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A Comparative Perspective of National Innovation Systems in Europe

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Abstract. This paper provides empirical evidence on the innovation performance in European countries in the period 2012-2014 based on a micro level analysis. We provide a comparative perspective among three different institutional settings in Europe: Central and Eastern European countries (CEE), Southern European countries and Northern European countries. We estimate the CDM model of simultaneous equations while using data from the Eurostat Community Innovation Survey 2014 (CIS2014). This model directly links R&D engagement and intensity to innovation outcomes measured either as process or as product innovation and then estimates the effectiveness of the innovative efforts in terms of productivity gains. In general, during our observation period, which fell in the aftermath of the 2008 financial crisis, the links between innovation inputs, innovation outputs and productivity were found to be rather weak. Another remarkable finding from our study is that, notwithstanding a higher participation in innovation by larger firms, among those firms that innovate, innovation output is relatively higher for small firms (compared to large firms) in Northern Europe. This relatively important role for small firms in innovation was not found for the other two country groups.

Keywords: innovation system, productivity, CDM model, European countries, CIS2014.

JEL classifications: L1, L60, O31, O33.

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1. Introduction

The concept of national innovation system emerged during the late 1980s and early 1990s (Freeman, 1987; Lundvall 1988; Nelson, 1993) and was subsequently adopted by the OECD (1997, 1999 and 2002). The national concept of innovation interprets the persistence of areas of industrial and technological strength and the presence of very specific institutional configurations in particular countries. However, national innovation systems are more than frameworks for interaction.

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They depend on a number of different factors such as knowledge, skills, financial resources, demand and other factors which to a large extent have been regarded as being provided within the nation (Edler and Fagerberg, 2017).

The general assessment is that many countries in the EU have innovation systems that are still developing, while a few advanced countries in Europe have very well developed innovation systems (Verspagen et al., 2018). Countries in Europe have different innovation capabilities and different levels of technological development. Some of them have excellent performance in research and scientific infrastructure but also major technological gaps are present between the countries in Europe. This creates the so called "European Paradox" and compared with the USA, European countries tend to achieve weaker performance in terms of industrial application and innovation outputs (Archibugi and Filippetti, 2011; Pavitt, 1998; Lorenz and Lundvall, 2006).

The role of companies is fundamental since they are primary sources of innovation. In this paper we analyze the national innovation systems on firm-based conception by using the CDM model of simultaneous equations (Crépon et al., 1998). The model directly links R&D engagement and intensity to innovation outcomes measured either as process or as product innovation, and then estimates the effectiveness of the innovative efforts in terms of productivity gains. We believe that this approach can increase the understanding of the functioning and dynamics of the national systems of innovation in European countries.

The research question of this paper is focusing on the determinants of firms' innovation behavior in Europe in different institutional settings. Since the dataset used in this paper provides statistics broken down by countries, types of innovators, economic activities and size-classes, we focus on cross-sectional samples for three groups of countries: i) Central and Eastern Europe (new EU members) comprising of: Bulgaria, Croatia, Czech Republic, Hungary, Romania and Slovakia; ii) "old" European (Union) countries representing the "Southern" countries: Spain, Portugal and Greece; and iii) "old" European countries representing the "Northern" nations: Norway and Germany.

In our three previous studies (Tevdovski et al., 2017; Toshevska-Trpchevska et al., 2019; Makrevska Disoska et al., 2020) we differentiated the countries into two institutional settings: one for the Central and Eastern European (CEE) countries, and the other for the Western European (WE) countries or "old" European Union countries. We were actually using the example of "old" European countries as a benchmark for the development and strength of their innovation systems. But, since in our previous analyses we acknowledged that the performance differences among the "old" European countries increased, for the purposes of this paper we divide the "old" European countries into two groups: one representing the "Northern" national innovation systems of Germany and Norway, and the other, representing the so-called "Southern" European countries and their national innovation systems: Spain, Portugal and Greece. Now, we use the Northern national innovation systems as a benchmark for the other two groups of countries. Introducing the separate group of "Northern" countries is one of the novelties of the present paper. Also, we are running the model with the latest available CIS2014 database in order to ensure the continuity of the research.[2]

Although the innovation systems in Europe are aiming towards interdependence and a systemic approach, there are considerable differences. By using information from the CIS14 database, the main aim of this paper is to show how the innovation systems of European countries work and to evaluate their effectiveness. This paper is among few that try to quantify the full interrelationship between R&D activity, innovation outputs and productivity, while also taking account of exogenous drivers of these firm performance indicators.

