THE EFFECTS OF PROCESS INNOVATION'S DIMENSION INTO PRODUCT INNOVATION – A COMPARATIVE FIRM LEVEL ANALYSIS FROM EU AND NON-EU COUNTRIES*

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Abstract *: This article evaluates the effect of process innovation's dimensions (new production methods, new logistics and distribution, new supporting activities) into the product innovation, considering a comparable pattern between EU and non-EU countries. To examine this cause-effect chain, 516 interviews with innovative firms, randomly selected using stratified random sampling method, are reported. The sample comprised two sub-samples: four EU countries (Italy, Greece, Slovenia, and Croatia) and four non-EU countries (Albania, Bosnia and Herzegovina, Montenegro and Serbia). The logistic regression analysis reveals a positive association between new or significantly improved methods of manufacturing and product innovation and this causativeness effect is stronger among firms in the EU countries. When it comes to the other process innovation dimensions (new logistics and distribution, new supporting activities), the analysis uncovers no significant association for both sub-samples. Analysing the control variables (firm size, export orientation and governmental support), firm size is not significantly associated with the product innovation. However, export orientation has a significant positive effect on firm's inclination to engage in product innovation. Similarly, government financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees, has a significant effect on product innovation.*

Keywords: *product innovation, process innovation, manufacturing methods innovation, logistic innovation, supporting activities innovation.*

1. INTRODUCTION

There is wide research that explains the differences between the product innovation and process innovation (Utterback and Abernathy, 1975; Cohen and Klepper, 1996). Schumpeter (1911) defines product innovation as goods with which ''customers are not familiar'' while process innovation as ''methods of productions that are not yet tested''. Another way of expressing the distinction between these concepts, is provided by OECD manual (2005) which explains that product innovation aims to meet the customer expectations by blueprint new or considerably improved products while process innovation refers to operations and supply chain's upturn. Hence, product innovation helps firms to create a sustainable competitive advantage towards their competitors (Porter, 1985), while process innovation upturns efficiency (Abernathy and Utterback, 1978). Identifying the differences between product and process innovation is of a high importance due to the dissimilar factors impacting their adoption (Tornatzky and Fleischer, 1990). Firms can draw upon product innovation or process innovation. However, due to different organizational structure requirements, firms which focus on a singular innovation typology are better (Bhoovaraghavan et

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al., 1996). The decision to conduct a type of innovation instead of both of them is fundamentally important as far as it has performance impact. Empirical research demonstrates that firms which are engaged only in process innovation have a lower performance compared to those who conduct both of them (product and process innovation) at the same time (e.g. Capon et al., 1992).
There are attempts to examine firms' engagement in both product and process innovation acknowledge such a fact (Athey and Schmutzler, 1995), but few research sheds light on the cause-effectiveness relationship that exist between them (e.g. Pisano 1996; Damanpour and Gopalakrishnan, 2001). This paper aims to replenish the scarce empirical evidence about the effect of process' innovation dimensions into the product innovation.

This paper has the following structure. In Section 2 the relevant literature is reviewed. Section 3 describes the data and method used. In section 4 we present the results of the empirical research. Section 5 outlines the key findings and implications.

2. THEORITICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

There are countless classifications of innovation according to the academic and professional literature. Besides giving it same names, its shapes have fundamental differences depending on their meaning and context. This is why there is variety of shades the term innovation means (Boer and During, 2001; Shavinina, 2003; Fagerberg et al., 2005). Several scholars argue that the underline features of innovation comprise change and novelty (Schumpeter, 1911; Porter, 1990; Kotler and de Bes, 2003). Contrary to this approach, other scholars argue that innovation is not meant to represent something entirely new (Tabas, et al., 2010). The founder of the economic theory of innovations, J. A. Schumpeter provides some options while describing innovation as ''producing a new good, introducing a new method of manufacturing which is not applied so far in a specific sector, creating a new market which has not been opened so far in a given sector, catching a new source of supply of primary inputs and developing a new way of industry's organization'' (Schumpeter, 1911). An important contribution on innovation typologies has been given by Oslo Manual designed by a crew of experts with the purpose of measuring and evaluating innovation activities. It defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD, 2005, p. 46). According to this manual, innovation typologies include product innovations, process innovations, marketing innovations and organisational innovations. This manual enhances knowledge on the links between different types of innovation.

