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External Conditions Influencing the Implementation of Eco-innovations in European Enterprises

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1. Introduction

Problems concerning the processes of generation and absorption of innovations favoring the environment (eco-innovations) are a subject of interest to scientific communities, economic entities and public authorities. The key role of eco-innovations in today's economy, i.e. a knowledge-based economy, results from the fact that environmentally-friendly innovations are a factor in the sustainable development of enterprises and economies which allows substitution of tangible inputs by knowledge capital, without the need for natural capital depletion [3, 5]. In the European economy, environmentally friendly innovations pretend to the term of coupling agent within both a strategy of sustainable development, which was set up to integrate and balance all areas of human activity [4], and a strategy of intelligent development, i.e. those based on knowledge and innovations.

Enterprise inclination towards eco-innovations is conditioned on the one hand by the occurrence of factors (premises) of an external character, e.g. market pressure, environmental regulations; while on the other hand it is determined by tangible assets possessed by market agents and intangible assets providing services required in the process of the design and implementation of new solutions favoring the environment [8, 11]. The aim of this paper is both a theoretical analysis of the influence of exogenous conditions on the decisions of enterprises regarding the implementation of eco-innovations and an empirical verification of the discussed relationships.

2. The concept and types of eco-innovation

The eco-innovation concept appeared in the 1990s and was for the first time introduced to environmental economics nomenclature by C. Fussler and P. James in their book *Driving Eco-Innovation: A Breakthrough Discipline for Innovation and Sustainability* [6]. The authors defined eco-innovations using alternatively the terms sustainable innovations, as new products and processes creating value for enterprises and clients, and reducing (negative) environmental effects.

In turn, according to the position of the European Commission, eco-innovation is a new or substantially improved product (manufacture or service), process, organization or marketing method, which reduces negative influences on an environment and/or optimize the use of resources [3].

Given the presented approaches for the definition of innovations beneficial for an environment, three dimensions of the analysis of the eco-innovative activity of market agents may be distinguished, i.e.:

1 Target – selection of subject range of eco-innovations, i.e. product, process, marketing or organizational method, institution.
2 Mechanism – way the aims are realized, i.e. 1) modifications in the form of small adjustments in the product or process, 2) re-design involving considerable changes in existing products, processes, organizational methods, 3) introduction of substitutes for previously offered products or services, 4) design and implementation of entirely new products, processes or organizational and marketing methods.
3 Impact – effect of eco-innovation on an environment, where the range of influence spreads from incremental environmental improvement to total elimination of harmfulness for an environment [5].

According to the target dimension of the analysis of the eco-innovation activity, eco-innovations include new or modified products/services providing environmental benefits (e.g. phosphate-free detergents, solid waste management, etc.) and environmental technologies (process eco-innovations) which may be divided into integrated technologies (preventive) and additive technologies (end-of-pipe) [19]. Technologies preventing the formation of pollutants constitute either the entirety or a part of the production process and are designed to decrease both the amount and the quality of pollution created during the production process

(e.g. membrane technology in chlor-alkali production). In turn, end-of-pipe technologies reduce or eliminate pollution after its production (e.g. wastewater treatment plants). Illustrative examples for these types of eco-innovations can be found in papers by A. Kowalczyk et al. [12] and T. Piecuch et al. [17].

Except for solutions of a product and process character, eco-innovations also include new organizational and marketing methods (e.g. systems of environmental management and eco-labeling, respectively) directed towards the solution of environmental problems.

3. External conditions influencing the implementation of eco-innovations

Decisions taken by enterprises in the area of environmentally-friendly innovation implementation may be considered as an aspect of interaction between two groups of factors of external character, i.e. economic-market factors and administrative-warrant factors [14]. In the former, the motives of market agents towards eco-innovation implementation result from economic calculations and market pressure; in the latter instance, a factor prompting enterprises to initiate innovative activity are legal environmental regulations in the form of standards including recommendations and warrants.