The paper is organized as follows. Section 2 presents an overview of the characteristics of different innovation systems in Europe and tries to work out some conceptual problems. Section 3 presents an overview of the literature dealing with related aspects. Sections 4 and 5 explain the econometric model and present the data used in the analysis. In Section 6 the results obtained from the analysis are presented and interpreted, followed by the Conclusion section.

2. Characteristics of Different Innovation Systems in Europe

In this section we present the main characteristics of the innovation systems in CEE countries as well as the "Northern" and "Southern" groups of European countries.

2.1. CEE Countries

The growth of productivity in CEE countries was remarkable during the 1990s (the years of transition), and it was a result of non-R&D factors. Van Ark and Piatkowski (2004) show that the reduction of labor costs was the main reason for increased productivity: 80% of the productivity growth was a result of job cuts. Other reasons were closure of unproductive lines of business and uneven paths of layoffs rather than technological improvements.

In the post-transition years, recovery of GDP growth has not been accompanied by parallel recovery in R&D. The R&D systems are characterized by low investments and low efficiency and they play a relatively small role in the current economic performance of CEE countries. This requires re-orientation of R&D systems from current exclusive knowledge generation orientation to knowledge diffusion and absorption orientation (Radosevic, 2012). Data from Croatia show that 82% of researchers were employed in the public sector

2. CIS is the Community Innovation Survey, a survey among companies in Europe exploring their innovation activities. The survey is coordinated by Eurostat. See also Section 5.

(Aralica, 2009), meaning that the private sector underperformed in innovation activities.

Since the beginning of the crisis, the countries from CEE were the most affected ones (Makrevska Disoska et al., 2020; Filippetti and Archibugi, 2010). According to Szabo et al. (2013), over 90% of the enterprises in CEE countries felt the recession and suspended their innovation activity. Firms in CEE countries are suppliers to core companies in advanced countries and therefore they faced strong cuts in R&D from the mother companies, during the financial and economic crisis (Filippetti and Archibugi, 2010; European Commission, 2009). The CEE region is classified as "peripheral" or "lagging behind", and suffers from a lack of skilled human capital as well as differences in the structural and sectoral composition of the "economic fabric", making them less prone to innovation, but more prone to the phenomenon of brain drain and deficient institutional settings (Rodriguez-Pose, 2015). In general, the innovation systems in these countries suffer from inefficiencies in the conversion of R&D and innovation outputs into productivity due to low R&D capacities, as well as low production and innovation capabilities.

2.2. "Northern" Countries: Germany and Norway

Innovation systems in Northern European countries are not only the strongest in terms of the size of R&D expenditures, but they are also well integrated in the local economies and societies, thus confirming that they are of a highly developed nature.

The German innovation system is characterized by apprenticeship schemes and universities as well as research institutes such as the Max Planck Society and large and innovative industrial companies—for example, BASF, Daimler, Hoechst, and Siemens. These industries became prominent in the second half of the 19th Century. Germany continues to have strengths in vehicles, mechanical engineering and certain electrical and chemical related industries (Allen, 2010). However, Germany lacks behind in the cutting-edge and medium to high-tech innovation performance relative to its competitors, USA and Japan.

Norway has demonstrated its ability to seize the initiative where opportunities arise, supporting the development of successful clusters in resource-based sectors, in particular in oil and gas, shipbuilding, fisheries and aquaculture. The revenues generated from these sectors became a driving force in the growth and technological upgrading of these sectors and helped to establish a virtuous circle for building strong, interlinked research and innovation capabilities. Norway is clearly more pragmatic and bases its innovation more on a "doing, using and interacting" innovation approach (Cooke, 2016).