Innovation itself is complex. The development of this concept has been associated with the evolution of innovation types, too. This historical advancement of innovation is mirrored into the classifications from the "classical" product and process innovation to such "blue ocean innovation" and "frugal innovation. For the purpose of this paper, we refer to the classical typology of innovations which are proposed by OECD methodology. According to this methodology, product innovation refers as ''innovations related to goods and services and the distinctive characteristics include significant improvements in the technical specifications, components and materials'' while process innovation refers as ''implementation of new or significantly improved methods of production or delivery of the product and the distinctive characteristics include significant changes in technology, production equipment and/or software''. These basic definitions, relate product innovation with market needs (Kraft, 1990) and process innovation with operations and supply chain management. Such a distinction is a boon to firms while they decide on

their strategic orientation. If the market stimulates the product differentiation strategy then firm should foster product innovation. If the market stimulates cost leadership strategy, then process innovation is much more appropriate than product innovation.
Several studies underline the importance of clearly defining the differences between product and process innovation due to particular skills their adoption require (Tornatzky and Fleischer, 1990). Although there is a wide literature that elaborates innovations' shapes, this has not been accompanied with the same pace on studies' development to examine the cause-effectiveness relationship between product and process innovation. The first empirical study that has explored the interaction effect between process and product innovation was developed by Kraft (1990) taking a sample of 56 Germany metal working firms. The results indicated that product innovation stimulates process innovation but evidences to see the reverse effect, lacks. However, there are studies that identified the complementarity between product and process innovation, e.g. (Milgrom and Roberts, 1995; Pisano, 1996; Miravete and Pernias, 2006). Process and product innovation can be interweaved (OECD, 2018). Reichstein and Salter (2006) confirm the interdependency between process and product innovation.

We draw on the third edition of Oslo manual (OECD, 2018), to define types of process innovation which include production methods, delivery and logistics methods and supporting activities (e.g. the maintenance of information and communication systems). We take each of the process innovation's dimensions to evaluate whether they foster product innovation.

Some empirical studies have led to the increased knowledge that manufacturing methods innovation is more likely to happen along with product innovation (Gómez, Salazar & Vargas, 2016). So, the following proposition is formulated.

H1. *New or significantly improved methods of manufacturing or producing goods or services are expected to be positively associated with the likelihood for firms to innovate their products.*

Other studies have found that logistics-related integration has an impact on company performance, including product innovation (Flynn et al., 2010; Prajogo and Olhager, 2012). So, the following proposition is formulated.

H2. *New or significantly improved logistics, delivery or distribution methods for inputs, goods or services are expected to be positively associated with the likelihood for firms to innovate their products.*

Some empirical studies tackled the impact of supporting activities onto the product innovation and revealed that new or significantly improved supporting activities are more likely to happen along with product innovation (Gómez, Salazar & Vargas, 2016). So, the following proposition is formulated.

H2. *New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing are expected to be positively associated with the likelihood for firms to innovate their products.*

3. METHOD AND EMPIRICAL MODEL

3.1. Data

To test the hypotheses, a sample of 516 innovative firms randomly selected using stratified random sampling method, was elaborated. The sample has these characteristics: 50% production firms and 50% service companies. In terms of firm's size, 15% are micro, 35% are small and 50% are medium sized. Same features are applied in similar research such as Community Innovation Survey (CIS). Considering the comparative nature of our study the sample has been divided in two subsamples; the first included 265 firms located in four non-EU countries, namely Albania, Bosnia and Herzegovina, Montenegro and Serbia; the second includes 242 firms located in EU countries, namely Italy, Greece, Slovenia and Croatia.

3.2. Measurements

Details of the constructs, measurement and the operationalizations of variables are provided in Appendix A and are discussed below.

Product innovation: Product innovation is measured by a dummy variable, taking 0 value for ‘‘the firm has not been engaged in product innovation during the last three years’’, and 1 ‘‘the firm has been engaged in product innovation during the last three years’’. Two other options of this variable have been measured also. The first one captures a more market-oriented type of product innovation focusing on innovation that is new to the market the firm is currently operating on. The second is more firm-oriented focusing on copycat type of product innovation that are new to the firm but have been already introduced by firm competitors (OECD, 2005).

Process innovation: Three dimension of process innovation have been used in this study, namely new production methods, new logistics and distribution, new supporting activities (OECD, 2005). The first dimension captures new or significantly improved methods of manufacturing or producing goods or services; the second, new or significantly improved logistics, delivery or distribution methods for inputs, goods or services; the third, new or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing.

We use firm size, export orientation and the support from the government as control variables.

Considering the unreliability of data related to firm's turnover we chose number of employees as a proxy to firm size. We operationalized size as a logarithm of number of employees (Segarra-Siprés et al., 2014).

Export orientation was measured as firm's current number of active export countries for 2013 (Love et al., 2016).

