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Effects of Innovation Activity in Industrial Enterprises in Eastern Poland

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Keywords: *innovation; industry; region*

Abstract: *Implementation of innovation in the field of product, process, organization and/or marketing, as part of the competitive struggle, is therefore linked to the achievement of various objectives and effects. The main objective of the study was to describe the relationship between the different effects of innovation activity and the extent of innovative activity of industrial enterprises, such as investment in innovation and implementation of innovative solutions. The survey had been conducted in years 2010-12 in 1067 industrial companies, operating in Eastern Poland (Warmia-Mazury, Podlasie, Lublin, Świętokrzyskie and Podkarpackie voivodeships). The methodological part of the analyses is based on the probability calculus - probit regression. Industrial enterprises in Eastern Poland indicated on improved quality of products offered on the market and increased range of products as the main effects of innovation activity. Analysis of innovation activity phenomena characterized in the article may have an impact on the perception of regional innovation policy, in terms of its nature and direction, as well as the vital*

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question of the effectiveness of instruments of supporting innovativeness of industrial enterprises in Eastern Poland.

Introduction

Modern enterprises that care about their own development systematically engage in the innovation process. It is possible for them to implement knowledge and technology acquired from outside, for example through the acquisition of machinery and equipment or non-pecuniary technology, such as technical documentation and know-how. Implementation of innovation in the field of product, process, organization and/or marketing, as part of the competitive struggle, is therefore linked to the achievement of various objectives and results. The most important effects are to increase range or entry into new markets, improve quality or increase the flexibility of production and/or production capacity, also lower unit labor costs and/or reduce per unit material and/or energy intensity of production limit the harm to the environment or fulfill of regulations and standards. Analysing the foregoing begs the fundamental question of whether and how the results of innovation activity affect the implementation of innovation?

The main objective of the study was to describe the relationship between different effects of innovation activity and the extent of innovative activity of industrial enterprises, such as investment in innovation and implementation of innovative solutions.

The survey had been conducted in years 2010–12 in 1067 industrial companies, operating in Eastern Poland (Warmia-Mazury, Podlasie, Lublin, Świętokrzyskie and Podkarpackie voivodeships). The theoretical part of the article concerns review of the goals and effects of undertaking innovation activity in enterprises.

This article is a part of a series of articles on the determinants of innovation in industrial enterprises operating in Eastern Poland.

Objectives and effects of innovation

Nowadays, especially in highly developed and catching-up countries, the issue of innovation activity plays a much greater role than ever before. Determinants of this phenomenon and the state of affairs can be sought to reduce the importance of traditional factors of competitive advantage in favor of increasing globalization, as well as the computer revolution in the field of information and communication technology (Audretsch, 1998, p. 19; Czerniachowicz, 2014, pp. 83-90).

Implementation of improved solutions in enterprises with respect to technology and organization is justified if it brings beneficial effects in (economic, technical, social, or/and environmental) (Motyka, 2011, p. 167). An innovative approach in enterprises requires proper development of products and services, technological processes, changes in the organization and marketing in order to be able to meet the needs of the present, but also potential customers. Such activities enable the company to increase the impact area, and what goes with it, the achievement of strategic and financial objectives (Janasz, 2009, p. 42). That is why enterprises incur expenditure on innovation for various reasons: desire to increase productivity, production or/and employment levels. In addition, some companies implement new solutions, because it is a consequence of changing the laws.

Different types of innovation have different areas of influence. Innovations within the product mainly concern the effects of competition, demand and market and have the task: to replace the products withdrawn from the market, to expand the company's offer in terms of products and services, to create products that are friendly to the environment, to increase or maintain market share, allow the company the entry into new markets. In addition, it is expected to enhance the quality of products and services, reduce consumption of materials and energy and the achievement of sectoral technical standards. Innovations within the process relate to shorten the response time to customer needs, increase flexibility of production or service provision, an increase in production or service, reduce the consumption of materials, shorten production cycle, improve working conditions and to fulfill regulatory requirements. Organizational innovations are aimed at improving the organization and work area, improving communication and interaction between employees, better sharing of information and knowledge, increasing adaptability related to new customer needs and the overall improvement of working conditions. Marketing innovations concern both internal and external customers of the company (Dzikowski, 2013, pp. 159-178).

