Relationship of University-Industry Cooperation and Innovative Activities – Case Study of Croatia, Czech Republic and Hungary[1]

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THE AIMS OF THE PAPER

Cooperation has no boundaries; we called it trans-sector cooperation (mostly university-industry and the government can be also incorporated). The knowledge and industrial sector cooperation is the most common now. The knowledge sector is perceived as a contractor (or creator) of various knowledge. Industrial enterprises use this knowledge for the emergence of innovation and also for commercialization. The advantages of cooperation are mutual, because it gives the possibility of implementing further basic and applied thereafter (industrially exploitable) research for the universities. Research institutions acquire also additional resources and cooperation allows their students to engage in practical issues. Enterprises acquire from the cooperation relatively cheap source of new knowledge, access to instrument and technological equipment. In regions, there are different tools on the principle of knowledge sharing and cooperation. These include for instance industrial clusters or business networking, as well as regional innovation systems and global production chains. The applications of public incentives and subsidies from public budgets are often applied because they are perceived as of regional policy tools. But there is the question about the efficiency of this public support, as well as about the efficiency of the cooperation among the mentioned entities.

METHODOLOGY

Therefore, we analyse the influence of University-Industry cooperation and public financing (from national and European funds) on the growth of turnover from innovated products in manufacturing industries in Croatia, Czech Republic and Hungary by using own multiple linear regression models and data from the Eurostat (CIS database) between the years 2010-2012.

MOST IMPORTANT RESULTS

In total, we analysed 7 189 firms, and the results show, that this kind of cooperation influence firms' innovation activities differently within each country.

RECOMMENDATIONS

We therefore recommend industries to strengthen their cooperation with universities and public research institutes, clients, customers and other competitors through improving trust and better management.

Keywords: university, industry, cooperation, innovation activities, manufacturing

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INTRODUCTION

Individual market players are trying to have an effective business strategy, which include even the most efficient use of factors of production, which are available for the firm. It turns out that firms precisely differ in their ability to generate innovations, ability to come to the market with new products or those which are demanded by other firms (in terms of individual orders: Gnyawali and Srivastava 2013). For the ability of the firm to generate innovations within a short time and under economic conditions, it is necessary to fulfil certain preconditions. The internal settings of the firm and the quality of available resources are the important prerequisites for every firm. These factors can involve: mainly the production factors (hard infrastructure, capital equipment, technology, etc.), but also soft infrastructure, which consist of suitable structure of employees and their abilities and competencies (Blöchliger 2013). Their knowledge, but also the ability to be creative and innovative, to come up with new ideas and improvements of existing production, are essential elements of an internal firm environment that is necessary for innovations (Hung and Chou 2013).

Another prerequisite is the existence of the company in an innovative environment (innovation ecosystem), i.e. an environment that encourages the development of innovations. There are many suitable partners for cooperation, knowledge-intensive and the most demanding customers, who are forcing firms to innovate and come up with new products. Innovative environment can help to stimulate the cooperative relationships between firms and possibly other entities that can play an important role in the cooperative chains. These entities are special knowledge-intensive organizations; their main activity is research and development (De Marchi and Grandinetti 2013).

The reminder of this paper is divided in the following way. The first section is focused on the problems of the university-industry collaboration. The second section describes the methodology and analysis results. The last section brings the conclusions and some political implications and recommendations.

THEORETICAL BACKGROUND

Variously knowledge-intensive production processes require different environments and knowledge inputs. For high-technology industries, they choose so called searching strategy for innovation inputs. It also includes the networking and cooperation in the development of innovations (Cheng and Huizingh, 2014, Laursen and Salter 2014). This special type of market (market of collaboration) is characterized by a very strong competition in the field of technologies and products. This market records strong dynamics and dependence on technological discoveries, but it reduces the technological uncertainty and the competition is mainly focused on costs (Parida et al. 2012).

