Determinants of Firms´ Innovation Activities in V4 Countries

Petra Cisková[1] | *Matej Bel University, Banská Bystrica, Slovakia*
Ina Ďurčeková[2] | *Matej Bel University, Banská Bystrica, Slovakia*

Abstract

Innovation is considered to be the driving force of competitiveness and growth of firms as well as countries. However, despite these benefits of innovation, not all firms undertake innovation projects. There are several barriers and factors determining the involvement of firms in innovation activities. The aim of the paper is to examine determinants affecting involvement of firms in innovation activities in V4 countries. The emphasis is put on issues that present the most pronounced barriers to commercialization of innovation. The analysis is based on data obtained from the Innobarometer 2016 survey. The paper is focused on examination of several determining factors that are studied for a variety of firms. These factors are represented mainly by type of innovation or innovation barriers and their impact on involvement of firms in innovation activities. The analysis is based on several probit models of micro-level data. It seems that R&D, turnover and innovation investments are among the main determinants of innovation activities of firms in V4 countries. We have also found that in V4 countries, product innovation was introduced mostly by smaller firms while larger firms tend to focus on process innovation. The main major barriers of innovation encountered by firms seem to be the lack of human resources and the fact that the market is dominated by competition.[3]

Keywords

Innovation activities, determinants, innovation barriers, Innobarometer 2016

JEL code

C32, O31, O32

INTRODUCTION

Innovation is a key factor affecting competitiveness and growth of firms. Firms therefore put emphasis on introducing new innovation to support their growth and reinforce their position on the market. Innovation can be defined as application of new or improved ideas, products, services or processes that bring increased utility or quality (Mataradzija et al., 2013). The importance of innovation in business environment is constantly increasing. This is also confirmed by the fact that business innovation activities not only lead

[1] Matej Bel University, Faculty of Economics, Department of Quantitative Methods and Information Systems, Tajovského 10, 975 90 Banská Bystrica, Slovakia. Corresponding author: e-mail: petra.ciskova@umb.sk, phone: (+421)484466617.
[2] Matej Bel University, Faculty of Economics, Department of Finance and Accounting, Tajovského 10, 975 90 Banská Bystrica, Slovakia. E-mail: ina.durcekova@umb.sk, phone: (+421)484466314.
[3] This article is based on contribution at the *International Scientific Conference for Doctoral Students and Young Scientists – Scientia Iuventa* in April 2019, Banská Bystrica, Slovakia.

to the generation of knowledge, which may manifest itself in new products and improved production methods used in the production process, but they also lead to higher productivity (Zemplinerová and Hromádková, 2012; Polder et al., 2010; Hashi and Stojcic, 2010; Mairessee and Robin, 2009; Van Leeuwen and Klomp, 2006; Lööf and Heshmati, 2002; Crépon, Duguet, Mairessee, 1998).

According to related literature, there are four main types of innovation activities: product, process, marketing and organizational innovation (OECD, 2005). This is in line with the types of innovation examined in Innobarometer 2016 survey, which defines five types of innovation, since it distinguishes two types of product innovation – significantly improved goods and significantly improved services – in addition to other three aforementioned types.

Even though the introduction of various types of innovation depends on different determinants, there are several factors affecting whether a firm introduces an innovation in general. These factors can generally be divided into three categories: macroenvironmental factors (such as political, economic or social factors), microenvironmental factors (such as suppliers, consumers or competitors) and internal factors (such as production, finance or personal of a firm) (Yachmeneva and Vol's'ka, 2014). These factors can also be divided into internal and external ones. Internal factors reflect various characteristics of a firm, such as its size or age, or decisions made by a firm. External factors describe the environment surrounding a firm, such as customs (EBRD, 2014). This paper is mostly focused on examination of internal factors influencing innovation activities of a firm, such as demographic factors. External factors affecting involvement of firms in innovation activities researched within the paper are mostly focused on problems firms consider to be barriers to introducing innovation.

There have been many studies focused on examining determinants of firm innovation in various countries and regions. Review of the main findings is summarized in Table 1.

Table 1 Determinants of firm innovation – review of the main findings

Determinant	Authors
Past innovation activities	Baldwin, Gu, 2004; Vega-Jurado et al., 2008; Romjin, Albaladejo, 2002
Technological competencies	Baldwin, Gu, 2004; Vega-Jurado et al., 2008
Intensity of R&D	Raymond, St-Pierre, 2010; Baldwin, Gu, 2004
Size of a firm	Fritz, 1989; Baldwin, Gu, 2004; de Jong, Vermeulen, 2004; Rosa, 2002; Oum, Narjoko, Harvie, 2014
Age of a firm	de Jong, Vermeulen, 2004
Foreign control of a company	Fritz, 1989; Guadalupe, Kuzmina, Thomas, 2012; Baldwin, Gu, 2004
Sector	Vega-Jurado et al., 2008; de Jong, Vermeulen, 2004; Rosa, 2002
Type of innovation	Raymond, St-Pierre, 2010; Fritz, 1989; Rosa, 2002
Access to finance	Oum, Narjoko, Harvie, 2014
Human capital	Oum, Narjoko, Harvie, 2014

Source: Authors

Some of the main findings related to the paper are as follows: Baldwin and Gu (2004) found that large firms have higher rates of process innovation than smaller ones and that foreign-controlled firms have

higher innovation rates than domestic ones. These conclusions are partially in line with results of Fritz (1989) who found that smaller, owner-run firms facing less competitive pressure have higher rate of product innovation. Even though the focus of research is often on large enterprises and the innovation they create, many authors emphasize the importance of micro-enterprises and SMEs in the area of innovation. SMEs are often seen as a valuable source of innovation, since their flexibility and simpler organization structure allows them to overcome innovation barriers easier than it is in larger enterprises (Czarniewski, 2016; Stephens, 2016; Lesáková et al., 2010).