According to the rule of economic calculations, enterprises tend towards the maximization of benefits (revenues) over costs. In such a situation the aim behind the implementation of environmentally-friendly innovations may be to increase revenues or/and decrease costs. Taking into account pro-ecological consumer attitudes observed especially in highly-developed countries, enterprises are willing to take the decision to introduce new environmentally-friendly products (so-called green products) which are characterized, inter alia, by lower energy consumption, lower emission of pollutants, as well as longer or repeated application. On the other hand, an increase in production factor prices (e.g. energy, materials), induced by resources scarcity, stimulates market agents in their search for new technological solutions and substitutes enabling unit cost decreases [16]. According to the theory of induced innovations formulated by J. Hicks, an increase in the price of production factor is an impulse for the design and implementation of inventions allowing the economization of an application of a relatively more expensive factor [7].

Market failure in the case of eco-innovations results first of all from the occurrence of externalities being a matter of issue for environment pollution [18, 19]. Problems with the internalization of environmental externalities, such that they were fully respected in economic calculations of manufacturers and consumers of goods, leads to suboptimal levels of innovations induced by the market. The lack or improper valuation of externalities may lead to limitation of work on innovations allowing environmental problems to be solved. It is worth noting that the results of estimating environmental and resource costs may differ when using different methods [15].

One possible solution revising the activity of market mechanisms is the application of economic instruments, inter alia, in the form of taxes/fees and tradable emission allowances. Theoretically, imposing a tax on an agent polluting an environment, known as Pigovian tax, may lead to an effective situation in the Pareto sense. In order to establish the level of this tax, it is necessary to ascertain the optimal pollution level [20]. An alternate solution involves the creation of a market for tradable emission allowances, where agents of lower emission costs may sell unused limits to other enterprises for which reduction of emission is more expensive. The exchange will be performed until the marginal costs of pollution reduction for particular agents are compensated, and are equal to the marker price of allowances for emissions.

Except for factors of a market and economic character, the basic premise for eco-innovation implementation by enterprises are legal regulations. The dominant opinion in the literature, i.e. that a stronger influence of environmental instruments of a economic character on eco-innovations [2], when compared to instruments of a "command and control" type, e.g. environmental performance and technology standards, is not unequivocally confirmed by the results of empirical studies [10]. Thus, the key issue for the enforcement or inducement of innovations is not the form of regulations, but their range and restrictiveness [13], and, as proved by R. Innes and J. Bial, technological leaders prefer stricter environmental regulations, since such requirements cause an increase in costs for technologically less advanced competitors [9].

4. Methodology and results of research

The aim of the study is an analysis of external conditions influencing eco-innovation implementation in European enterprises and

a determination of the influence of particular premises on the inclination of examined enterprises to adopt innovations. The analysis used the results of the investigation into the activity of European enterprises in the field of the implementation of eco-innovations conducted in 2011 by Gallup Hungary at the request of the European Commission. The survey was conducted on a randomly selected sample composed of 5222 managers of small and medium–sized enterprises from the 27 EU countries [1].

According to the results of the study, nearly 30% of the surveyed enterprises introduced new or significantly improved eco-innovative production processes or methods (Fig. 1). The most active market agents in this field of innovation activity appeared to be enterprises from Poland (42% of all enterprises), Malta (35%) and Luxembourg (35%). The lowest inclination towards process eco-innovations was demonstrated by Hungarian enterprises (15%). Organizations from Hungary were also characterized by low activity in terms of implementation of organizational eco-innovations (12%). A similar situation was identified in Finland (7%). The highest percentage of enterprises implementing organizational eco-innovations was noted in the group of agents from Poland (35%) and Luxembourg (35%). In the case of new or significantly improved eco-innovative products or services being brought to the market, the highest proportion of declarations of the introduction of this type of eco-innovation was noted among enterprises from Cyprus (40%), while the lowest was among market agents from Hungary (12%).

Analyzing the opinions of the surveyed enterprises concerning drivers that could accelerate eco-innovation uptake and development, it may be concluded that the highest number of agents suggested expected future increases in energy prices as a factor very strongly stimulating the implementation of eco-innovations, and the highest percentage of such responses was noted among enterprises from Cyprus, Greece and Spain. The next two factors assessed by the respondents as being very important in terms of their influence on eco-innovation implementation were the current high energy and material prices. In contrast, existing regulations appeared to be cited least often as being of high significance for the process of eco-innovation absorption (Fig. 2). It is noteworthy that companies from Bulgaria and Romania most frequently quoted obligatory standards as a factor very strongly supporting the introduction of environmentally-friendly innovations.