Objectives related to the implementation of innovative solutions in enterprises can be achieved or not. On the other hand, innovation may lead to the achievement of other or additional effects in relation to what in the first place was the motive for their implementation. The objectives therefore relate to motivate to innovation activity, while the effects relate to actually observed effects of implementation of innovative solution. It is recommended therefore to collect data on the effects of innovations implemented by the company during the relevant period. Questions about the actual achieved results may be a source of valuable information on innovative activity of enterprises. Table 1 provides a list of factors that relate both to

objectives and effects for all four types of innovations distinguished in Oslo Manual.

Table 1. Factors relating to the objectives and effects of innovation activity

The impact area	Product innovation	Process innovation	Organizational innovation	Marketing innovation
Competition, demand and markets				
Replacement products withdrawn from the market	+			
Extending the range of products and services	+			
Creating environmentally friendly product	+			
Increase or maintain market share	+			+
Entering new markets	+			+
Increasing the visibility or exposure of the product				+
Shortening the response time to customer needs		+	+	
Production and delivery				
Improvement of the quality of products and services	+	+	+	
Increasing the flexibility of production or service provision		+	+	
Increase in production or service		+	+	
The reduction in unit labor costs		+	+	
Reducing the consumption of materials and energy	+	+	+	
Lowering the cost of product design		+	+	
Shorten the production cycle		+	+	
Achieving sectoral technical standards	+	+	+	
Reduce operational costs associated with the provision of services		+	+	

Table1 continued

The impact area	Product innovation	Process innovation	Organizational innovation	Marketing innovation
Increasing the efficiency and speed to provide or delivery of products or services		+	+	
Improving IT capacity		+	+	
Organization of the workplace				
Improve communication and interaction between various divisions in the company			+	
Increasing the share or transfer of knowledge in dealing with other entities			+	
Increasing the ability to adapt to different customer requirements			+	+
Strengthening relations with customers			+	+
Improving working conditions		+	+	
Others				
Limitation of the effects on the environment or the improvement of health and safety	+	+	+	
Filling the regulatory requirements	+	+	+	

Source: Oslo Manual (2008, s. 112).

More specific effects of innovation can also be (Pomykalski, 2001):

- The number of new products introduced in the last three years,
- The percentage of sales and / or profits made from it (new products)
- The number of new ideas generated within the organization,
- Failed projects
- Customer satisfaction
- Time to market
- The cost of the product compared with current trends in the sector
- Quality in comparison with trends in the sector,

– Production capacity in a given sector
– Hours attributable to new product
– The average time of entire innovation process.

Foreign literature also points to other effects of innovation activities, such as increasing market share, improving product quality, reducing material costs per unit of output, improving the ecological, safety and health aspects and compliance with laws and standards (Bozic & Radas, 2005, p. 36). It is expected that all of these results lead to increased profitability by stimulating demand products or by reducing production costs.

The change in ideas into effective new technologies or viable products is associated with having a broader knowledge. The company needs technical and marketing competence (Iansiti, 1995, pp. 521-542; Rooster & Zander, 1992, pp. 383-397). As shown, knowledge and skills lead to an increase in corporate profits (Leiponen, 2000). Therefore, it is expected that the development of employees in connection with the implementation of innovations are the positive effects of innovative activity as well.

New or enhanced solutions, through processes of diffusion, spreading and reaching out to different companies, have an impact on improving their productivity. This is a reference also to competitors who receive the most modern, more efficient and effective solutions to mitigate advantage thanks to technological leader (Bukowski *et. al*, 2012, p. 4).

Methodological Conditions of the Research – Probit Modeling

The methodological part of the analyses is based on the probability calculus. When a dependent variable takes dichotomous values, the possibilities of using the popular multiple regression, widely used for quantitative phenomena, are limited. The problem can be solved by an alternative solution – the logistic regression (Frenkel, 2000, pp. 315-341). Its advantage is that an analysis and interpretation of results are similar to the classical regression method, hence the methods of selecting variables and testing the hypotheses have a similar pattern. There are, however, also differences, which include: more complex and time-consuming calculations and producing the residual plots usually do not contribute significantly to the model (Stanisz, 2007, p. 217).

Generally, the logistic regression is a mathematical model which can be employed to explain the impact of several variables X_1, X_2,..., X_k on a dichotomous variable Y. If all the independent variables are qualitative, the logistic regression model is equivalent to a log-linear model. To describe

such a phenomenon one could also employ the *probit regression* (Świadek, 2011, p. 102, Tomaszewski, 2013, p. 477).