The paper is structured as follows: Section 1 provides the details of methodology and describes the data and the details of the probit models. In Section 2 the introduced probit models are applied to data of V4 countries and the results are discussed. Main findings of the paper are summarized in the part "Conclusion".

1 METHODOLOGY

In this paper we use data from Flash Eurobarometer 433 – Innobarometer 2016 – EU Business Innovation Trends survey[4] that was held between February 1st and February 19th of 2016. Innobarometer survey gathers a firm-level data from 28 Member States of European Union, Switzerland and United States concerning information about innovation, design, plans for future investments in innovation and the problems encountered with introducing a new – innovative or non-innovative – goods and services into the market. The methodology of the Eurobarometer was used in the survey and the interviews were conducted with the key decision makers of companies. Innobarometer survey data is used within analyses published by many authors (e.g. Tether, 2005; Lorenz, 2011; Filippetti and Archibugi, 2011; Trigo, 2013; Montresor and Vezani, 2016; Božić and Botric, 2017; Guerzoni, 2014). The data used in the paper was obtained from GESIS based on the instructions from the official website of the European Union in addition to official aggregated data published by the European Union. However, some inconsistencies can be seen between data provided by GESIS and aggregated data published by the European Union, probably due to methodology used to summarize the findings. In our paper, we follow the data provided by GESIS.

We focus on analysis of the Visegrad Group countries consisting of the Czech Republic, Hungary, Poland and Slovakia (hereinafter referred to as "V4"). The countries are selected based on their similar levels of innovation performance according to Summary Innovation Index which stems from their similar geographic and economic positions. Since the survey questions are changed between years, we decided to focus on comparison of selected countries within one year (2016). The data is analyzed using descriptive statistics and the probit models.

The survey covers a wide range of questions related to innovation. Respondents are asked several questions concerning the firms´ innovation activities, whether the company introduced any new or significantly improved goods, services, or processes. In addition, respondents provide various types of demographic information (such as size of a firm, sector in which the firm operates, year of establishment) and information directly connected to innovation activities of a firm (such as type of innovation or innovation barriers).

In V4 countries, the questionnaire of Innobarometer survey was answered by 500 firms from the Czech Republic, 500 firms from Slovakia, 500 firms from Hungary and 501 firms from Poland, which gives us a total number of 2 001 observations. For the purposes of the paper, innovative firm is defined based on the Innobarometer survey question Q2 regarding introduction of types of innovation by a firm. Innovative firm in the paper is defined as a firm that undertook any type of innovation. Innovation activities are crucial to increase market share and competitiveness of a firm which is shown by the fact that approximately 68% of the surveyed firms in V4 countries were involved in innovation activities

[4] Available at: <*https://zacat.gesis.org*>.

in the year under review. Table 2 shows that out of 2 001 firms, 1 359 were involved in any type of innovation activity. The highest number of innovative firms was in Poland, closely followed by the Czech Republic and Slovakia, while the least innovative firms were in Hungary. Overall, more than half of the surveyed firms undertook some type of innovation in all countries. It can also be seen that the structure of the innovative firms consisted of over 43% of microenterprises, 29% of SMEs and 27% of large firms. We assume that the high representation of microenterprises within innovative firms stems from the fact that many start-ups, which are mostly innovative firms, belong to the group of microenterprises.

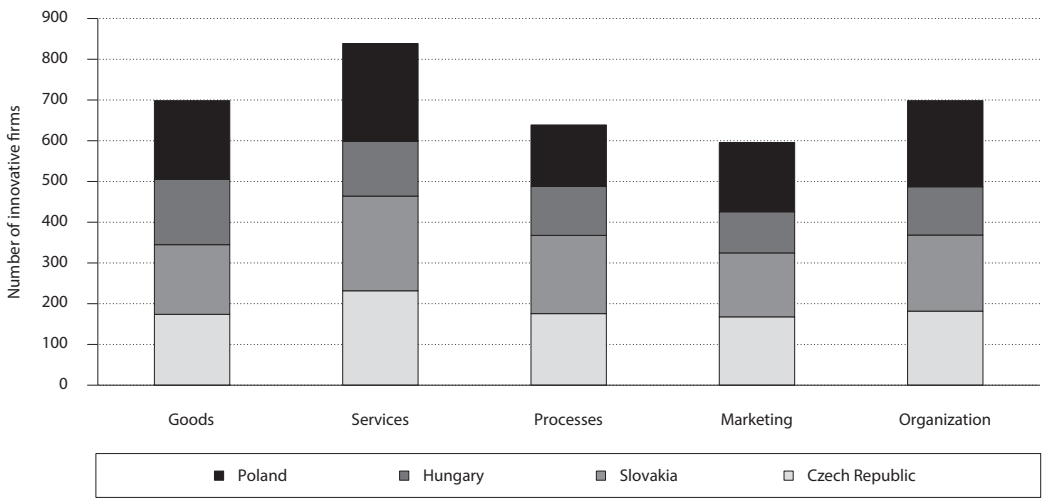
Table 2 Number of innovative and non-innovative firms based on their size in V4 countries