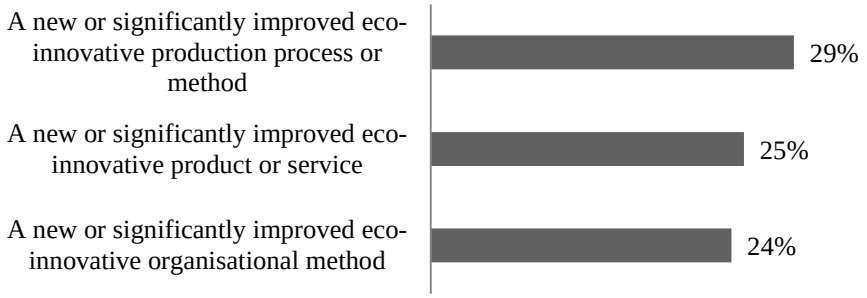

Fig. 1. Propensity of enterprises to eco-innovations
Rys. 1. Skłonność przedsiębiorstw do ekoinnowacji

In order to verify the influence of the above factors on whether or not organizations implemented eco-innovations, a logistic regression model was used, where analysis subjects were groups of enterprises from the 27 EU countries. In particular variants of the model, the inclination for eco-innovations measured as a proportion of enterprises which implemented particular kinds of environmentally-friendly innovations in 2009–2010 was chosen as a dependent variable. Independent variables used in models were factors influencing the decisions by companies as to whether they should implement eco-innovations. All independent variables were assessed by respondents on an ordinal scale from 1 – not at all important factor to 4 – a very important factor. For the given objects of our analysis, i.e. the 27 groups of enterprises from EU countries, the values of independent variables were calculated as weighted means, where the weights were fractions of inquired respondents assessing given factors as very important, somewhat important, not important or not at all important. The applied logistic regression model is presented by the equation:

$$Y = \ln\left(\frac{P}{1-P}\right) = \alpha_0 + \alpha_1 X_1 + \cdots + \alpha_k X_k + \varepsilon \qquad (1)$$

where:

P_1 – percentage of enterprises which introduced eco-innovative products in the years 2009–2010.

P_2 – percentage of enterprises which introduced eco-innovative processes in the years 2009–2010.

P_3 – percentage of enterprises which introduced eco-innovative organizational methods in the years 2009–2010.
X_1 – expected future increases in energy prices.
X_2 – current high energy prices.
X_3 – current high material prices.
X_4 – access to existing subsidies and fiscal incentives.
X_5 – increased market demand for green products.
X_6 – expected future material scarcity.
X_7 – limited access to materials.
X_8 – expected future regulations imposing new standards.
X_9 – existing regulations, including standards.