On the side of dependent variables, there were attributes of innovation highlighted in accordance with the international standards set by the OECD countries and Eurostat. These variables included (Oslo Manual, 2008):

- expenditures on the innovation activity in relation to their structure,
- implementation of new products and technological processes.

Considering the fact that the variables are binary (i.e. they take two values – 0 or 1), the majority of the results will be presented at the level of the structural form of the model. A "plus" sign preceding a parameter denotes that the probability of an innovative phenomenon in the selected group of entities is higher than for the rest of the population. Probit modeling is an efficient research tool in the case of big yet static samples where the dependent variable is qualitative. Each questionnaire was entered to the *Excel* spreadsheet for initial processing based on formal logic. The actual calculations were made with the *Statistica* software.

Analysis of the Performance of Innovation activity in Industrial Enterprises in Eastern Poland

In the conducted survey 1067 industrial enterprises had participated. Effects of innovation activity in a group of surveyed enterprises are presented in Table 2.

Results of the study showed that in terms of innovative performance the largest number of enterprises, because almost 21% of them improved the quality of the assortment offered on the market and led to its increase (slightly more than 15%). A large number of companies also reported other effects to expand its market expansion, specifically in the form of entering new markets (nearly 15%), increased flexibility of production (almost 15%) and increased production capacity (almost 11%). It must be remembered that this also depends on the business cycle, which may have an impact on emerging issues in the field of rationalization of costs only when there is a slump in sales.

The lowest indications, taking into account the effects of innovation activity took place in relation to a reduction in unit labor costs, comply with the provisions and standards, limiting the harm done to the environment and to reducing the unit material and/or energy intensity of production, accordingly 8.5%, 6.3% , 5.4%, 3.6%. These effects occurred thus far more rarely.

Table 2. The structure of industrial enterprises in Eastern Poland from the standpoint of effects if innovative activity in 2010–2012

Lp.	Effects of innovation activity	Number of enterprises	Percentage
1.	Increased range of products	361	15,3%
2.	Entered new markets	345	14,7%
3.	Improved quality	491	20,8%
4.	Increased production flexibility	344	14,6%
5.	Increased production capacity	257	10,9%
6.	Lowered labor unit costs	200	8,5%
7.	Reduced unit material and/or energy intensity of production	86	3,6%
8.	Limited the harm done to the environment	128	5,4%
9.	Filled regulations and standards	145	6,3%

Source: own study based on research.

Implementation of innovative solutions can have a significant impact on the achievement of a number of positive effects, as indicated above. The results of the studies in this regard are presented also in Tables 3 and 4.

Table 3. The value of the parameter with the independent variable „effects of innovation activity" in probit models describing innovations of the industrial system in Eastern Poland in 2010-2012

Effect of innovation activity The scale of innovation activity	Increased range of products	Entered new markets	Improved quality	Increased production flexibility
Investments in R&D	0,29x-0,52	0,18x-0,48	0,31x-0,57	0,31x-0,53
Investments in funds not used yet assets (including):				
a) buildings, premises and land			0,22x-0,89	0,32x-0,90

Table 3 continued

Effect of innovation activity **The scale of innovation activity**	**Increased range of products**	**Entered new markets**	**Improved quality**	**Increased production flexibility**
b) machinery and technical equipment	0,28x+0,40	0,36x+0,38	0,24x+0,38	0,32x+0,39
Software	0,21x+0,05	0,24x+0,04	0,19x+0,03	0,51x-0,04
Introduction of new products	0,96x-0,27	0,18x-0,01	0,81x-0,32	-0,17x+0,10
Implementation of new technological processes (including):				
a) methods of manufacturing	0,40x-0,23	0,24x-0,17	0,29x-0,23	0,31x-0,20
b) production related systems	0,32x-0,58	0,21x-0,53	0,45x-0,69	0,40x-0,60
c) supporting systems	0,29x-0,89	0,33x-0,90	0,24x-0,90	0,45x-0,95

Source: own study based on research.