Country	Innovative firms			Non-innovative firms
	Microfirms	SMEs	Large firms	
Czech Republic	139	117	108	136
Slovakia	155	114	88	143
Hungary	112	82	76	229
Poland	185	85	97	134
Total	**591**	**399**	**369**	**642**

Notes: Microfirms: 1–9 employees; SMEs: 10–49 employees; large firms: 50 and more employees.
Source: Own calculations based on Innobarometer 2016

However, it is not only important to look at the aggregate number of how many firms were involved in innovation activities, but to also examine the types of innovation they introduced. Overall, the surveyed firms were mostly focused on innovating their services. The only country where service innovations were

Figure 1 V4 innovative firms according to type of innovation they introduced

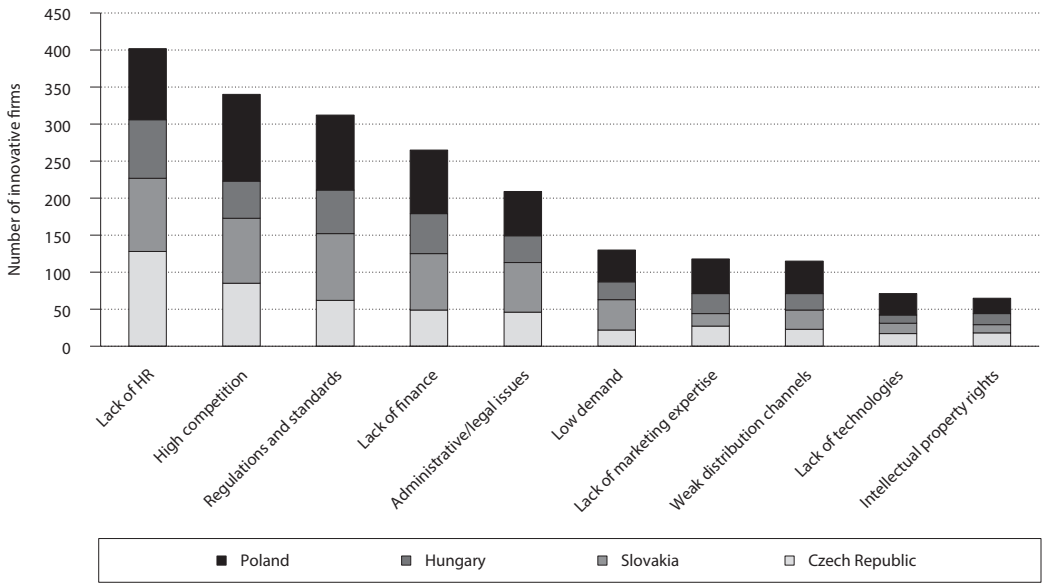


Source: Own calculations based on Innobarometer 2016

not dominant was Hungary, where firms were mostly involved in innovations focused on improving their goods. On the other hand, the V4 firms were least interested in launching marketing innovation.

It it obvious that innovation is an important element of increasing competitiveness of a firm and therefore is very beneficial to a firm. However, despite these benefits, not all firms introduce new innovations. That raises the question of why do not all firms undertake innovation activities. The answer is that firms encounter several difficulties while launching innovation projects. The most pronounced barriers to innovation according to surveyed firms are summarized in Figure 2.

Figure 2 Major barriers to innovation according to innovative firms in V4 countries



Source: Own calculations according to data from Innobarometer 2016

It is apparent that the main major barrier to innovation according to innovative firms in V4 countries is the lack of human resources, closely followed by the fact that the market is dominated by competition. Standards and regulations as well as lack of financial resources were also found to be problematic by innovative firms.

1.1. Descriptive analysis

Our strategy to choose variables is based on similar studies examining the determinants of firm innovation. In addition, we have been strongly influenced by the findings in Capozza and Divella (2017), Rehman (2016) and Montresor and Vezzani (2016).

We employ three probit models where the dependent variables are one of the three following types of innovation that company introduced since January 2013:

- product innovation (y_1),
- service innovation (y_2),
- process innovation (y_3).

Then, we use wide range of independent variables, that were divided into three groups according to their similar characteristics:

- demographic variables,
- variables of innovation impact,
- barrier variables.

The characteristics of a list of variables are described in Table 3.

