The Influence of Information Sharing and Collaboration on the Extent of Innovation activities

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***Abstract*—In the present day, developed economies that function on the basis of knowledge indicate better economic performance. Many studies have shown that one prerequisite for economic growth is the availability of information and new findings – when the conditions of creativity and high technology are also present (not only for companies but also for regions and entire economies). Economic players face ever increasing pressure to find these resources while respecting restricting conditions such as time (innovation must be introduced in the market very quickly) and cost. Another frequently emphasized prerequisite is the effectiveness with which the factors of production are used – in addition to the ability to cooperate with other market players or partners in business networks. Therefore, this paper's goal is to analyze how the availability of information, information sharing and cooperation influence the extent of innovation activities in enterprises. The analysis was conducted by using CIS data for Germany, Slovenia, Portugal and Bulgaria in years 2010-2012. The results indicate that companies try to obtain information from various partners as well as from documents and use them to create innovations. The most frequently used sources of information are different within countries according to their innovation performance. For our analyses, own multiple linear regression models were used.**

Keywords-information sharing; collaboration; case study

I. INTRODUCTION

Individual countries' economies are faced with constant change, which requires partial or complete transformation on their part. This is primarily a result of globalizing tendencies but also of the changing economic environment, the evolution of input prices (primarily the price of labor and capital), new findings, and advances in the areas of communication and technology. New types of economies are emerging along with their corresponding economic theories; these describe the basic production factor upon which the economy's performance depends. The most advanced economies have been transforming from product-based economies to knowledge-based economies.

Private companies must deal with change very rapidly if they want to be successful on international markets. In small transition economies, the development of the business sector is slower; however, in many export-oriented economies, reforms actually occur under the influence of relationships with international partners, the arrival of new investors, the implementation of foreign direct investment, etc. In order for companies to effectively use all their opportunities and achieve their necessary production (and competitive) advantage, they primarily seek out and effectively use non-financial assets such as patents, know-how, new technologies, or ICT [26]. These are assets that are dependent on knowledge and can be primarily developed by educated workers.

It is interesting to note that this does not only result in changes in the private sector, because distinct reform pressures also emerge in the public sector. Primarily, these involve improving education, creating a highly qualified work force, building knowledge and ICT infrastructure, and increasing IT literacy. There is also a noticeable effort on the part of the state (and the regional governments) to define public policies so that they support private organizations in the specific areas mentioned here. In this way, the public sector supports the growth of productivity and increasing the competitiveness of the economy as a whole using state aid [12, 18].

The remainder of this paper is structured as follows. In the next section, we present the theoretical background for knowledge economy determinants and the main research questions. Section 3 provides the characteristics of the dataset and the research methodology. Section 4 provides the experimental results. In Section 5, we discuss the results that were obtained and conclude the paper with suggestions for future research.

II. THEORETICAL BACKGROUND

In his work, Drucker [13] predicted that, in the future, competitive advantage will be determined by knowledge, whose bearers (knowledge workers) will be able to use it to create innovation. This is the thinking that is often behind many businesses when they attempt to increase their absorption capacity in this way. These tendencies have also been confirmed by a number of studies and scholars. They primarily focus on companies' ability to identify, capture, produce, share, transfer, or accumulate knowledge [14, 36, 38]. However, many scholars point out that merely having knowledge (or being able to obtain it) does not suffice; it is also necessary to be able to work with, use, and effectively share it internally (within the company; [2, 16, 38]). Knowledge sharing, which contributes to increasing knowledge capacity and thus influences the production

function of individual entrepreneurs, appears to be a very effective knowledge process [1, 19]. Its positive influence has been proved by numerous studies (e.g., [9, 10, 15, 29]. They have confirmed that effective knowledge sharing results in new projects, an increase in company performance, new innovations, and market growth from production that has undergone innovation. To be objective, it is also necessary to list studies in which the authors confirm that sharing knowledge does not lead directly to increasing organizations' performance [20]. However, this only means that the statement needs to be modified. Their results state that increased performance results indirectly and under the influence of the knowledge and communication processes that have been implemented at the companies. However, it is not critical to distinguish whether company performance is influenced directly or indirectly for the purposes of this article.