Support from the government includes financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees during the last three years (Govindaraju et al., 2013).

3.3. Empirical Model

Binary logistic regression model is used to estimate the firm's likelihood to engage in product innovation. This model was selected considering the dichotomous nature of the dependent variable (Peng et al., 2013).

The model has the following form:

$$Ln\left(\frac{P_i}{1-P_i}\right) = a + b_i x_i + \ldots + c_i z_i + e \tag{1}$$

Where P_i, is the probability that the firm *i* is engaged in product innovation; $1\text{-}P_i$, the probability that the firm *i* does not engage in product innovation; *a*, a constant; x_i, z_i, the independent variables namely, new production methods, new logistics and distribution, new supporting activities; and b_i, c_i, vectors of parameters to be estimated.

The odds ratio will be given by the equation below:

$$\frac{P}{1-P} = e^{a+b_i x_i + c_i z_1} \tag{2}$$

The odds ratio for the case at hand should be interpreted as follows: one-unit change in the production method increases by e^{b1} the ratio of probability that a firm engages in product innovation to the probability that firm does not.

4. RESULTS

Table 1 summarizes the results of the logistic regression with product innovation as independent variable. Control and independent variables have been included in the analysis in separate blocks. The following interpretation is based on final results of our analyses.

New or significantly improved methods of manufacturing or producing goods or services, as a dimension of the process innovation, are positively and significantly associated with product innovation and this cause-effect chain is stronger among firms in the EU countries. When it comes to the other process innovation dimensions (new logistics and distribution, new supporting activities), the analysis revealed no significant association for both sub-samples. Export orientation has a significant positive effect on firm's inclination to engage in product innovation. Support from government financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees, has a significant effect, albeit at a relaxed level, on product innovation.

Hypothesis 1 is supported for both sub-samples. New or significantly improved methods of manufacturing or producing goods or services are positively and significantly associated with product innovation. The parameter Exp (B) for *Production methods* is 1,837 statistically significant at $p<0.05$ for the non-EU countries subsample (Table 1a). While, *Production methods* is 1,837 statistically significant at $p<0.05$ for the EU countries subsample. These results show that firms that have invested in new production methods are more inclined to develop innovative products.

Hypothesis 2 and 3 are rejected for both subsamples. These hypotheses, positing respectively a positive relationship between new or significantly improved logistics or distribution methods

and product innovation, and new or significantly improved supporting activities for your processes and product innovation, were not supported (table 1a).
Hosmer and *Lemeshow* test assessing the goodness of fit of a model shows p>0.05 ensuring the validity of our model. More than 1/3 of the variance for the EU subsample can be attributed to the independent variables (*Nagelkerke R Square* is 0,347). While, for the non-EU subsample only around 7% of the variance is explained by the model, suggesting that the model is not very useful in predicting product innovation.

Analysing firm size, support from the government and export orientation of the firms as control variables, we conclude, surprisingly, that there is no significant variability in the relationship between predictors and depending variable due to the effect of firm's size; such effect is statistically insignificant. While, as expected, export orientation has a significant positive effect on firm's inclination to engage in product innovation. Support from government financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees, etc. has a significant effect, albeit at a relaxed level, on product innovation.

Table 1a. Results of the logistic regression for the two subsamples

	Dependent variable - Product innovation					
Variables	Non-EU countries			EU countries		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Ln (size)	-.100	.112	.905	0.016	0.125	1.016
Support from government	.138	.503	1.148	1.034†	0.558	2,811
Export orientation	.235*	.112	1.264	0.477***	0.107	1.611
New production methods	.608*	.303	1.837	1.548***	0.325	4.700
New logistics and distribution	.142	.334	1.153	0.058	0.352	1.059
New supporting activities	.206	.325	1.229	0.298	0.349	1.347
Constant	.509	.424	1.664	-1.314	0.421	0.269
Nagelkerke R Square	0.064			0.347		

*0.01 ≤ p < 0.05, **p < 0.01, ***p < 0.001, †0.05 ≤ p < 0.1

These results are supported by the data pertaining to sub-variants of product innovation. Defining product innovation as the introduction of a new or significantly improved product onto the market before competitors our analysis produced similar results (Table 1b). Production method innovation has a positive and significant effect on firm's inclination to engage in the production of products that are new to the market. The only difference concerns the independent variable - new support activities that is significant at a relaxed level for the non-EU countries sub-sample. Nagelkerke R Square statistics show a slightly better predictability of the model for the non-EU subsample compared to the previous one.