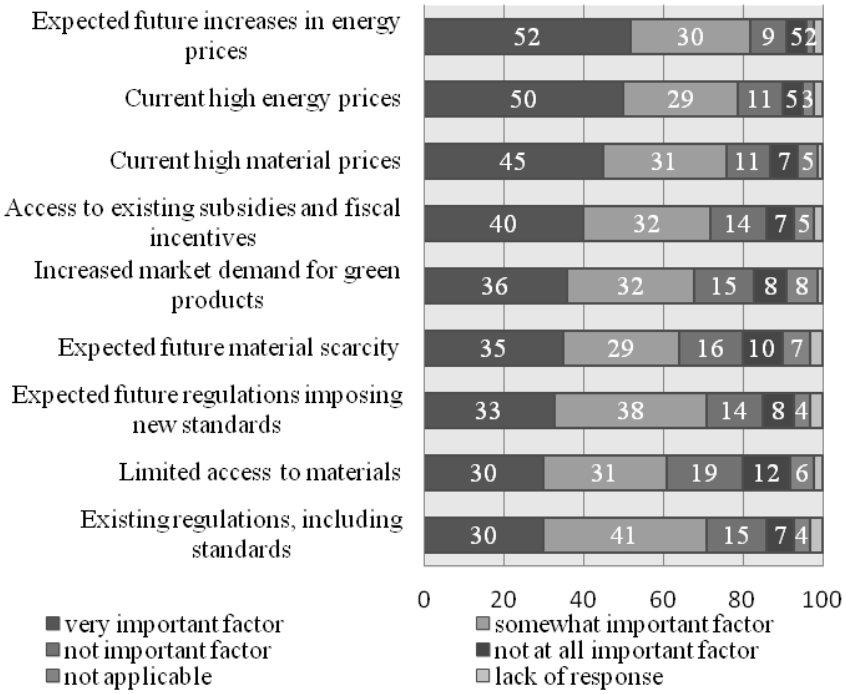

Fig. 2. Role of external factors in the implementation of environmental innovations (% of responses)
Rys. 2. Rola uwarunkowań zewnętrznych we wdrażaniu innowacji sprzyjających środowisku (%wskazań)

Table 1 contains the results of an estimation of the parameters of the logistic regression models and the results of their verification. In order to include only significant exogenous variables in the models of logistic regression function, the backward stepwise regression method was used.

Table 1. Parameters estimates and measures of models goodness-of-fit
Tabela 1. Estymatory parametrów oraz miary dopasowania modeli

Independent variables	Dependent variables		
	P_1	P_2	P_3
Constant	-2.796***	-1.788 ***	-2.750***
X_1	x	x	x
X_2	x	x	-1.355**
X_3	x	0.538***	1.469**
X_4	x	x	0.719*
X_5	0.578***	x	x
X_6	x	x	x
X_7	x	x	x
X_8	x	x	x
X_9	x	-0.277**	x
R^2	0.285	0.356	0.412
F (p value)	9.987 (0.004)	6.646 (0.005)	3.858 (0.015)

*x – eliminated variable, *Statistical significance at level 0.1, **Statistical significance at level 0.05, ***Statistical significance at level 0.01, F – test of model utility.*

According to the results of the calculations, the only factor which positively influenced product eco-innovation implementation appeared to be an increase in market demand for "green" products. With respect to process eco-innovations it may be concluded that the current high prices of materials used in production processes acted as a stimulant to the implementation of new or significantly improved eco-innovative production processes or methods new. Contrary to our theory-based expectations, existing environmental regulations negatively affected the inclination of the surveyed enterprises to adopt process eco-innovations. Current high prices of materials and access to subsidies and fiscal incentives had posi-

tive effects on dependent variables in the model describing the influence of the analyzed factors on enterprise inclination for organizational eco-innovations. The only factor negatively affecting the percentage of enterprises implementing organizational eco-innovations were the current high energy prices. This aberration may be explained by the fact that organizational eco-innovations are indirectly focused on using less energy in production as opposed to eco-innovations of a process type.

5. Conclusions

The above theoretical considerations and analysis of empirical studies allowed the formulation of the following conclusions:

1 External conditions stimulate market agents towards the implementation of environmentally-friendly innovations, and on the basis of recent studies, the strength of the impact of particular factors is equivocal.
2 Analysis of the results of the survey concerning the activity of European enterprises in the field of eco-innovation implementation conducted at the request of the European Commission in 2011 demonstrates that the most often cited type of implemented eco-innovation was a new or significantly improved eco-innovative production process or method. Next in terms of the frequency of responses were product/service eco-innovations and organizational eco-innovations. Among the factors very strongly stimulating eco-innovation implementation the respondents listed expected future increases in energy prices, current high energy prices and current high materials prices. In contrast, existing regulations appeared to be the premise most rarely given as being of high significance for the process of eco-innovation absorption.
3 An estimation of parameters of logistic regression models allows the conclusion that the factors significantly positively affecting eco-innovation implementation include: an increase in market demand for "green" products, current high prices of materials and access to subsidies and fiscal incentives.