Table 3 Variable description

Dependent variables	
Product innovation (y_1)	1 if company introduced a new product since January 2013; 0 otherwise
Service innovation (y_2)	1 if company introduced a new service since January 2013; 0 otherwise
Process innovation (y_3)	1 if company introduced a new process since January 2013; 0 otherwise
Independent variables	
Demographic variables	
Firm´s size (x_1)	1 if number of employees are between 1 to 9; 2 for companies with 10 to 49 employees and 3 for companies with more than 50 employees
Young (x_2)	1 if company was established after 1 January 2010; 0 otherwise
Group (x_3)	1 if company belongs to a business group; 0 otherwise
Turnover (x_4)	–1 if company´s turnover has decreased since January 2013; 0 if turnover remained approximately the same; 1 if turnover has increased
Variables of innovation impact	
Innovative products and services (x_5)	1 if 0% of company's turnover was due to innovative goods or services that have been introduced since January 2013; 2 if the percentage of turnover was between 1 and 5%; 3 if the percentage of turnover was between 6 and 10%; 4 if the percentage of turnover was between 11 and 25%; 5 if the percentage of turnover was between 26 and 50%; 6 if the percentage of turnover was 51% and more
Investing in innovation (x_6)	1 if company has not invested in innovation activities; 2 if company has invested in innovation activities less than 1% of turnover in 2015; 3 if company has invested between 1 and 5%; 4 if company has invested between 6 and 10%; 5 if company invested more than 11%
R&D (x_7)	1 if company has not invested in research and development since January 2013; 2 if company invested in R&D less than 1% from turnover; 3 if company has invested between 1 and 5% of turnover; 4 if company has invested more than 5% of turnover
Training (x_8)	1 if company has not invested in training since January 2013; 2 if company invested in training less than 1% from turnover; 3 if company has invested between 1 and 5% of turnover; 4 if company has invested more than 5% of turnover
Organization investments (x_9)	1 if company has not invested in organization or business process improvements since January 2013; 2 if company invested less than 1% from turnover; 3 if company has invested between 1 and 5% of turnover; 4 if company has invested more than 5% of turnover
Acquisition of assets (x_{10})	1 if company has not invested in acquisition of machines, equipment, software or licenses since January 2013; 2 if company invested less than 1% from turnover; 3 if company has invested between 1 and 5% of turnover; 4 if company has invested more than 5% of turnover
Marketing innovation (x_{11})	1 if company introduced a new marketing strategy since January 2013; 0 otherwise
Organization innovation (x_{12})	1 if company introduced a new organizational method since January 2013; 0 otherwise
Barrier variables	
Lack of HR (x_{13})	1 if company considers the lack of human resources as a major problem in the commercialization of company´s innovative goods and services; 0 otherwise
Regulations and standards (x_{14})	1 if company considers the cost or complexity of meeting regulations or standards as a major problem in the commercialization of company´s innovative goods and services; 0 otherwise
Competitors (x_{15})	1 if company considers the market dominated by established competitors as a major problem in the commercialization of company´s innovative goods and services; 0 otherwise

Source: Authors

Innobarometer survey is a structured type of questionnaire, where the respondents select (mostly) one-choice or multiple-choice answers. If some questions are linked to previous question and the answers are not applicable, or if respondents chose not to answer, we decided to exclude these observations from our sample. Choices are often offered as intervals, with different widths of scale (respondents are subsequently divided into several categories, e.g. according to their R&D investments, with the R&D investment being 0%, lower than 1%, lower than 5% or higher than 5% of the turnover, etc.). Considering

Table 4 Description of NACE classification and corresponding categories

NACE classification	Categories
Manufacturing	C – manufacturing
Industry	D – electricity, gas, steam and air conditioning supply E – water supply, sewerage, waste management and remediation F – construction
Retail	G – wholesale and retail trade, repair of motor vehicles and motorcycles
Service	H – transportation and storage I – accommodation and food service activities J – information and communication K – financial and insurance activities L – real estate activities M – professional, scientific and technical activities N – administrative and support service activities R – arts, entertainment and recreation

Source: Authors based on Innobarometer 2016

Table 5 Number of innovative firms based on NACE classification and firm size (in regards to the data used in probit analysis)

NACE classification	Microfirms	SMEs	Large firms	Total
Manufacturing	28	47	96	171
Industry	59	43	76	135
Retail	157	119	45	321
Service	128	105	82	315
Total	**372**	**314**	**256**	**942**

Notes: Microfirms: 1–9 employees; SMEs: 10–49 employees; Large firms: 50 and more employees.
Source: Own calculations based on Innobarometer 2016

the different widths of intervals, it is difficult to statistically evaluate the results of the survey. However, Innobarometer survey does not determine the exact share, only an interval to which the surveyed firm falls under. Thus, it is not possible to unify the methodology of scaling variables and we therefore must use the scales provided by the survey. This methodology is also used by other papers studying various Eurobarometer surveys (e.g. Ehrmann, Soudan, Stracca, 2013; Horváth and Katuščáková, 2016; Capozza and Divella, 2017).

After data cleansing, we worked with 942 observations. Two types of control variables – country dummies and NACE variables – were also included in models. Economic agents in the paper are clustered in line with NACE classification shown in Table 4. Table 5 shows the number of innovative firms (regardless of their country of origin) based on NACE classification and size of a firm in regards with the cleansed number of data used in probit analysis. In Table 6 we present correlation analysis of all variables used in models.

