DRIVERS AND BARRIERS TO THE IMPLEMENTATION OF ECO-INNOVATION IN THE STEEL AND METAL INDUSTRY IN POLAND

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Abstract

Implementation of eco-innovations plays a crucial role in achieving sustainable development. This is particularly important in the industries characterized by the high level of energy and pollution intensity. Therefore, the studies of eco-innovation determinants are very important for the efficient stimulation of such activities. The main purpose of this article was to identify the drivers and barriers to eco-innovations on the basis of the empirical analysis of steel and metal enterprises in Poland. The study has shown that the most important motivations to introduce eco-innovations are: the opportunity of the cost savings, existing environmental regulations, improving of corporate image and securing or increasing existing market share. The main obstacles to the implementation of eco-innovations are: the lack of external financing, uncertain return on investment for eco-innovation, the lack of funds within enterprises and the lack or uncertain market demand for green products. The results of conducted research indicate differences between the drivers of product and process eco-innovations. The level of the product eco-innovation's implementation is mostly related to demand side factors. On the other hand, the level of process eco-innovation's adoption is related with regulatory, supply side as well as demand side factors. Due to diversity of identified drivers, the selected instruments to support eco-innovation activities in the Steel and Metal Industry were also presented.

Keywords: eco-innovation, eco-innovation determinants, steel and metal industry.

1. INTRODUCTION

One of the key challenges in achieving sustainable development is to reduce the environmental impact of business activity. This calls for a comprehensive approach encompassing systemic shifts in manufacturing processes and in products manufactured and offered on the market. Eco-innovations, the characterisation of which requires a broader view on the complexity of interactions between economy and environment, play a crucial role in this context. Still, eco-innovative activity is undertaken by enterprises relatively rarely. It is therefore vital that the motivations and obstacles for undertaking such activity are thoroughly investigated. A gap has existed in such analyses until now in respect of the steel and metal industry in Poland and the gap was to be bridged to a certain extent by the results of the study presented in this article.

The literature study and empirical analysis presented set a basis for considerations the purpose of which was, in particular:

- to identify motivations for undertaking eco-innovative activity by steel and metal enterprises in Poland,
- to determine barriers for undertaking eco-innovative activity by above mentioned enterprises,
- to investigate the relationships between the importance attached by steel and metal enterprises to specific eco-innovative activity motivations and the level of their eco-innovation,
- to present instruments supporting eco-innovative activity.

2. THE ESSENCE OF ECO-INNOVATION, ITS DETERMINANTS AND IMPORTANCE FOR THE STEEL AND METAL INDUSTRY

There is no commonly accepted definition of eco-innovation. In general, all definitions emphasize that eco-innovations reduce the environmental impact caused by production and consumption activities,

irrespective of the main motivation for their implementation [1]. Fussler and James, in one of the first appearance of this concept in the literature, define eco-innovation as a process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact [2]. According to more complex definition, eco-innovation is the production, assimilation or exploitation of a product, production process, service, management or business method that is novel to the organisation (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 [3].

There are different classifications of factors that influence the development and adoption of eco-innovation. Oltra distinguishes three categories of determinants of eco-innovations. These categories include regulation and policy determinants, supply side determinants and demand side determinants [4]. Horbach uses a framework of four groups of main determinants of eco-innovation: firm specific factors, technology push factors, market pull factors and environmental regulation [5]. According to del Río González, determinants influencing the engagement in environmental technological change include factors internal to the firm, factors external to the firm and characteristics of the environmental technologies [6]. All of these factors may change over time, changing the incentives for eco-innovation.

The steel and metal industry is among the most energy and pollution intensive branches. Regardless the fact that steel and metal industry has significantly limited its environmental impact in the recent years, eco-innovative solutions still need to be developed and implemented in numerous areas. Some examples of development directions in this field include, notably, blast furnace gas recycling, coke free steelmaking, direct reduction of iron-ore with natural gas, iron-ore electrolysis, hydrogen and biomass based steel production [7]. Moreover, the rational management of resources and utilities as well as environmental protection is one of the primary research fields of the Strategic Research Programme for the iron and steel industry in Poland established by the Polish Steel Technological Platform. Four priority directions of exploration, forming a basis for eco-innovative solutions, were selected in this research field: rational use and saving of charge materials, efficient use of energy and other utilities in metallurgical processes, recycling of iron-bearing materials and steel industry waste utilisation and reduction in environment pollution [8].