From the observation of the practice, we see that different firms need to build their competitive advantage on the different type of knowledge, depending on the firm´s life cycle or the new product´s life cycle. It has been proven in many studies that tacit knowledge is very important for the early phases of product development. For the successful application in the market and commercialization, it is necessary to use the relationships between firms and other organizations. Knowledge transfer (or acquisition) is the significant synergistic effect in the application of knowledge and creation of new innovative products (Laursen 2012). All this is subjected to geographical proximity in many industries. It multiplies the effectiveness of cooperative links (Prevenzer 1997, Broekel and Boschma 2012). This applies not only to firms but also to proximity to the knowledge-intensive institutions. It has been demonstrated that high-quality research at universities may increase the agglomeration of innovation activities. However, the knowledge of skilled workers is grouped together in all phases of the industrial cycle (Audretsch 1998).

In mature industries, the firms should rely on the codified knowledge that becomes the basic substance of innovation (Robertson and Smith 2008). However, development and globalization trends bring new knowledge and technologies and firms have to react quickly. It entails the constant need for adaptation of firms, their investments in technology (Freddi 2009; von Tunzelmann 2009) and seeking well-skilled labour force.

These changes are costly and time consuming especially in high-technology sectors (McGahan and Silverman 2001). Therefore, many firms in the high-tech productions rely on the availability of technology and knowledge what are produced by universities and research institutes. Mature industries conversely acquire market knowledge from customers or competitors. Robertson and Smith (2008) argue that, in mature industries, market knowledge provides the framework for the recombination and creation of knowledge through problem solving, via a range of activities and R and D (Freitas et al. 2013, Mina et al. 2014).

Especially high-tech industries will cooperate with universities much more frequently. The firms have the opportunity to gain scientific support for the development of their products (Powell et al. 1996, Lee 2000). The effective cooperation will be implemented based on personal contacts (not merely on formal level; Furman and MacGarvie 2009). Taking into account the objectives of the involved organizations, also the students and alumni will be involved in research in framework of the university-industry collaboration (Freitas et al. 2013). The results can be published firstly in the form of conference (or journal) papers, and later in the form of patents (Furman and MacGarvie 2009).

University-industry cooperation is one form of such cooperation. The aim of this article is to examine the influence of the university-industry cooperation on innovative activities of the selected firms. The analysis will be conducted in selected EU countries. It will be interesting to see which of innovation environmental indicators (in a selected sample of firms) influence the variable and what impact they will have on the variable if they act alone or cooperate.

DATA AND METHODOLOGY

In our analyses, we created original multiple linear regression models to investigate the relationship between one dependent variable, represented by the % of turnover in new or improved products introduced during 2010–2012 (=*innovation performance*), and a number of selected independent variables (6 different groups of determinants affecting innovation activities – see Table 1: Independent variables). As a data source, we used harmonized questionnaire Community Innovation Survey (CIS) that was conducted between the years 2010-2012 by Eurostat. CIS is part of the EU's science and technology statistics and is carried out every two years by the EU member states and a number of ESS member countries. Only firms with more than 10 employees and with a response rate greater than 60% were used for the survey. In total, we analysed 7,189 firms from the manufacturing industries (NACE Categories 10-33) in Croatia (1280 firms), Czech Republic (3110 firms) and Hungary (2799 firms) by using own multiple linear regression models. These models are commonly used for these kinds of analyses (e.g., Nieto and Quevedo 2005; Chen and Huang 2009; Schneider and Spieth 2013). Data from Eurostat we don't consider as censored or truncated (as in study of Doran and Ryan 2016).

Multiple linear regression models take the general form as follows (Chatterjee and Hadi, 2013):

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \varepsilon \quad (1)$$

where

y is a dependent variable;

$x_1, x_2 \ldots x_n$ are independent variables;

ε is an error term that accounts for the variability in y that cannot be explained by the linear effect of the n independent variables;

$\beta_1, \beta_2 \ldots \beta_n$, called the regression parameters or coefficients, are unknown constants to be determined (estimated) from the data.