Table 4. The value of the parameter with the independent variable „effects of innovation activity" in probit models describing innovations of the industrial system in Eastern Poland in 2010–2012

Effect of innovation activity **The scale of innovation activity**	**Increased production capacity**	**Lowered labor unit costs**	**Reduced unit material and/or energy intensity of production**	**Limited the harm done to the environment**	**Filled regulations and standards**
Investments in R&D	0,35x-0,51	0,45x-0,51	0,36x-0,45	0,32x-0,46	
Investments in funds not used yet assets (including):					
a) buildings, premises and land	0,31x-0,87	0,33x-0,86	0,44x-0,83	0,42x-0,84	0,39x-0,85

Table 4 continued

Effect of innovation activity **The scale of innovation activity**	**Increased production capacity**	**Lowered labor unit costs**	**Reduced unit material and/or energy intensity of production**	**Limited the harm done to the environment**	**Filled regulations and standards**
Investments in R&D	0,35x-0,51	0,45x-0,51	0,36x-0,45	0,32x-0,46	
Investments in funds not used yet assets (including):					
a) buildings, premises and land	0,31x-0,87	0,33x-0,86	0,44x-0,83	0,42x-0,84	0,39x-0,85
b) machinery and technical equipment	0,47x+0,39	0,40+0,42			
Software	0,25x+0,06	0,41x+0,04			0,28x+0,08
Introduction of new products	0,58x-0,09	0,67x-0,08	0,37x+0,01	0,53x-0,02	0,37x-0,01
Implementation of new technological processes (including):					
a) methods of manufacturing	0,66x-0,26	0,56x-0,20	0,20x-0,11	0,31x-0,13	0,24x-0,13
b) production related systems	0,38x-0,56	0,60x-0,59	0,61x-0,52	0,51x-0,53	0,47x-0,54
c) supporting systems	0,40x-0,89	0,53x-0,90	0,33x-0,81	0,39x-0,84	0,45x-0,85

Source: own study based on research.

The table presented above shows that four out of nine effects of innovation activity accepted for testing had an impact on a featured scale innovative activity in a positive way in all accepted in the study areas (8/8) and, therefore, they activated all possible actions of innovations. This therefore means that the probability of these events is greater than in the rest of the group of effects. This included the effects related to improved quality of the product, increased flexibility in production and production capacity and

reduced unit labor costs. It can be argued that this phenomenon is not surprising. Expanding the business often requires an increase in production (including up-building of the machinery), as well as maintaining the high quality of the product range on the market. The only exception is less potential for the development of innovative character for the effect of increased production flexibility. This effect negatively affected marketing of new products. Production flexibility means being able to dictate lower prices than the competition, which is a strategy based more on standardization and cost advantages and innovative activities, not to diversify enterprise market (which explains the negative relationship).

In the following two cases, which were the effects of increased product range and entered new markets, seven of the eight possible statistically significant models have been recorded. There were no statistically significant relationship only for investment in buildings, premises and land.

In other cases, the situation is similar. For any effect: reduced unit material and/or energy intensity of production, limited harm done to the environment and filled regulations and standards, six of the eight possible statistically significant models occurred. In all three cases, there were no statistically significant relationship in respect of investments in machinery and technical equipment. In the case of effect of fulfillment of regulations and standards, there was no relationship associated with investments in research and development, and in the case of reduced unit material and / or energy intensity of production and limited harm done to the environment, there was also no relation to investments in computer software. In general, however, these relationships were positive, which means that these effects increased the probability of innovation activity in industrial enterprises in Eastern Poland.

Conclusions

Conducted in Eastern Poland research, along with their results, show some positive phenomena that occurred in regional industrial system of Eastern Poland. Basically, the test results have showed the fact that all adopted to study effects of innovation activity affected the scale of innovation activity of industrial enterprises in a positive way (with one exception, which was a model with a negative sign of the parameter).

Industrial enterprises in the regions of Warmia and Mazury, Podlasie, Lublin, Świętokrzyskie and Podkarpackie, in 2010–2012 indicated on improved quality of products offered on the market and increased range of products as the main effects of innovation activity. This was also confirmed

by the probit modeling, as it was noted that the biggest impact on efforts to increase innovation had the same effects (number of models statistically significant).

Analysis of innovation activity phenomena characterized in the article may have an impact on the perception of regional innovation policy, in terms of its nature and direction, as well as the vital question of the effectiveness of instruments of supporting innovativeness of industrial enterprises in Eastern Poland.

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