3. MATERIALS AND METHODS

The empirical study presented in this article is a part of the research conducted in November and December 2013 on a sample of 37 steel and metal enterprises (NACE code C24 - Manufacture of basic metals) operating in Poland. The surveyed group included 18 small, 12 medium and 7 large enterprises. The research method applied was an interview with a questionnaire conducted among representatives of the enterprises: owners, management board members or other decision-makers in a given organisation.

The thematic scope of the research concerned the selected aspects of eco-innovation. In relation to the aspects being the subject of this article, they were particularly concerned with motivations and barriers to the implementation of eco-innovation [9], as well as the level of eco-innovative activity.

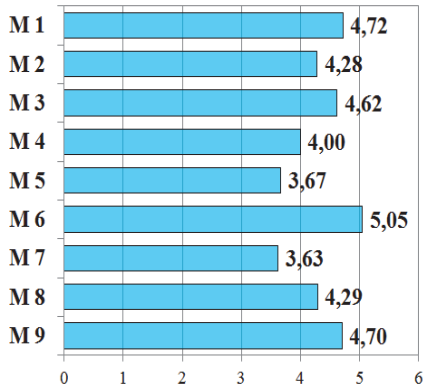
The studied enterprises assessed particular motivations and barriers to the implementation of eco-innovation using a 7 point Likert scale (1 - definitely does not contribute, 7 - strongly contributes). The assessed motivations included: existing environmental regulations (M1), expected environmental regulations (M2) (representing regulatory factors), securing or increasing existing market share (M3), new market entry (M4), increasing market demand for green products (M5) (representing demand side factors), opportunity of cost savings (M6), access to existing subsidies and fiscal incentives (M7), voluntary environmental agreement (M8), and improving of corporate image (M9) (representing supply side factors). The investigated barriers included: the lack of funds within enterprise (B1), uncertain return on investment or too long payback period (B2), the lack or uncertain demand from the market (B3), the lack of external financing (B4), insufficient access to existing

subsidies and fiscal incentives (B5), the lack of qualified personnel (B6), insufficient technological capabilities (B7), limited access to external information and knowledge (B8), the lack of suitable business partners (B9), and the lack of collaboration with research institutes and universities (B10).

The studied enterprises assessed the level of eco-innovation compared to key competitors according to a 7 point Likert scale (1 - strongly disagree, 7 - strongly agree), by presenting their opinion to the following statements: we were usually the first on the market to introduce new eco-innovative products (E1), we have introduced more products that are eco-innovative (E2), we have introduced products that are more eco-innovative (E3), we were the first to introduce new, environment friendly methods of manufacturing, maintenance and logistics (E4), we have introduced more new or significantly improved processes bringing environmental benefits (E5), we are improving environmental parameters of our processes more effectively (E6), and we have higher expenditures for environmental R&D activity (E7).

4. RESULTS AND DISCUSSION

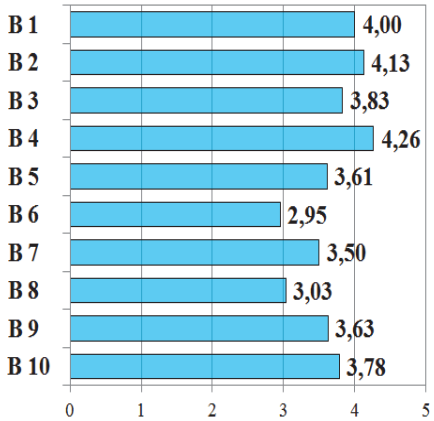
The study carried out reveals that opportunity of cost savings, existing environmental regulations, improving of corporate image and securing or increasing existing market share are the most important motivations for undertaking eco-innovative activity as indicated by the representatives of the surveyed enterprises (**Fig. 1**).