According to other studies, however, the effectiveness of knowledge sharing is influenced by a whole range of determinants [24]. One of the fundamental determinants is the influence of the environment in which the economic actors are located. This is primarily created and influenced by individual entities. However, macroeconomic aspects are also influential, followed by organizations from the public sector and public policies that can help shape and cultivate the environment [33]. A number of scholars call attention to the positive influence of business networks or regional innovation systems and, recently, global production chains. All these often work on the Triple Helix principle; they are knowledge- and collaboration-based [27]. Knowledge sharing occurs within them, and – to a large degree on account of the cooperation and communication between the individual actors – it also leads to the emergence of spillover effects [31]. Their emergence makes sharing knowledge markedly more effective as a process of communication and innovation.

Knowledge sharing often takes place within economic units (enterprises) as well. Information sharing, communication, discussion, and knowledge sharing in a collective all lead to using knowledge within production processes, which often results in innovative products and services. This should then contribute to the competitive advantage of the company as a whole. The individual processes in which knowledge sharing occurs have been described in many studies. One example of these is the SECI model (socialization, externalization, combination, and internalization; Polanyi, 1966 in [23]). The model works with tacit and explicit knowledge and describes the processes in which they emerge and are shared. Knowledge sharing practices in the organization as a whole are very important for preserving valuable heritage, learning new techniques, solving problems, creating core competences, and initiating new situations [38]. It is necessary to mention that tacit knowledge emerges within the process of socialization, whereas explicit knowledge is relevant to all the phases described in the SECI model. Consequently, it is possible to easily share explicit knowledge within an institutionalized structure. Overall, it is easy to capture, map, manage, influence, and evaluate its effectiveness, whereas sharing tacit knowledge is far more difficult. Nearly always, this materializes and is transmitted only through personal contact. There must be a high degree of trust and willingness between the provider and the recipient as well as sufficient input knowledge on the part of the recipient in order for the transmission of tacit knowledge to occur at all [17, 37]. Studies describe many obstacles to this type of knowledge transmission. The most significant ones are that it is absolutely incapable of being measured, it is difficult to express or capture, the effects show up only over the long term, and it is interdependent on the mental processes of the provider and the recipient. For this reason, it is almost impossible to evaluate the benefits and effectiveness of sharing tacit knowledge.

Sharing explicit knowledge is also difficult to measure, but there are studies that evaluate the effectiveness of such processes (e.g. [32, 39]). They are distinctly influenced by information technologies, which support this knowledge sharing [11]. The source of the information and knowledge that companies have available is also a determinant. In fact, these can distinctly influence a company's ability to acquire necessary information or knowledge, use them, and positively influence their performance. Therefore, the goal of this study is to analyze how various information sources and collaboration partners influence firms´ innovation activities within countries with different innovation performance. The main purpose of this research is to identify significant information sources and collaboration partners for firms according to their countries overall innovation performance. These results could support decision making of policy makers and firms´ stakeholders and provide overview of important information sources and collaboration ties that should be deeply analyzed in the future research.

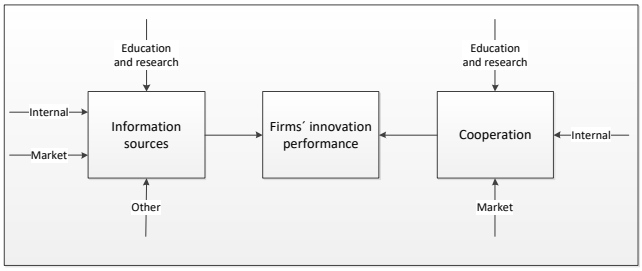
III. Data and Methods

In this paper, we analyse the influence of information sources and cooperation with different partners on firms´ innovation performance within selected countries, according to their innovation performance measured by European Commission (EC). EC annually publishes its Innovation Union Scoreboard, which provides a comparative assessment of the EU member states' research and innovation performance. The countries are divided into four groups according to their innovation performance: innovation leaders, strong innovators, moderate innovators, and modest innovators.