Table 6 Correlation matrix

	y_1	y_2	y_3	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
y_1	1																	
y_2	–0.472	1																
y_3	0.121	0.055	1															
x_1	–0.005	–0.057	0.199	1														
x_2	–0.032	0.057	0.007	–0.152	1													
x_3	0.037	–0.080	0.099	0.327	–0.012	1												
x_4	–0.008	0.029	0.171	0.061	0.149	0.099	1											
x_5	0.144	0.050	0.222	–0.035	0.132	0.031	0.166	1										
x_6	–0.020	0.142	0.244	0.040	0.071	0.045	0.126	0.277	1									
x_7	0.212	–0.060	0.251	0.205	0.060	0.130	0.099	0.253	0.340	1								
x_8	–0.063	0.145	0.120	0.141	–0.026	0.085	0.034	0.075	0.195	0.224	1							
x_9	–0.022	0.175	0.197	0.114	0.077	0.077	0.073	0.166	0.305	0.220	0.356	1						
x_{10}	–0.020	0.110	0.172	0.117	0.001	0.083	0.155	0.131	0.356	0.187	0.280	0.249	1					
x_{11}	0.092	0.131	0.243	0.031	0.103	0.020	0.058	0.177	0.082	0.124	0.087	0.265	0.039	1				
x_{12}	–0.038	0.193	0.262	0.136	0.025	0.018	0.066	0.142	0.145	0.120	0.179	0.354	0.130	0.265	1			
x_{13}	0.099	–0.049	0.086	0.042	0.005	0.006	0.043	–0.025	0.098	0.054	0.075	0.077	0.107	0.046	0.099	1		
x_{14}	–0.006	0.027	0.014	–0.062	0.017	–0.067	–0.007	–0.004	0.041	–0.023	0.034	0.079	0.034	0.106	0.022	0.163	1	
x_{15}	**0.056**	**–0.032**	**0.041**	**0.035**	**–0.030**	**0.028**	**–0.153**	**–0.011**	**0.021**	**0.081**	**0.063**	**0.073**	**0.048**	**0.106**	**0.083**	**0.110**	**0.133**	**1**

Source: Authors

1.2. Model specification

For analyzing the determinants of firms´ innovation activities in V4 countries we use binary probit models, that correspond to a probabilistic model with the form:

$$P(y_{ij} = 1|x_{ik}, \beta_{jk}) = \Phi(c_j + \beta_{j1}\, x_{i1} + \beta_{j2}\, x_{i2} + \ldots \beta_{j15}\, x_{i15}), \tag{1}$$

where: $\Phi(\cdot)$ is distribution function of a normal distribution $N(0, 1)$.

Our models can be written:

$$y_{ij} = f(dem'_{ij}; inno'_{ij}; bar'_{ij}; c_{ij}; nace_{ij}; country_{ij}) + \varepsilon_{ij}\,, \tag{2}$$

where:

$$y_{ij} = \begin{cases} y_{i1} - \text{product innovation}, \\ y_{i2} - \text{service innovation}, \\ y_{i3} - \text{process innovation}, \end{cases} \tag{3}$$

$$dem'_{ij} = (x_{i1}, x_{i2}, x_{i3}, x_{i4})',$$
$$inno'_{ij} = (x_{i5}, x_{i6}, x_{i7}, x_{i8}, x_{i9}, x_{i10}, x_{i11}, x_{i12})',$$
$$bar'_{ij} = (x_{i13}, x_{i14}, x_{i15})'.$$

Symbol i means the response of a company, j corresponds to a type of innovation, k is a number of a variables, β_{jk} denotes the regression coefficients, vector dem'_{ij} signs demographic variables, $inno'_{ij}$ is a vector of variables of innovation impact, vector bar'_{ij} designates the barrier variables, c_j is an intercept, control variables $nace_{ij}$ and $country_{ij}$ represent a NACE and country dummies and ε_{ij} is an estimate error.

Now we can rewrite a system (1) corresponding to (2) into the following probabilistic models:

$$\begin{aligned} P(y_{i1} = 1|\cdot) &= F(f(dem'_{i1}; inno'_{i1}; bar'_{i1}; c_{i1}; nace_{i1}; country_{i1})) \\ P(y_{i2} = 1|\cdot) &= F(f(dem'_{i2}; inno'_{i2}; bar'_{i2}; c_{i2}; nace_{i2}; country_{i2})) \\ P(y_{i3} = 1|\cdot) &= F(f(dem'_{i3}; inno'_{i3}; bar'_{i3}; c_{i3}; nace_{i3}; country_{i3})) \end{aligned} \tag{4}$$

2 RESULTS

In many studies, the researchers have tried to explain why companies innovate and what are the main drivers of innovations. In this paper we focused on the firms´ innovation activities in V4 countries. Using the maximum likelihood estimation (MLE), we found interesting results. Table 7 presents the results from three probit regression analyses introduced in previous section.