M 1 - Existing environmental regulations
M 2 - Expected environmental regulations
M 3 - Securing or increasing existing market share
M 4 - New market entry
M 5 - Increasing market demand for green products
M 6 - Opportunity of cost savings
M 7 - Access to existing subsidies and fiscal incentives
M 8 - Voluntary environmental agreements
M 9 - Improving of corporate image

Fig. 1 Motivations to the implementation of eco-innovation in the surveyed enterprises [own analysis]

As far as barriers to the implementation of eco-innovation are concerned, the greatest obstacles are: the lack of external financing, uncertain return on investment for eco-innovation, the lack of funds within enterprises and the lack or uncertain market demand for green products. It should be added that the lack of qualified personnel or limited access to external information and knowledge are not indicated as barriers (**Fig. 2**).



B 1 - Lack of funds within enterprise
B 2 - Uncertain return on investment or too long payback period
B 3 - Lack or uncertain demand from the market
B 4 - Lack of external financing
B 5 - Insufficient access to existing subsidies and fiscal incentives
B 6 - Lack of qualified personel
B 7 - Insufficient technological capabilities
B 8 - Limited access to external information and knowledge
B 9 - Lack of suitable business partners
B 10 - Lack of collaboration with research institutes and universities

Fig. 2 Barriers to the implementation of eco-innovation in the surveyed enterprises [own analysis]

The Spearman's rank correlation coefficients (Rs) were applied to analyse the relationships between importance attributed by the surveyed enterprises to specific motivations for undertaking eco-innovative activity and the level of their eco-innovation (**Table 1**).

Table 1 Relationships between motivations of surveyed enterprises to the implementation of eco-innovation and level of their eco-innovation - Spearman's rank correlation coefficients [own analysis]

	E 1	E 2	E 3	E 4	E 5	E 6	E 7
M 1	0,22	0,23	0,30	0,42*	0,51**	0,47**	0,39*
M 2	0,15	0,21	0,31	0,34*	0,46**	0,41*	0,43**
M 3	0,47**	0,34*	0,21	0,32	0,28	0,08	0,10
M 4	0,46**	0,31	0,35*	0,46**	0,51***	0,45**	0,37*
M 5	0,37*	0,48**	0,56***	0,27	0,36*	0,52**	0,43**
M 6	0,11	0,08	0,30	0,11	0,24	0,13	0,17
M 7	0,10	0,30	0,24	0,18	0,15	0,23	0,16
M 8	0,29	0,30	0,35*	0,38*	0,44**	0,60***	0,32
M 9	0,31	0,31	0,25	0,30	0,28	0,29	0,31

Notes: * $p < 0,05$, ** $p < 0,01$, *** $p < 0,001$

With reference to the variables describing the level of product eco-innovation (E1, E2 and E3 items), statistically important, relatively strong correlations occurred with variables concerning demand side factors (perceived opportunity of maintaining or increasing existing market share (M3), new market entry (M4) and increasing market demand for green products (M5)). On the other hand, the strongest, statistically important, correlations for variables describing the level of process eco-innovation (E4, E5, and E6 items) can be observed with one supply side factor (voluntary environmental agreements introduction - M8), 2 demand side factors (opportunity of the new market entry (M4) and increasing market demand for green products (M5)), as well as 2 regulatory factors (perceived importance of existing environmental regulations (M1) and expected environmental regulations (M2)). Interestingly, no major statistical correlations were observed for the level of eco-innovation with possible cost savings, which represented the main motivation for implementation of eco-innovations as indicated by the surveyed enterprises. This may stem from the fact that the similar importance of this motivation is assigned by the representatives of enterprises with both low and high eco-innovation performance. With reference to expenditures for environmental R&D activity (E7), the strongest, statistically important, correlations were observed with both assessed regulatory factors (M1 and M2) and 2 demand side factors (M4 and M5).

The outcomes of the presented study indicate that it is of vital importance to apply diverse instruments to stimulate up eco-innovation, understanding the interactions of regulatory, demand and supply incentives. By doing so, demand for eco-innovative solutions is stimulated on the one hand and, on the other hand, eco-innovations will be more and more commonly embodied in business models of enterprises [10] as a potential source of competitive advantage, thus generating the supply of such solutions.