For our analyses, we created original multiple linear regression models to explain the relationship between one dependent variable (firms´ innovation performance), represented by the % of turnover in new or improved products introduced during 2010–2012 (new to the market), and information sources and cooperation (independent variables). Relationship between variables is shown in Fig. 1. Both, information sources and cooperation consisted of several variables that were divided into multiple groups according to their origin. All variables and their influences are shown in Table 1.

In total, we analysed 15 062 enterprises from 4 countries from the manufacturing industries (NACE Categories 10-33).

Each country represents one group of innovation performance. We analysed firms in the manufacturing industries in Germany (innovation leader), Slovenia (a strong innovator), Portugal (a moderate innovator), and Bulgaria (a modest innovator). Countries were selected according to their innovation performance measured in Innovation Union Scoreboard 2015 by European Commission.



Source: own

Figure 1. Relationship between dependent and independent variables.

Multiple linear regression models are commonly used for these kinds of analyses (e.g. [4, 8, 22] – logistic regression; [28] - multiple linear regression) and therefore we suppose these models sufficient. Regression models take the general form as follows [7]:

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

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.

Data for the analyses were obtained from the Community Innovation Survey 2010–2012. The Community Innovation Survey (CIS) is a harmonized questionnaire, which is part of the EU's science and technology statistics. It is carried out every two years by the EU member states and a number of ESS member countries. Verification of whether the data from the CIS were correlated was conducted using Spearman's test. 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 d_i. The general formula for Spearman's rank correlation coefficient takes the general form as follows [5, 40]:

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

The values of Spearman´s test rejected the hypothesis that the data are correlated with a level of significance at $p<0.05$. Moreover, we also tested the collinearity among the independent variables by using Variance Inflation Factor (VIF) for each regression model (country). Multicollinearity was not observed in any of the models (VIF<5). All calculations were made using the statistical software STATISTICA [30]. After fulfilling the first prerequisite (uncorrelated data) and the rejection of multicollinearity in the model, the analysis itself was conducted.

IV. Results

Results of multiple linear regression models created for each country are shown in Table 1. These results show that information sources and cooperation with different partners influence firms´ innovation performance differently within countries.

In Germany, three information sources significantly influenced the growth of firms' turnover from innovation in positive way. These sources are clients or customers from the private sector that enabled firms to flexibly respond to customer needs (innovative) and go ahead their competitors. Focusing on clients and customers' needs is highlighted by user theory, which states that user-centered innovation is a very powerful and general phenomenon that supports innovative activities [34-35]. Scientific journals and trade/technical publications represent other significant firms´ source in Germany. It allows easy and cheap way how to spread existing and create new knowledge and ideas that could support innovation performance. Professional and industry associations represent third important information source for firms´ in German manufacturing industries. On the other hand, sharing information sources within enterprise group significantly decreased firms´ innovation performance and led to the knowledge outflows and to the creation of negative spillover effects. Also using information from suppliers of equipment, materials, components, and software led to decreasing of innovation performance in Germany.

Analyses of the influence of cooperation with different partners on firms´ innovation performance within German manufacturing industries showed that these kinds of cooperation did not significantly influenced firms´ innovation performance. Cooperation with clients or customers from the private sector (significant source of information, see above) led to the growth of firms´ innovation performance as well as cooperation with universities or other higher education institutions. In Germany, the Vocational Education and Training (VET) dual system support cooperation between firms´ and education & research institutes. The role of knowledge and competence represent key principles of VET [41].

VET system could support practical skills that are necessary for researchers because it offers qualifications in a broad spectrum of professions and flexibly adapts to the changing needs of the labour market [6].