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Zewnętrzne uwarunkowania wdrażania ekoinnowacji w przedsiębiorstwach europejskich

Streszczenie

Aktywność przedsiębiorstw w zakresie wdrażania innowacji sprzyjających środowisku można rozpatrywać w aspekcie oddziaływania dwóch grup czynników o charakterze zewnętrznym, tj. czynników ekonomiczno-rynkowych oraz czynników administracyjno-nakazowych. W pierwszym przypadku motywy podmiotów rynkowych do wprowadzania ekoinnowacji wynikają z rachunku ekonomicznego oraz presji rynkowej, przy czym działalność mechanizmu rynkowego może być korygowana przez państwo w oparciu o instrumenty ekonomiczne pozwalające na internalizację efektów zewnętrznych. Z kolei, w drugim przypadku czynnikiem stymulującym przedsiębiorstwa do aktywności innowacyjnej są prawne regulacje środowiskowe w postaci standardów obejmujących zalecenia i nakazy. Należy podkreślić, iż dominujący w literaturze przedmiotu pogląd o silniejszym wpływie na ekoinnowacje instrumentów środowiskowych o charakterze ekonomicznym, np. podatki lub prawa zbywalne, w porównaniu do instrumentów z obszaru polityki administracyjno-nakazowej typu „command and control", np. normy wyników i technologii, nie znajduje jednoznacznego potwierdzenia w wynikach badań empirycznych.

Analiza wyników badania dotyczącego aktywności przedsiębiorstw europejskich w zakresie wdrażania ekoinnowacji, przeprowadzonego na zlecenie Komisji Europejskiej na losowo dobranej próbie składającej się z 5222 przedstawicieli kadry zarządzającej małych i średnich przedsiębiorstw z 27 krajów

UE, wskazuje, że najczęściej deklarowanym rodzajem wdrożonych ekoinnowacji były nowe rozwiązania o charakterze procesowym. Wśród najbardziej aktywnych podmiotów rynkowych w tym obszarze działalności innowacyjnej znalazły się przedsiębiorstwa z Polski, Malty i Luksemburga. Z kolei najmniejszą skłonność do ekoinnowacji procesowych wykazywały przedsiębiorstwa węgierskie. Kolejne miejsca pod względem częstości wskazań zajmowały ekoinnowacje produktowe/usługowe oraz ekoinnowacje organizacyjne. W przypadku ekoinnowacji produktowych/usługowych stanowiących nowość w skali rynku najwyższy udział deklaracji wprowadzenia tego typu ekoinnowacji odnotowano wśród przedsiębiorstw z Cypru, zaś najniższą wśród podmiotów z Węgier. Natomiast najwyższy odsetek firm wprowadzających ekoinnowacje organizacyjne wystąpił w grupie podmiotów z Polski i Luxemburga.

Wśród czynników bardzo silnie stymulujących do wdrożenia ekoinnowacji indagowani respondenci wskazywali najczęściej przewidywany wzrost cen energii, przy czym najwyższy odsetek takich odpowiedzi odnotowano wśród przedsiębiorstw z Cypru, Grecji i Hiszpanii. Kolejnymi dwoma czynnikami, których wpływ na wdrażanie ekoinnowacji respondenci ocenili jako bardzo ważny, okazały się wysokie bieżące ceny energii oraz wysokie bieżące ceny materiałów. Z kolei, istniejące regulacje okazały się przesłanką najrzadziej wskazywaną jako tą o dużym znaczeniu dla procesu absorpcji ekoinnowacji. Należy zauważyć, że wśród przedsiębiorstw najczęściej postrzegających obowiązujące standardy jako czynnik bardzo silnie stymulujący do wprowadzania innowacji sprzyjających środowisku były podmioty z Bułgarii oraz Rumunii.

Wyniki estymacji parametrów modeli regresji logistycznej przedstawiających zależności pomiędzy skłonnością do ekoinnowacji a siłą oddziaływaniem uwarunkowań zewnętrznych pozwalają na wyciągnięcie wniosku, że czynnikami mającymi istotny, pozytywny wpływ na wdrażanie ekoinnowacji są: wzrost popytu rynkowego na „zielone" produkty, wysokie ceny materiałów oraz dostęp do subsydiów i zachęt fiskalnych.