Table 7 Results from probit regression

Explanatory variable	Explained variable		
	Product innovation (y_1)	***Service innovation*** (y_2)	***Process innovation*** (y_3)
Firm´s size (x_1)	–0.1560** (0.0619)	–0.0048 (0.0677)	0.2037*** (0.0616)
Young (x_2)	–0.2200 (0.1382)	0.1244 (0.1565)	–0.1790 (0.1388)
Group (x_3)	0.1397 (0.1277)	–0.2823** (0.1336)	0.0354 (0.1281)

Table 7 (continuation)

Explanatory variable	Explained variable		
	Product innovation (y_1)	***Service innovation*** (y_2)	***Process innovation*** (y_3)
Turnover (x_4)	–0.0841 (0.0642)	0.0486 (0.0683)	0.2060*** (0.0642)
Innovative products and services (x_5)	0.1630*** (0.0357)	–0.0296 (0.0379)	0.1143*** (0.0353)
Investing in innovation (x_6)	–0.1027** (0.0467)	0.1491*** (0.0515)	0.1556*** (0.0471)
R&D (x_7)	0.3146*** (0.0503)	–0.1986*** (0.0529)	0.1616*** (0.0479)
Training (x_8)	–0.1194** (0.0522)	0.1504*** (0.0574)	–0.0119 (0.0521)
Organization investments (x_9)	–0.0421 (0.0526)	0.1293** (0.0575)	–0.0307 (0.0518)
Acquisition of assets (x_{10})	–0.0569 (0.0502)	0.1183** (0.0527)	0.0557 (0.0504)
Marketing innovation (x_{11})	0.2881*** (0.0964)	0.2243** (0.1037)	0.4723*** (0.0942)
Organization innovation (x_{12})	–0.1416 (0.0989)	0.3752*** (0.1060)	0.4408*** (0.0965)
Lack of HR (x_{13})	0.3558*** (0.0976)	–0.2823*** (0.1028)	0.0955 (0.0960)
Regulations and standards (x_{14})	–0.0502 (0.1021)	–0.0264 (0.1115)	0.0002 (0.1016)
Competitors (x_{15})	0.1174 (0.1007)	–0.1819* (0.1068)	0.0234 (0.1008)
Intercept (c)	1.0647*** (0.2701)	–1.1630*** (0.2918)	–1.6774*** (0.2783)
Control variable			
NACE	Yes	Yes	Yes
Country	Yes	Yes	Yes
Log likelihood	–540.95	–462.86	–543.63
AIC	1.1847	1.0187	1.1904
SIC	1.2872	1.1211	1.2929
McFadden *pseudo* R^2	0.1385	0.1568	0.1706
% Correctly predicted	69.80	75.84	69.80

Notes: Standard errors are in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.
Source: Authors

If we look at the first group of explanatory variables, namely demographic variables, we find that firm´s size is statistically significant in two types of innovations – product and process. It seems that bigger firms invest more money to introduce a new technology or method (process innovation) than smaller firms. On contrary, smaller firms are more efficient in introducing new products. There findings are in line with Baldwin and Gu (2004) and Fritz (1989). The variable *young* is not statistically significant and the variable *group* is significant and negatively associated with service innovation. It means that being

a part of a business group seems to be a disadvantage when it comes to introducing new services. One of the most important financial indicators is a firm´s turnover. Stable and sustainable turnover growth is a key factor for long-turn success of firm. In our analysis, increasing (decreasing) *turnover* growth is positively (negatively) associated with the process innovation.

Many ratios are calculated on the turnover basis. Our models are no exceptions. We have included several variables. For example, greater percentage of turnover due to *innovative products and services* has a positive impact on product and process innovation. For a company to gain a competitive advantage, it is necessary to make an effort to improve its innovation activity. It is also important to create a business strategy to identify key factors affecting the level of innovation activities. A statistically significant variable supporting these claims is *investing in innovation*. This variable is positively associated with service and process innovation, but it has negative impact on product innovation. Many studies (such as Zemplinerová and Hromádková, 2012; Vokoun, 2014; Griffith et al., 2003; Crépon, Duguet, Mairessee, 1998) focus on examining the impact of R&D in innovation activities. R&D helps stimulate the innovation performance to make the business processes more efficient. We found that the higher investment of company´s turnover in R&D has a positive impact on product and process innovations and negative impact on service innovation. This may be due to the fact that the R&D is frequently oriented towards products and processes rather than services. We also found that higher percentage of turnover spent on *training* employees has a positive impact on service innovation. Training programs help employees improve their knowledge and skills and, consequently, lead to higher productivity. Service innovation also seems to be positively impacted by *organization improvements* and *acquisition of assets*.

In addition to product, service and process innovations, the Innobarometer 2016 survey also examined an introduction of marketing and organization innovations. *Marketing innovation* represents the implementation of new marketing methods such as design creation, product promotion and placement. We can describe *organizational innovation* as an introduction of a new organizational method or improvement of business relationships. We used these variables as explanatory variables to our three main types of innovation – product, process and service innovation. *Marketing innovation* seems to have a positive impact on product, service and process innovation. This means that the introduction of marketing method is an important innovation activity. The explanatory variable *organizational innovation* is statistically significant and means that if a company introduces an *organization innovation*, the probability of introduction a service and process innovation will also increase. We can therefore state that marketing and *organizational innovation* are crucial determinants of innovation activities in firms and support the introduction of other types of innovation.