Table 1b. Results of the logistic regression for the two subsamples

	Dependent variable - Product innovation (new to the market)					
Variables	Non-EU countries			EU countries		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Ln (size)	-.013	.101	.987	0.014	0.113	.986
Support from government	.235	.448	1.265	.847†	0.443	2,332
Export orientation	.187*	.090	1.206	0.252***	0.070	1.286
New production methods	.637*	.280	1.891	1.486***	0.310	4.419
New logistics and distribution	.036	.303	1.036	0.156	0.313	1.169
New supporting activities	.563†	.296	1.756	0.077	0.330	1.080
Constant	-.549	.397	.578	-1.584	0.397	0.205
Nagelkerke R Square	0.089			0.250		

*0.01 ≤ p < 0.05, **p < 0.01, ***p < 0.001, †0.05 ≤ p < 0.1

Similarly, we run a third analysis using another definition of product innovation a new or significantly improved product that was already available from your competitors in your market but new to the firm. The results are similar (Table 1c). Nagelkerke R Square statistics show an even better predictability of the model for the non-EU subsample compared to the two previous ones.

Table 1c. Results of the logistic regression for the two subsamples

	Dependent variable - Product innovation (new to the firm)					
Variables	Non-EU countries			EU countries		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Ln (size)	.070	.114	1.073	0.077	0.117	1.080
Support from government	.294	.548	1.342	.949*	0.473	2.584
Export orientation	.312**	.117	1.366	0.306***	0.077	1.358
New production methods	.862**	.306	1.367	1.362***	0.315	3.906
New logistics and distribution	.294	.352	1.342	-0.172	0.325	.842
New supporting activities	-.298	.343	.752	0.410	0.335	1.507
Constant	-.383	.443	.682	-1.712	0.409	0.180
Nagelkerke R Square	0.127			0.277		

*0.01 ≤ p < 0.05, **p < 0.01, ***p < 0.001, †0.05 ≤ p < 0.1

Our data that new production methods are a good predictor of product innovation; that is investing in new manufacturing methods, technology and processes needed to deliver services which leads to the development of new products and services. However, this cause-effect chain is stronger among firms in the EU countries. While our analysis seems to suggest, yet not convincingly, that a similar pattern can be observed in on-EU countries. Other factor not accounted in this analysis need to be investigated.

5. CONCLUSIONS

This paper endeavors to institute the relationship between dimensions of process innovation and product innovation. Particularly, we explore the cause-effectiveness chain between process innovations' dimensions (new methods of manufacturing, new logistics and distribution, new supporting activities) and product innovation. We use data gathered from 516 innovative firms to empirically test this cause-effect chain. Additionally, we include, firm size, government support and export orientation as the main controls. As key results, first it can be highlighted that new or significantly improved methods of manufacturing or producing goods or services are positively and significantly associated with product innovation and this cause-effect chain is stronger among firms in the EU countries compared with firms in non-EU countries. It appears that new technologies, manufacturing methods lead to product innovation and eventually to better performance and competitiveness. Innovation in logistics and supporting activities has not a significant effect on product innovation. The effect of firm's size is statistically insignificant. Export orientation has a significant positive effect on firm's inclination to engage in product innovation. More than 1/3 of the variance for the EU subsample can be attributed to the independent variables (*Nagelkerke R Square* is 0,347). While, for the non-EU subsample a rather smaller variance is explained by the model, suggesting that the model is not very useful in predicting product innovation. In terms of future research, it would be of a high interest to explore on the factors that lead to product innovation for non-EU countries (developing countries). Another idea to get studied is to see if market and industry factors have a stronger effect in terms of magnitude on product innovation.

APPENDIX A. DETAILS OF CONSTRUCTS AND MEASURES

Variable		**Number of items**	**Measurement**
Dependent variable			
Product innovation (three versions of the dependent variable - innovation in general, product innovation that is new to the market, and new to the firm)		1	*Dummy*, 1= product innovation 0= no product innovation
Independent variable			
New production methods	New or significantly improved methods of manufacturing or producing goods or services	1	*Dummy*, 1= new production methods in the last three years, 0 = no new production methods in the last three years
New logistics and distribution	New or significantly improved logistics, delivery or distribution methods for inputs, goods or services	1	*Dummy*, 1= new logistics and distribution in the last three years, 0 = no new logistics and distribution in the last three years
New supporting activities	New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing	1	*Dummy*, 1 = new supporting activities in the last three years, 0 = no new supporting activities in the last three years
Control variables			
Firm size	Number of employees	1	Logarithm of number of employees
Support from the government	Financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees	1	*Dummy*, 1= support from the government, 0 = no support from the government
Export orientation	Number of countries firm exports	1	Continues

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