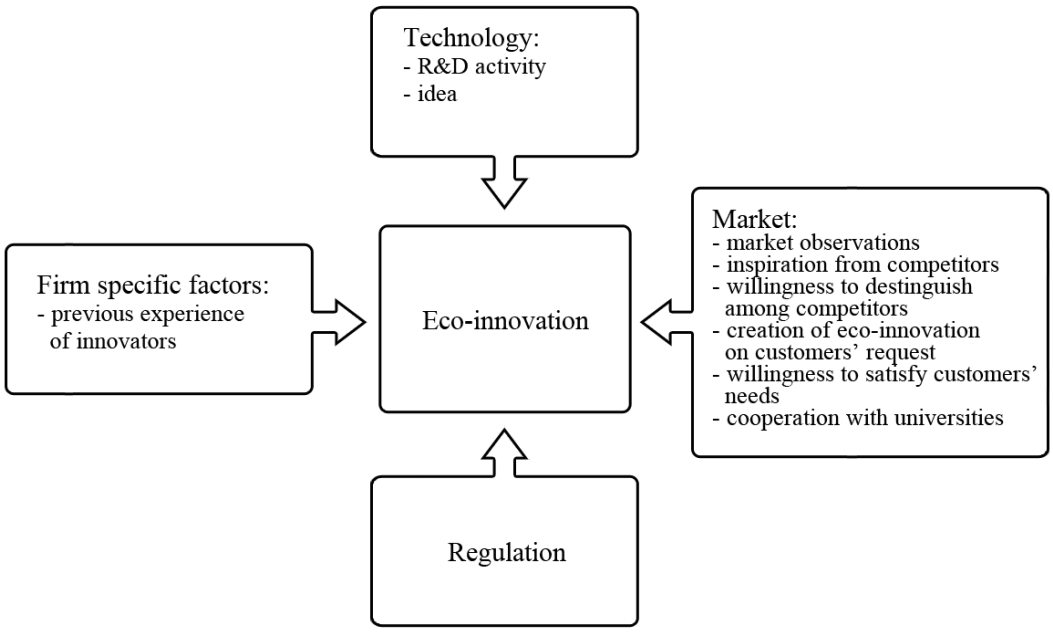
Discussion

The empirical research conducted among selected the selected Polish enterprises provides the evidence that there are many determinants of eco-innovations in the environmentally sound technologies industry in Poland. These factors can be classified on the basis of both, the concept of innovation sources applied in theory to general innovations and the specific classification of the determinants of eco-innovations provided by the researchers, who study the topic of environmental novelties (Horbach, Rammer, Rennings, 2012). The research findings are generally in line with both theoretical frameworks (see: figure 5).

The interviewed companies can be a good example of the technological approach to the determinants of eco-innovation, according to which research and development activities carried out within the firms result in the improvement of their technological performance and influence their eco-innovativeness (Horbach, 2008).

The second most important group of determinants of eco-innovation among the companies from the sample was related to the market factors, mainly the customers and competitors. Opposite to other empirical studies (Demirel, Kesidou, 2012; Rehfeld, Rennings, Ziegler, 2007) customers in Poland commit the companies to undertake actions in order to develop new solutions. Enterprises declared that such approach has been fruitful for both, the companies, which developed their solution and the users, who were able to get the product that fully served their needs. However, customers were rarely involved in the process of eco-innovation' development. This phenomenon of customers playing the key role in motivating firms for the eco-innovations creation in Poland, but rarely taking part in the process of elaborating these new solutions can be caused by the fact that environmentally sound technologies awareness and market in Poland are still pre-mature and relatively new. As companies develop mainly in-house solutions and do not seek for international cooperation in the phase of product development, customers are strongly motivated to look for the products that may serve their needs on the domestic market. It also should be taken into account that the process of creation of many of the products offered by the interviewed companies started at the time of economic transformation of Polish market, when the ability to seek for products abroad had been to some extent limited. This is a second reason, there were some determined customers, who were more willing to work together with the innovators on their products. Supply side of the market also seems to be an important source of inspiration, which directly led to the development of novelties. In general, market research is seen as highly important in the development of eco-innovative products.

Figure 5. The determinants of eco-innovations: theoretical framework confronted with empirical results from Poland



Source: Own elaboration based on Horbach, Rammer, Rennings, 2012, p. 113 and interviews.

Another determinant that was found to be important for the creation of eco-innovations in Poland lays inside the company. Firm specific factors including the resources gathered in the company, played a significant role in Polish enterprises. The respondents have

noted that the most important of these factors is the knowledge and experience of employees and inventors of an eco-innovation. In many cases people that contributed to the development of environmentally friendly technologies were the former or current academics and also had an experience in multinational and domestic environmental industry or advanced technology firms. At this point, in case of Polish companies, two groups of the determinants of eco-innovative activity, technology and firm specific factors, coincide with each other as in many cases the previous experience of inventors highly influenced the research carried out in the company.

Surprisingly, the regulatory aspect has not been listed as a determinant of eco-innovations by any of the 40 Polish companies-suppliers of environmentally sound technologies. The evidence provided by the research is according to this aspect in opposition to the findings of Brunnermeier and Cohen (2003), Rennings (2000), Triguero, Moreno-Mondéjar and Davia (2013) and Horbach, Rammer and Rennings (2012). However, this finding of the empirical research could be justified with the approach proposed by Oltra (2008) and Cleff and Rennings (1999), who claim that regulatory aspect should be treated as the supportive one, to market pull and technology push factors. In the case of Polish companies, market and technological determinants are the core ones, so the lack of regulatory aspect in the respondents' interviews might be caused by the fact that it does not directly influence the creation of eco-innovations, but it is only the support for other determinants, as stated in the literature.

Conclusions and future research directions

Based on the interviews conducted with the selected 40 companies, it is possible to specify the determinants and sources of eco-innovative activity and the motivation for creating eco-innovations in Poland. They are mainly market- and technology-related factors. This conclusion is in line with the studies emphasizing the role of market, technology and firm specific factors as the determinants of eco-innovations, but in opposition to the results supporting the thesis that regulatory aspect is highly important for the companies that create and develop environmentally friendly novelties.

The paper also shows that the main motivation and inspiration of eco-innovative activity in Poland is the market behavior of competitors. 60% of the companies from the sample state that they drew inspiration from the similar solutions developed by other companies. However, in most cases the inspiration was not aimed at coping existing successful ideas, but gaining knowledge about their features and weaknesses. It happens that Polish firms imitate and adapt to their needs the some solutions introduced by their competitors. That is why, many developed eco-innovations can be seen as incremental, new to the company, but not new to the market. At the same time, 67,5% of interviewed enterprises in their eco-innovation activity relay mainly on their own internal R&D activity. Just a few enterprises declare that there is some cooperation with universities and research organizations. The new ideas developed by research institutions are rarely used by the companies.

Furthermore, there is a high pressure coming from policy makers on implementing by enterprises ecological solutions, partly induced by the European Union policy. There is also a

growing flow of public funds supporting eco-innovativeness. However, awareness about the need to be eco-efficient is still relatively low among Polish enterprises.

Since the evidence of this research cannot be applied to the whole population of companies, because within the interviewed population were the suppliers of own, advanced environmentally sound technologies in Poland, while amongst other enterprises from the sector, there are also distributors of technologies or manufacturers of less advanced solutions, there is a need for further research of this complex phenomenon. The next step of such study could be a multiple case study research on the basis of which, it will be possible to discover and analyze in depth the reasons, why some determinants are more important than others, and explain the lack of regulatory aspect amongst these factors.

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