The last group of variables presented in the paper are barrier variables. Figure 2 in section Methodology illustrates the major barriers that firms face. In our analysis we used three most relevant barrier variables: *lack of HR*, *regulations and standards* and *competitors*. Based on the results, we can state that the *lack of HR* is significant in two output innovation variables: product and service innovation. Human resources are very important especially for the service sector. At present, many companies are struggling with the problem of lack of skilled human resources. In V4 countries, this is most apparent in health and IT sector. The lack of human resources is mainly due to the lack of labor force, the migration of more skilled labor force abroad and inability to adapt to the dynamics of innovation changes. However, we find it interesting that the *lack of HR* is positively associated with the product innovation. This means that the *lack of HR* is not a barrier to product innovation, but, on contrary, is a factor that positively affects introduction of new products. This may be due to the fact that, at present, we face Industry 4.0 and many processes are being automatized. Labor force is being replaced by fully automated lines and machines, hence the *lack of HR* ceases to be a problem in product innovation to some extent. The variable *regulations and standards* is not statistically significant and the variable *competitors* is significant and negatively associated with the service innovation, which means that competition proves to be a significant barrier to service innovation.

CONCLUSION

It is indisputable that innovation is crucial in terms of growth and competitiveness of firms and thus for the whole economy. However, despite these benefits brought by innovation, just a few firms are involved into innovation activities. The aim of the paper was to examine determinants affecting involvement of firms in innovation activities in V4 countries.

We analyzed data from Innobarometer 2016 survey for V4 countries. We used probit models to determine key factors affecting the involvement of V4 firms in innovation activities. Determinants were divided into three categories: demographic variables, variables of innovation impact and barrier variables. We examined the impact of these variables on three different innovation activities firms could have undertaken: product innovation, service innovation and process innovation. We found that product innovation is mostly introduced by smaller firms oriented towards R&D that also introduced new marketing methods. On the other hand, process innovation is mostly developed in larger firms with higher turnover that also invest more in innovation. R&D, marketing innovation and organization innovation are also important determinants of process innovation in V4 countries. Service innovation can mostly be found within firms that invest in innovation and focus on training their employees. Introduction of new organization and marketing methods are also drivers of service innovation in firms. However, being a part of a business group seems to be a disadvantage when it comes to introducing service innovation. Main barriers of innovation were lack of human resources, regulations and standards and competition on the market.

Even though there are many papers focused on examining determinants of innovation, only a small percentage of them uses Eurobarometer surveys in their analysis. The papers aimed at examination of Eurobarometer surveys are mostly focused on analysis of all 28 EU countries, which present an important transnational overview, but sometimes provide overly generalized results and recommendations. We think that the use of firm-level data is significant in finding the key drivers of innovation, while using data for a smaller group of countries (such as a sample of V4 countries) provides specific results that have direct implications related to innovation activities of firms in these countries. Our results can be therefore further used by policy makers in creating optimal innovation policies in a country. However, we realize that our research also has its restrictions. Since the questions asked in Eurobarometer surveys change annually, it is difficult to compare the results between years, so our research is only based on data obtained within one year. We therefore think that it would be interesting to select several questions that are repeated in the questionnaire for more than one year and analyze the data in the longer run. It may be useful to see how the answers of surveyed firms change between years and to look for the changes that may have influenced respondents' answers.

ACKNOWLEDGMENT

The paper was financially supported by the grant scheme VEGA 1/0385/19 *"Determinants of business innovation performance on the basis of Quadruple helix model"* of the Ministry of Education, Science, Research and Sport of the Slovak Republic.

References

BALDWIN, J. R. AND GU, W. Innovation, Survival and Performance of Canadian Manufacturing Plants. *SSRN Electronic Journal*, 2004, 22, 49 p.

BOŽIĆ, L. AND BOTRIC, V. Innovation investment decisions: are post(transition) economies different from the rest of the EU? *Eastern Journal of European Studies*, 2017, 8(2), pp. 25–43.

CAPOZZA, C. AND DIVELLA, M. Organizational changes and innovation: firm-level evidence from European countries. *Annali del Dipartimento Jonico*, 2017, pp. 41–54.