However, the country is still highly dependent on oil and gas and the goal is to move towards a more competitive, effective and efficient innovation system with sufficient incentives and checks and balances for better performance in research and innovation (OECD, 2017). Both countries remain resilient to the effects of the crisis: Germany due to its strong economic fundamentals, well-established innovation system and advanced sectoral specialization and Norway because of the strong economic fundamentals based on its resource abundance (Izsak et al., 2013).

2.3. "Southern" Countries: Spain, Portugal and Greece

"Southern" European countries are characterized by the so called "Southern European mentality". The overall structures of the industrial sectors of the economy and exports are still dominated by low-profit industries such as the wood and textile industries, fisheries, tobacco and shipbuilding.

The characteristics of the innovation system are a lack of collective goods and inputs for innovation, under-investment in the training of highly skilled human capital, a predominant role played by the State with respect to private actors in relation to R&D activities and a weak system of relations and cooperation between the actors participating in innovative processes (Donatiello and Ramella, 2017).

Since the beginning of the crisis the attention in these countries was shifted from innovation policies toward macroeconomic stabilization due to the budget constraints and financial restrictions. An additional problem due to the low investments in science, spending and salary cuts concerns the outmigration of talented young people. This can cause an irreversible weakening in these countries' research and innovation systems (Izsak et al., 2013).

3. Literature Review

Firm-level characteristics play a significant role in shaping innovation activity within industries and also within countries (Frenz and Lambert, 2009). The "prime units for innovation" are private firms (Lundvall, 2007). Of course, the innovation performance of the firm depends on the "innovation" environment in which the firm is operating. Knowledge assets, knowledge creation and knowledge flows are components of the institutional conditions that form the arena for innovation and growth of firms (Nelson and Nelson, 2002). The key idea of innovation systems analysis is that interaction between different actor categories stimulates innovation, and determines the nature of innovation. Three specific actor categories in the innovation systems in the EU are: the higher education sector, the (semi-)public research institutes sector, and private firms (Verspagen et al., 2018). These environments differ across countries and that is why evident differences in the innovation systems exist in the EU (Hinloopen, 2003).

One key research question of this paper is whether there is a positive or negative relationship between innovations and productivity levels. In theory, firm level innovations increase productivity levels through reduction of input costs, improved production processes and/or improvement in products that can lead to increased demand and higher economies of scale, and therefore improve the firm's capacity to grow (Edler and Fagerberg, 2017). Empirically, different authors measure different aspects of the relationship between innovation and productivity. Most notably, different innovation measures are used such as innovation output (innovative sales per employee), process innovation, and product innovation. Moreover, regarding productivity measures, some studies use productivity levels while others use productivity growth.

The creators of the CDM model, Crépon et al. (1998), were among the first ones to explore this relationship empirically and estimated that firm productivity correlates positively with innovation output. Many other studies in this field conclude that innovation leads to a better productivity performance (Mairesse et al., 2005; Benavente, 2006; Jefferson et al., 2006; Criscuolo, 2009; Hall et al., 2009; Kijek and Kijek, 2019). Hashi and Stojcic (2013) claim that productivity increases with innovation output although the relationship is stronger in Western European countries compared to Central Eastern European (CEE) countries. Baum et al. (2017) confirm the positive and significant relationship for six different sectors.

Most of the studies consider the impact of four types of innovation – product, process, organizational and marketing innovation. Having in mind the imperfect measurement of innovation and the simultaneity of different types of innovation, it is difficult to isolate the individual effect of each type of innovation on productivity performance. Therefore, if we go into further exploration of the link between innovation and productivity, we can find mixed empirical evidence among different types of innovation and productivity. Hence, although several studies — mentioned above — find a positive relationship between innovation and productivity, Table 1 presents findings that confirm a *negative* (inverse) relationship between different types of innovation and productivity.