Verification of whether the data from the Community Innovation Survey were correlated was conducted by using Spearman's test. The general formula for Spearman's rank correlation coefficient takes the general form as follows (Weinberg and Abramowitz 2002, Borradaile 2013):

$$r_s = 1 - \frac{6\sum d_i^2}{N^3 - N} \quad (2)$$

Spearman's coefficient (r_s) measures the strength of the linear relationship between each two variables when the values of each variable are rank-ordered from 1 to N, where N represents the number of pairs of values (the N cases of each variable are assigned integer values from 1 to N inclusive, and no two cases share the same value). The difference between ranks for each case is represented by di. All calculations were made using the statistical software STATISTICA (StatSoft Inc. 2011). The values of Spearman´s test rejected the hypothesis that the data are correlated with a level of significance at $p<0.05$. After fulfilling the first prerequisite (uncorrelated data) and the rejection of multicollinearity in the model, the analysis itself was conducted.

Table 1: Independent variables

Financing	Cooperation	Innovation	Expenditures	Firm Activities	Other
Public funding from local or regional authorities (FUNLOC)	Cooperation arrangements on innovation activities (CO)	Introduced a new or significantly improved product into the market (INN_G)	Intramural R&D (RRDIN)	Merge with or take over another enterprise (ENMRG)	The largest market in terms of turnover between 2010-2012 (LARMAR)
Public funding from the central government (FUNGMT)	Other enterprises within an enterprise group (COGP)	Introduced a new or significantly improved service into the market (INN_S)	Extramural R&D (RRDEX)	Sell, close, or outsource some of the company's tasks or functions (ENOUT)	
Public financial support from the EU (FUNEU)	Suppliers of equipment, materials, components, or software (COSUP)	Introduced a new or significantly improved process into the market: method of production; logistic, delivery, or distribution system; supporting activities (INN_P)	Acquisition of machinery (RMAC)		
	Clients or customers (COCUS)		Acquisition of external knowledge (ROEK)		
	Government or public research institutes (COGOV)				
	Competitors or other enterprises in the sector (COCOMP)				
	Universities or other higher education institutions (COUNI)				

Source: own construction

RESULTS OF REGRESSION ANALYSES IN CROATIA, CZECH REPUBLIC AND HUNGARY

In the first step, we analysed single effects of each determinant of innovation activities on firms´ innovation performance within the countries. Results in Table 2 show that determinants of innovation activities vary across countries because every country has different initial conditions and background for innovation activities.

Table 2: Comparison of determinants of innovation activities between the countries

	Croatia R=0.616; R^2=0.380 p=3.35E-11	**Czech Rep.** R=0.502; R^2=0.252; p=3.1E-05	**Hungary** R=0.985; R^2=0.970 p=0.008
FUNGMT	0.117	0.901	0.003***
FUNEU	-	0.532	0.002***
COGP	-	-	0.001***
COSUP	-	-	0.002***
COCUS	0.035**	-	0.319
COCOMP	0.055*	-	-
COUNI	0.149	0.105	0.008***
COGOV	0.128	-	-
INN_G	-	-	0.002***
INN_S	-	0.017**	0.119
INN_P	-	0.437	-
RRDIN	0.825	0.000***	0.001***
RRDEX	0.569	0.644	0.001***
RMAC	0.701	0.530	0.005***
ROEK	0.653	0.992	0.002***
ENMRG	0.482	0.752	-
ENOUT	0.000***	-	-
LARMAR	0.186	0.017**	0.002***

Legend: significant at P<0.1; ** significant at P<0.05; *** significant at P<0.01
Source: own calculations

In Croatia and in the Czech Republic, there is a lack of single effects on innovation performance determinants. Therefore, there is a need for proper combinations of selected determinants that could lead to the creation of more significant results affecting innovation performance. It is clear and it was empirically proved that innovations do not occur in isolation (Stejskal and Hajek 2015, Hajek *et al.* 2016, Prokop and Stejskal 2016). The University-Industry cooperation within these countries was completely insignificant. On the other hand, Hungarian manufacturing firms, that focused on the determinants of innovation activities, significantly affected innovation performance independently (without further combinations of these determinants), also in the case of University-Industry cooperation, that significantly influenced firms´ innovation performance (0.008***). In the next section, we consequently analyzed the combinations of determinants of innovation activities that could lead to the creation of synergies and spillover effects in every country.