CRÉPON, B., DUGUET, E., MAIRESSE, J. Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level. *Economics of Innovation and New Technology*, 1998, 7, pp. 115–158.
CZARNIEWSKI, S. Smal and medium-sized enterprises in the context of innovation and entrepreneurship in the economy. *Polish Journal of Management Studie*s, 2016, 13(1), pp. 30–39.
D'ESTE, P., IAMMARINO, S., SAVONA, M., TUNZELMANN, N. V. What hampers innovation? Revealed barriers versus deterring barriers. *Research Policy*, 2012, 41, pp. 482–488.
DE JONG, J. P. J. AND VERMEULEN, P. A. M. Determinants of product innovation in small firms: A Comparison Across Industries. *International Small Business Journal*, 2006, 24 p.
EBRD. *Innovation in Transition* [online]. EBRD Transition Report 2014. [cit. 20.3.2019]. <https://www.ebrd.com/publications/transition-report-2014-english.pdf>.
EHRMANN, M., SOUDAN, M., STRACCA, L. Explaining European Union Citizens' Trust in the European Central Bank in Normal and Crisis Times. *Scandinavian Journal of Economics*, 2013, 115(3), pp. 781–807.
FILIPPETTI, A. AND ARCHIBUGI, D. Innovation in times of crisis: National Systems of Innovation, structure and demand. *Research Policy*, 2011, 40(2), pp. 179–192.
FRITZ, W. Determinants of Product Innovation Activities. *European Journal of Marketing*, 1989, 10, pp. 32–43.
GRIFFITH, R., REDDING, S., VAN REENEN, J. Mapping the two faces of R&D: Productivity growth in a panel of OECD industries. *Review of Economics and Statistics*, 2004, 86(4), pp. 883–895.
GUADALUPE, M., KUZMINA, O., THOMAS, C. Innovation and Foreign Ownership. *The American Economic Review*, 2012, 7, pp. 3594–3627.
GUERZONI, M. An Application of Graphical Models To The Innobarometer Survey: A Map of Firms's Innovative Behaviour. *SSRN Electronic Journal*, 2014, 22 p.
HASHI, I. AND STOJIC, N. The impact of innovation activities on firm performance using a multi-stage model: Evidence from the Community Innovation Survey 4. *CASE Network Studies & Analyses,* 2010, 410, 39 p.
HORVÁTH, R. AND KATUŠČÁKOVÁ, D. Transparency and trust: the case of the European Central Bank. *Applied Economics*, 2015, 58(57), pp. 1–14.
LESÁKOVÁ, Ľ. et al. *Determinanty inovačnej aktivity malých a stredných podnikov v SR.* 1st Ed. Banská Bystrica: Matej Bel University, 2010.
LORENZ, E. Do Labour Markets and Educational and Training Systems Matter for Innovation Outcomes? A multi-level analysis for the EU27. *Science and Public Policy*, 2011, 38(9), pp. 691–702.
LÖÖF, H. AND HESHMATI, A. On the relationship between innovation and performance: a sensitivity analysis, *Economics of Innovation and New Technology*, 2006, 15, pp. 317–344.
MAIRESSE, J. AND ROBIN, S. Innovation and productivity: a firm-level analysis for French Manufacturing and Services using CIS3 and CIS4 data (1998–2000 and 2002–2004). *Working paper,* Paris: CREST-ENSAE, 2009, 20 p.
MATARADZIJA, A. et al. *Innovation and innovative performance in the European Union* [online]. International Conference 2013: Active Citizenship by Knowledge Management & Innovation. [cit. 12.2.2019]. <http://www.toknowpress.net/ISBN/978-961-6914-02-4/papers/ML13-225.pdf>.
MONTRESOR, S. AND VEZZANI, A. Intangible investments and innovation propensity: Evidence from the Innobarometer 2013. *Industry and Innovation*, 2016, 23(4), pp. 331–352.
OECD. *Oslo Manual. Guidelines for Collecting and Interpreting Innovation Data.* 3rd Ed. Paris: OECD Publications, 2005.
OUM, S., NARJOKO, D., HARVIE, CH. Constraints, Determinants of SME Innovation, and the Role of Government Support [online]. *ERIA Discussion Paper Series*, 2014. [cit. 20.3.2019] <http://www.eria.org/ERIA-DP-2014-10.pdf>.
POLDER, M., LEEUWEN, G., MOHNEN, P., RAYMOND, W. Product, Process and Organizational Innovation: Drivers, Complementarity and Productivity Effects. *MPRA Paper*, University Library of Munich, Germany. 2010.
RAYMON, L. AND ST-PIERRE, J. R&D as a determinant of innovation in manufacturing SMEs: An attempt at empirical clarification. *Technovation*, 2010, 30, pp. 48–56.
REHMAN, N. U. Innovation performance of Chilean firms, a bivariate probit analysis. *Journal of Entrepreneurship in Emerging Economies*, 2016, 8(2), pp. 204–224,
ROMIJN, H. AND ALBALADEJO, M. Determinants of innovation capability in small electronics and software firms in southeast England. *Research Policy*, 2002, 31, pp. 1053–1067.
ROSA, J. M. Determinants of Product and Process Innovation in Canadas' Dynamic Service Industries [online]. *Working papers – Science, Innovation and Electronic Information Division*, 2002. [cit. 20.3.2019] <https://pdfs.semanticscholar.org/5123/d88298e9ae2bd2677d785679abade75c6f73.pdf>.
STEPHENS, S. Innovation in micro enterprises: reality or fiction? *Journal of Small Business and Enterprise Development*, 2016, 23(2), pp. 349–362.
TETHER, B. S. Do services innovate (Differently)? Insights from the European innobarometer survey. *Industry and Innovation*, 2005, 12(2), pp. 153–184.
TRIGO, A. Mechanisms of learning and innovation performance: The relevance of knowledge sharing and creativity for Non-Technological Innovation. *International Journal of Innovation and Technology Management*, 2013, 10(6), article number 1340028.

VAN LEEUWEN, G. AND KLOMP, L. On the contribution of innovation to multi-factor productivity growth. E*conomics of Innovation and New Technology*, 2006, 15, pp. 367–390.
VEGA-JURADO, J. The effect of external and internal factors on firms' product innovation. *Research Policy*, 2008, 37, pp. 616–632.
VOKOUN, M. R&D and innovation activities – search for better definitions and an economic-historical approach. *2nd Economics & Finance Conference*, 2014, pp. 553–576.
YACHMENEVA, V. AND VOL'S'KA, G. Factors influencing the enterprise innovation. *Econtechmod. An International Quarterly Journal*, 2014, 1, pp. 133–138.
ZEMPLINEROVÁ, A. AND HROMÁDKOVÁ, E. Determinants of firm´s innovation. *Prague Economic Papers*, 2012, 4, pp. 487–503.