Lööf and Heshmati (2003) find that the link between process innovations and productivity is statistically significant and negative in Sweden. The results are confirmed in the study of Janz et al. (2003) and Van Leeuwen and Klomp (2006). The coefficient for process innovation in Griffith et al. (2006) is negative but statistically non-significant in Spain. Lööf and Heshmati (2006) find a negative relationship between process innovations and productivity in both the manufacturing and the service sector. Roper et al. (2008) explain the negative innovation effect on productivity as a disruption effect. The introduction of new products to a plant may disrupt production and reduce productivity if they are produced inefficiently with negative productivity consequences before becoming established.

The post-crisis period was characterized by a negative impact on the intensity of R&D activity (measured as R&D expenditures as a percentage of GDP), and resulted in subdued innovation activity. Therefore, most recent studies even find a negative relationship between innovation and productivity; this is especially evident in the CEE countries (Toshevska-Trpchevska et al., 2019; Makrevska Disoska et al., 2020) since CEE countries were the most severely hit by the recession and this is affecting the process of convergence in innovation performance in the EU (Archibugi and Filippetti, 2011).

In conclusion, the empirical literature provides inconsistent results about the relationship between innovation and firm level productivity.

Table 1. Empirical literature on the productivity – innovation inverse relationship

Authors (year)	Country	Observations	Method	Innovation measure	Output measure	Estimated impact of innovation on productivity [a, b]	Results
Lööf and Heshmati (2003)	Finland Norway Sweden	1994-1996; 353 firms 1995-1997; 485 firms 1994-1996; 407 firms	CDM model variation: 3SLS	Log innovative sales per employee	Log sales per employee	FI: 0.090 (0.058) prod -0.029 (0.060) proc NO: 0.257 (0.062)***prod 0.008 (0.044) proc SE: 0.148 (0.044)***prod -0.148 (0.043)***proc	Positive feedback in Norway, but not in Finland; mixed evidence in Sweden. Control for process innovation dummy.
Janz et al. (2003)	Germany Sweden	352 firms; 1998-2000 206 firms; 1998-2000 (from knowledge-intensive manufacturing)	Sequential IV+IMR	Process	Log sales per employee	GE: -0.136** (0.069) SE: -0.030 (0.119)	Innovation intensity is controlled for
Van Leeuwen and Klomp (2006)	The Netherlands	1994-1996; 1926 firms	CDM variation: 3SLS	Log innovative sales per employee	Log growth of sales per employee	0.133 (0.026)*** prod -1.256 (0.471)*** proc	Positive influence of product innovation, but significantly negative of process innovation on productivity; Control for capital/ employee and for share of innovative sales.
Lööf and Heshmati (2006)	Sweden	1974 manufac-turing firms; 1996-1998 1081 services firms; 1996-1998	3SLS +IMR	Process	Log value added per employee	-0.071***mfg -0.071 services	Innovation intensity is controlled for.

Griffith et al. (2006)	France Germany Spain UK	3625 firms 1998-2000 1123 firms 1998-2000 3588 firms 1998-2000 1904 firms 1998-2000	Sequential IV	Product and process	Log sales per employee	0.060*** prod 0.069** proc -0.053 prod 0.022 proc 0.176*** prod -0.038 proc 0.055*** prod 0.029 proc	
Roper et al. (2008)	Ireland and Northen Ireland	1991-2002		Share of innovative sales	Value added per employee	-0.302*** (0.067)	Control for process innovation dummy
Makrevska Disoska et al. (2020)	CEE WE (Western Europe)	2010-2012 8 countries from CEE (41,287 firms) 4 countries from WE (50,371 firms)	CDM	Innovation output (product innovation)	Log of total turnover per employee	CEE: -1.551 (0.414)*** WE: -0.228 (0.184)	
Toshevska-Trpchevska et al. (2019)	CEE WE	2008-2010 9 countries from CEE (44,984 firms) 4 countries from WE (51,847 firms)	CDM	Innovation output (product innovation)	Log of total turnover per employee	CEE: -1.149 (0.193)*** WE: 5.317 (1.186)***	

[a] Numbers in parentheses are standard errors.
[b] In this column, prod = product innovation; proc = process innovation.
***: $p < 0.01$; ** $p < 0.05$.