Creating successful eco-innovation policy requires well-designed standards and regulations, including their appropriate stringency, flexibility and time frame. Supply measures should take into consideration equity support (in particular in SMEs), environmental research and development, pre-commercialisation (the post-R&D stages of eco-innovation), education and training for developing the human capital needed to deliver eco-innovative solutions, networking and partnerships target the development of eco-innovation and provision of essential infrastructure. Demand measures should include the shaping of environmental friendly attitudes and behaviours among customers, green public procurement, and technology transfer and know-how support [11, 12]. This requires effective measures and the use of proper instruments at the EU, national and regional levels.

Eco-innovative activity inscribes itself into the proposed development goals for the EU's new financial framework for 2014-2020. This is especially true for the planned thematic objective of research, technological development and innovation support, considering the relevance of specific research, development and innovation activities for SMEs. The Eco-innovation Action Plan (EcoAP), detailing a leading project of the "Europe 2020" strategy - Innovation Union in the area of eco-innovation - is of underlying importance for the EU's eco-innovation policy [13]. The key objective of the Programme for the Competitiveness of Enterprises and Small and Medium-Sized Enterprises (COSME) is innovation and improvement of the competitiveness of enterprises, including activities for eco-innovation [14].
The importance of eco-innovation in the "Horizon 2020" - a framework programme for research and development for 2014-2020, will be increased, hence ensuring funds for implementation of the EcoAP. For the steel and metal industry, this particularly applies to part II of Horizon 2020 - "Industrial Leadership" (e.g. Advanced Materials: cross-cutting and enabling materials technologies, materials development and transformation, management of materials components and optimisation of the use of materials; Advanced Manufacturing and Processing: technologies for factories of the future, sustainable, resource-efficient and low-carbon technologies in energy-intensive process industries and new sustainable business models) [15].

Support for eco-innovation in Poland, at the national level, is one of the measures envisaged by the draft of Enterprise Development Programme 2020, executive programme of the Strategy for Economy Innovation and Efficiency. Modern material technologies were ranked in the National Research Programme amongst 7 strategic directions of research and development works forming a basis for the development of strategic research programmes supported by the National Centre for Research and Development. In accordance with the European Commission's recommendations, eco-innovations will be given priority in the Operational Programme Intelligent Development (PO-IR) and undertakings concerning innovative technological solutions leading to the reduction of harmful effects on the environment will be supported. It should be added that more than 400 innovative projects were implemented under the Operational Programme Innovative Economy 2007-2013 in the steel and metal industry, including such dedicated predominantly to the reduction of environmental impacts.

Eco-innovation will be also supported on the regional level by following, notably, regional operational programmes and regional innovation strategies. For example, the main idea of the innovative development of the Silesian Province for 2014-2020 is innovation ecosystem of the Silesian Province based on dynamically changing innovative environments. Regional Innovation Strategy involves the development and transformation of the regional innovation system into the ecosystem of innovation. The development priorities of an innovation ecosystem and regional innovation strategy of Silesian Province create new conditions for development of innovation and ecoinnovation in the steel and metal enterprises [16].

CONCLUSIONS

The results of the presented research indicate differences between the drivers of product and process eco-innovations in the steel and metal enterprises in Poland. The level of the product eco-innovation's implementation is mostly related to demand side factors such as perceived opportunity of maintaining or increasing existing market share, new market entry and increasing market demand for green products. On the other hand, the level of the process eco-innovation's adoption is related to regulatory factors (i.e. perceived importance of existing environmental regulations and expected environmental regulations), voluntary environmental agreements introduction which represents supply side factor as well as demand side factors (i.e. opportunity of the new market entry and increasing market demand for green products). However, it should be noted that the number of surveyed steel and metal enterprises can be considered as limitation of this study thus further research is needed in this area.

The outcomes of the presented analyses emphasize that it is of vital importance to apply diverse instruments to stimulate up eco-innovation. The use of numerous, various supporting measures is required due to the

complexity of eco-innovative activity's determinants. The selected examples of such instruments, at the EU, national and regional levels, relating to the steel and metal industry, were pointed out in the article.

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