However, no kind of cooperation significantly influenced firms´ innovation performance. One of the reasons are that innovation leaders are not pushed by competitors to create change and to find other sources (information, cooperation partners). Firms do not cooperate (to protect their own knowledge) but they are using external information sources.

Therefore, firms in German manufacturing industries should focus on internal information sources that significantly decreased firms´ innovation performance. In addition, finding new (proper) cooperation partners could support creation of positive knowledge spillovers and bring new knowledge.

TABLE I. RESULTS OF ANALYSES

		Countries			
		Innovation Leader	**Strong Innovator**	**Moderate Innovator**	**Modest Innovator**
		Germany	Slovenia	Portugal	Bulgaria
Information source		R=0.735 R2=0.540	R=0.821 R2=0.674	R=0.735 R2=0.540	R=0.341 R2=0.116
Internal	Within enterprise or enterprise group	0.012** (-0.289)	0.949 (0.059)	0.678 (0.254)	0.473 (0.167)
Market	Suppliers of equipment, materials, components, or software	0.037** (-0.189)	0.027** (-6.897)	0.083* (-2.459)	0.927 (0.072)
	Clients or customers from the private sector	0.002*** (0.272)	0.048** (5.858)	0.569 (-1.357)	0.882 (-0.846)
	Clients or customers from the public sector	0.959 (-0.004)	0.009*** (-8.775)	0.114 (6.806)	0.923 (0.475)
	Competitors or other enterprises in industry	0.210 (-0.131)	0.002*** (-7.330)	0.105 (-1.963)	0.953 (0.112)
	Consultants and commercial labs	0.568 (-0.050)	0.004*** (11.231)	0.142 (5.949)	0.969 (-0.085)
Education & research institutes	Universities or other higher education institutions	0.911 (-0.009)	0.023** (6.954)	0.162 (-4.744)	0.955 (0.334)
	Government, public or private research institutes	-	0.564 (-0.206)	0.383 (1.699)	0.952 (0.079)
Other	Conferences, trade fairs, exhibitions	0.259 (-0.118)	0.668 (-0.081)	0.534 (1.425)	0.970 (0.284)
	Scientific journals and trade/technical publications	0.099* (0.186)	0.064* (0.400)	0.202 (-4.909)	0.979 (0.245)
	Professional and industry associations	0.027** (0.199)	0.280 (-0.305)	0.210 (4.579)	0.983 (-0.047)
Type of cooperation partner					
Internal	Other enterprises within enterprise group	0.423 (-0.019)	0.174 (-0.080)	0.024** (-0.131)	0.821 (-0.007)
Market	Suppliers of equipment, materials, components, or software	0.467 (-0.018)	0.117 (0.129)	0.752 (0.020)	0.280 (0.044)
	Clients or customers from the private sector	0.451 (0.018)	0.310 (-0.081)	0.617 (-0.035)	0.565 (-0.026)
	Clients or customers from the public sector	0.822 (-0.005)	0.160 (0.104)	0.680 (-0.027)	0.857 (0.007)
	Competitors or other enterprises in sector	0.006*** (-0.062)	0.870 (-0.013)	0.452 (0.048)	0.765 (0.013)
	Consultants and commercial labs	0.738 (-0.008)	0.936 (0.006)	0.448 (-0.055)	0.793 (-0.011)
Education & research institutes	Universities or other higher education institutions	0.434 (0.025)	0.844 (0.017)	0.860 (0.013)	0.927 (0.004)
	Government, public or private research institutes	0.230 (-0,033)	0.059* (-0.146)	0.369 (0.068)	0.910 (-0.005)

Legend: R = correlation coefficient; R2 = coefficient of determination;*** significant at p<0.01; ** significant at p<0.05; * significant at p<0.10; Beta coefficient is shown in brackets and shows whether selected variables influenced dependent variable in positive or negative way and led to its growth or decrease.