4. Model and Methodology

In this paper we use a modified version of the CDM model. The original CDM model is named after its inventors Crépon, Duguet and Mairesse in Crépon et al. (1998) and it is a model of simultaneous equations for estimation of the relationship between the drivers of innovation and productivity. The model tries to estimate the effect of R&D engagement and intensity on innovation outcome (process or product innovation) and then estimates the effectiveness of the innovative efforts leading to productivity gains.

This modified version of the CDM model is a multi-stage model proposed by Hashi and Stoji (2013) and has many similarities with the model used by Lööf and Heshmati (2002, 2006). A limited degree of correlation is allowed between the two parts of the model through the inclusion of the inverse Mills ratio in the innovation output equation. Also, the CDM model adopted in this paper encompasses several types of innovations, namely: process, product, marketing and organizational innovations.

We point out that a slight drawback of the original CDM model is that it focuses only on the cross-sectional nature of data while a possible temporal dimension is eschewed (Baum et al., 2017). However, even though a growing body of literature tries to incorporate this dimension within the CDM model (Aw et al., 2011; Mairesse and Robin, 2017), the results presented there are not compatible with the known conclusions for CEE economies (Toshevska-Trpchevska et al., 2019, and Makrevska Disoska et al., 2020).

The estimation procedure consists of two general stages which can be divided into two additional sub-stages. In the first stage we implement a Heckman correction model to estimate the innovation input constrained on a variable that models the decision to innovate. Mathematically, this stage can be explained with the following equations

$$Prob(d_i = 1 \mid x_{i0}) = \Phi(\beta_0 x_{0i}) + u_{0i} \tag{1}$$

$$w_i = \alpha d_i + \beta_1 x_{1i} + u_{1i} \, . \tag{2}$$

Equation (1) models the unobserved decision to innovate d_i of a firm i as a probit regression (with Φ denoting the cumulative standard normal distribution) dependent on a vector x_{0i} of covariates and their parameter vector β_0. With Equation (2) we estimate the unobserved innovation input w_i , measured as the log of the amount (in Euro) of expenditure on intramural or extramural R&D, acquisition of machinery, equipment and software or acquisition of other external knowledge in year of survey (CIS survey questionnaire), using a vector x_{1i} of covariates, weighted by parameters β_1 and adding d_i as an additional explanatory variable that helps us to “correct” for the potential selection bias which arises due to using only data for firms that decided to invest in innovation.

The second stage utilizes the three-stage least squares (3SLS) methodology to simultaneously estimate the innovation output and the productivity of the firm. We note that the first two equations have been already estimated with robust standard errors while the third and fourth equation standard errors are estimated via bootstrap. This stage is specified as

$$r_i = \beta_w w_i + \beta_q q_i + \beta_2 x_{2i} + u_{2i}, \tag{3}$$

$$q_i = \beta_r r_i + \beta_3 x_{3i} + u_{3i} \, . \tag{4}$$

In equation (3) r_i is the innovation output measured as the logarithm of the firm’s percentage of turnover in year of survey coming from goods or services that were new to market or to enterprise in 3 years prior to survey (CIS survey questionnaire), and u_{2i} is the error term. Together with this equation we estimate equation (4) – the productivity q_i of the firm, quantified as the log of the firm’s turnover divided by number of employees in year of survey, as a linear function of the innovation output r_i and a vector of exogenous explanatory variables x_{3i} with parameter vector β_3. As in the previous equations, u_{3i} is the error term.

In order to show the robustness of the model, we re-estimated the third and fourth equations by adding measures for human capital and firm ownership in the labor productivity equation, and by using the Two-stage least squares estimator.

The results of both experiments are quite similar and are available on request from the authors.