MUTUAL EFFECTS OF INNOVATION PERFORMANCE DETERMINANTS WITHIN SELECTED COUNTRIES

Firstly, we analysed firms´ situation in Croatian manufacturing industries and the effects of University-Industry cooperation on firms´ innovation performance. Results in Table 3 show, that firms in manufacturing industries in Croatia were able to significantly influence their innovation performance by using an appropriate cooperation partners (Universities and Public Research Institutes). In Croatia, as is shown in Table 3, the determinants of innovation activities did not influence firms´ innovation performance in isolation. Companies are not able to benefit from these determinants, and they consequently fail to increase their innovation output. On the other hand, companies that choose proper cooperation partners and other determinants of innovation activities (e.g., FUNLOC, FUNGMT, LARMAR, and ENOUT) significantly influenced their performance (Table 3).

Table 3: Influence of University-Industry Cooperation on Innovation Performance in Croatia

	Universities (or Other Higher Education Institutions)	**Public Research Institutes (or the Government)**	**Clients or Customers**	**Competitors (or Other Enterprises in the Sector)**
FUNLOC	0.001***	0.380	0.006***	0.002***
FUNGMT	0.000***	0.004***	0.465	0.685
ENOUT	0.016**	0.020**	0.714	0.756
ENMRG	0.024**	0.022**	0.331	0.934
COGOV	0.029**	-	0.018**	0.645
COUNI	-	0.029**	0.001***	0.765
COCUS	0.001***	0.018**	-	0.941
COCOMP	0.765	0.645	0.941	-
LARMAR	0.011**	0.008***	0.797	0.552

Legend: significant at P<0.1; ** significant at P<0.05; *** significant at P<0.01
Source: own calculations

In the manufacturing industries in the Czech Republic, the situation was different (in comparison with Croatia) and firms were not able to succeed from the University-Industry cooperation. On the other hand, regression models showed creation of other advanced factors´ combinations and significant links influencing firms´ innovation performance. Largest market in terms of turnover (LARMAR), in combination with proper determinants, proved as important determinant with influence on dependent variable (Table 4).

Table 4: Advanced combinations of variables in the Czech Republic

	European subsidies and Market orientation	**European subsidies and National subsidies**	**Market orientation and National subsidies**	**Market orientation and Service innovation**	**National subsidies and Merge with or take over another enterprise**
INN_P	0.029**	0.987	0.027**	0.040**	0.837
INN_S	0.024**	0.411	0.025**	-	0.033**
CO	0.009***	0.282	0.543	0.653	0.110
	European subsidies and Service innovation	**Market orientation and Merge with or take over another enterprise**	**Merge with or take over another enterprise and Service innovation**	**Merge with or take over another enterprise and Cooperation with universities**	
INN_P	0.587	0.152	0.264	0.173	
INN_S	-	0.076*	-	0.011**	
CO	0.028**	0.003***	0.004***	-	

Legend: significant at P<0.1; ** significant at P<0.05; *** significant at P<0.01
Source: own calculations

For example, public financial support from the EU was shown as insignificant in manufacturing industries in the Czech Republic (Table 2 – FUNEU: 0.532). On the other hand, in combination with LARMAR and with introduction of process innovation (INN_P), we found significant impact on innovation performance (Table 4 - FUNEU*LARMAR*INN_P: 0.029***). This is important finding, because, as we can see, there is an emerging inefficiency in provision of public financial support (both from national and European funds). For example, common combinations of national and European funds do not lead to the creation of significant effects (Table 4 - FUNEU*FUNGMT*INN_P: 0.987; FUNEU*FUNGMT*CO: 0.282). To reach stronger results, involvement of cooperation is necessary (Table 4 - ENMRG*INN_S*CO: 0.004***; LARMAR*ENMRG*CO: 0.003***).