Source: own

In Slovenia, results showed that firms´in manufacturing industries were influenced by various sources of information. Similarly, to Germany, clients or customers from the private sector and scientific journals and trade/technical publications led to the growth of firms´ innovation performance. Moreover, Slovenian firms were significantly influenced by other information sources. These sources are consultants and commercial labs and universities or other higher education institutions that represent the place where the new knowledge are usually created and one of the cheapest sources of information for firms (in general). On the other hand, following information sources led to decrease of firms´ innovation performance: (i) suppliers of equipment, materials, components, or software; (ii) clients or customers from the public sector; (iii) competitors or other enterprises in industry.

We could assume that firms in Slovenian manufacturing industries are more pushed to compete; find new sources of knowledge and to create change (innovate), in comparison with firms in German manufacturing industries. However, not every information source (as well as cooperation partner) influence firms´ innovation performance positively. Therefore, it is necessary to support using of proper sources of information and focus on inefficient sources of information.

In Portugal and Bulgaria – countries whose innovation performance was below the EU average – the information sources and cooperation with different partners were not used in efficient way. In fact, some of information sources led to the growth of firms´ innovation performance in Portugal but not significantly. These sources were, for example, internal information sources (within enterprise or enterprise group). On the other hand, cooperation with other enterprises within enterprise group significantly decreased firms´ innovation performance within manufacturing industries in Portugal. In Bulgaria, there were no significant factors influencing firms´innovation performance but some information sources and cooperation partners led to the growth of firms´innovation performance (not significantly) – for example education & research institutes (information source), clients or customers from the public sector (cooperation partners). All results are concluded in the following part, including practical implications for policy makers.

V. Conclusions

In this study, we analyzed the influence of information sources and cooperation with different partners on firms´ innovation performance within four European countries representing groups of innovation performance (innovation leader - Germany, strong innovator - Slovenia, moderate innovator – Portugal, modest innovator - Bulgaria) according to Innovation Union Scoreboard published by European Commission. Results show that within countries that are ahead (or close to) EU average in innovation performance (Germany and Slovenia), information sources are used in more efficient way. These countries are more able to exploit their innovation potential and share knowledge. Clients and customers from the private sector represent one of the most significant information sources for these countries and therefore we propose focusing on the customers' needs and requirements (specifically innovation). Scientific journals and trade/technical publications represent other significant source that offers easy and relatively inexpensive access to new knowledge and information.

On the other hand, these countries are not forced to collaborate and do not collaborate in efficient way because of emergence of lock-in effect. Ref. [21] states that firms are by definition resistant to radical change, and firms will always to prefer to maintain the status quo if it does not endanger their competitiveness (firms are often slow in changing their dominant designs, because they are path dependent and technologically locked in). By their very nature, all innovation systems have some degree of inertia, and this may lead to lock-in. Moreover, while offering a veneer of protection to existing systems in the shorter term, innovation lock-in tends to create barriers to more sustainable innovation [3]; this can lead to a country's decline in innovation performance as well as a decline in its competitive advantage and prosperity. Therefore, we propose to focus on cooperation and to find proper cooperation partners – clients and customers from the private sector and universities or other higher education institutions in Germany; suppliers of equipment, materials, components, or software and clients or customers from the public sector in Slovenia.

In the countries that are below the EU average in innovation performance (Portugal and Bulgaria), firms are not able to fully exploit information sources and opportunities of cooperation with different partners. One of the reasons could be that sufficient innovation background for the sharing of knowledge (e.g. infrastructure, absorption capacity) is missing within these countries. In these countries, we can see typical example of innovation paradox. These countries face obstacles in elements of its environment and therefore, determinants of innovative activities (e.g., information sources and cooperation) are not able to influence the growth of turnover from innovation (even if they were provided with sufficient public funds). The country struggles with a lack of absorption capacity but may also be hampered by a lack of demand for innovation outputs (from both enterprises and research organizations). Therefore, we strongly suggest coordinating public policies, building sufficient infrastructure in the country, supporting the identification of innovative needs and the demand for innovation outputs, and helping promote trust among organizations [25]. For the future research, we plan to explore links between information sources and their impact on firms' innovation activities within other European countries.

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