In Hungary, proper market orientation, as well as in the Czech Republic, leads to creation of strong links influencing the dependent variable (in all cases). It is the same for the innovation of services, most strongly in the case of cooperation within groups of companies. On the other hand, innovation of goods is significant only if it is well targeted on the proper market (0.004***) or supported by national funds (0.004***). University-Industry cooperation was insignificant in most cases.

Moreover, as we can see in Table 5, provision of public subsidies (national and/or European) could be effective, but there is a need to find proper factors´ combinations. However, combination of national and European funds is not strong and significant (0.132). This seems to be a problem because most of collaborations (industry-industry; university-industry; university-government-industry) are supported from both national and European funds (in most cases, these combinations are required).

Table 5: Advanced combinations of variables in Hungary

	Market orientation	**European subsidies**	**National subsidies**	**Cooperation within groups of companies**
European subsidies	0.003***	-	0.132	0.007***
National subsidies	0.005***	0.132	-	0.198
Services innovation	0.002***	0.002***	0.004***	0.001***
Goods innovation	0.004***	-	0.004***	-
	Cooperation with suppliers	**Innovation of goods**	**Cooperation with universities**	
European subsidies	0.005	-	0.219	
National subsidies	0.002***	0.004***	0.009***	
Services innovation	0.002***	0.003***	-	

Legend: significant at P<0.1; ** significant at P<0.05; *** significant at P<0.01
Source: own calculations

CONCLUSION AND PRACTICAL IMPLICATIONS

Innovations play an important role in the process of gaining competitive advantage and economic growth of firms or countries. In the era of globalised knowledge economy, each economic entity is pushed to find new knowledge sources (collaboration partners) that will help them to share their knowledge, create knowledge spillovers and innovate. Universities play an important role in the process of cooperation because they provide cheap source of new knowledge and ideas. On the other hand, universities and firms have different goals and aims and therefore cooperation with universities is not only effective. Therefore, we analysed different influence of University-Industry Cooperation on firms´ innovation performance within Croatia, Czech Republic and Hungary. Results confirmed our claim and showed that this kind of cooperation influence firms' innovation activities differently within each country and is not always efficient. It is clear because finding of proper determinants of innovative activities (in general) represent a complex process lacking universal formula of which variables positively affect innovation creation and performance. Each country, firm and industry has different initial position at the market and individual innovation potential and ability to absorb foreign knowledge. For these reasons, we provide some practical implications for firms in manufacturing industries in each country (see Table 6) that could help them to innovate more efficiently.

Table 6: Practical implications

Country	Practical implications
Croatia	strengthening coop. with Universities and Public Research Institutes promote cooperation with clients, customers and competitors (Lead user theory: e.g. Von Hippel, 2005; Co-opetition theory: e.g. Gnyawali and Park, 2011) Strengthening the cooperation of universities and public research Institutes, cooperation with clients, customers and competitors through improving trust and better management, this can build efficient and effective communication paths among the collaborating partners leading to success (Dodgson, 1992; Perkmann & Salter, 2012)
Czech Republic	support innovative activities and proper market orientation properly target public subsidies Government should evaluate the impact of subsidy programs to determine how R&D subsidy programs could be made effective. Corrective measures on government's unfavorable tax climate must be addressed.
Hungary	proper market orientation and support service innovation do not combine national and European subsidies Government, universities, industries and policy makers need to support crucial mechanisms that can improve firm's innovative performance by means of providing public funding and tax break incentives for R&D collaboration.

Source: own construction

For future research, we plan to make consequent analyses within other European countries and also within other industries of national economies. The fact that the CIS dataset does not contain details about the content of cooperation of companies with the different partners could be expected as limitation of this research.

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