5. Data

The analysis is based on data provided by Eurostat in the Community Innovation Survey 2014 (CIS14). The CIS14 represents a harmonized survey which aims to collect microdata on innovation activities conducted between years 2012 and 2014 in enterprises from EU member states and a number of ESS (European Statistical System) member countries. The CIS database is the only source of information on innovation at the firm level that is available for Europe as a whole.[3]

We focus on cross-sectional samples for three groups of countries: Central and Eastern Europe (CEE) as new EU members, and we divide the other European countries into old European countries representing the "Southern" nations and old European countries representing the "Northern" nations. The sample of CEE countries includes firms from the following new EU members: Bulgaria, Croatia, Czech Republic, Hungary, Romania and Slovakia. The sample of "Southern" European countries includes firms from Spain, Portugal and Greece and the sample of "Northern" European countries from Germany and Norway. Certain countries are left out from the analysis due to unavailability and limited access of CIS data. The CEE sample contains 40,531 firms, the NE sample contains 11,327 firms and SE 39,923. Table 2 presents the summary statistics of the innovation and productivity variables. Most of the firms (in the three observed groups of countries) operate on the national market, as well as on the European market. Also, the firms have reported that the sources of product and process innovation are mostly from within the enterprises.

3. The CIS Survey questionnaires can be found here: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/bfcf3592-83a3-4066-ab70-f9a5cf492253

Table 2. SummaryStatistics (Sample averages of the variables)

	CEE (Central and Eastern Europe)	NE (Northern Europe)	SE (Southern Europe)
Decision to innovate	0.245	0.493	0.413
Innovation Input	195,382	9,888,928	392,225
Innovation Output	0.062	0.057	0.142
Labor Productivity	107,670	555,459	199,815
Firm size	104.912	165.01	105.45
Markets			
National	0.658	0.723	0.772
European	0.508	0.449	0.501
Other	0.230	0.330	0.347
Part of a group	0.258	0.578	0.304
Abandoned or ongoing innovations	0.027	0.135	0.087
Innovations			
Organizational Innovations	0.134	0.341	0.286
Marketing Innovations	0.139	0.321	0.231
Subsidies			
Local	0.035	0.126	0.076
National	0.207	0.312	0.120
European	0.206	0.084	0.048
Sources of product innovation			
Within enterprise	0.100	0.260	0.179
With other enterprise	0.056	0.182	0.083
Sources of process innovation			
Within enterprise	0.896	0.735	0.883
With other enterprise	0.787	0.663	0.697
Observations	34295	10422	39066

Unfortunately, the dataset from CIS 2014 does not contain the variables for the factors hampering innovation that were available in the previous CIS survey questionnaires. Those are: cost factors (lack of finance or too high cost of the innovation); knowledge factors (lack of qualified personnel, lack of information on technology and markets, difficulty in finding cooperation partners for innovation); market factors (market dominated by established enterprises, uncertain demand for innovative goods or services) and reasons not to innovate (due to prior innovations by your enterprise or because of no demand for innovations). This fact might be taken into consideration when interpreting the results from the empirical analysis.

6. Interpretation of Results

The results are presented step-by-step in 4 separate sub-sections in order as the analysis was done. The estimation procedure was conducted in parallel for the three samples of companies from Central and Eastern Europe, Northern and Southern Europe.

6.1. Decision to Innovate

The first stage of the model estimates the importance of certain factors and their influence on the decision of firms to initiate the innovation activity. The results from the first stage are presented in Table 3. The factors that were taken into account to estimate their influence over innovation activity were: firm size, market orientation, being part of a group, having previously abandoned innovation activity, and applying organizational or marketing innovation activities. For the three samples of countries completely similar and logical results were obtained. These findings are similar to those previously observed by Hashi and Stoji (2013) and Makrevska Disoska et al. (2020) but quite different to the results that Toshevska-Trpchevska et al. (2019) obtained by using CIS 2010 data.

All factors that were taken into the estimation procedure appear to be statistically significant and have a positive influence over the decision of companies to perform any kind of innovation activity. Larger firms have higher probability to engage in innovation activity in all three country settings. Market orientation no matter whether national, orientation towards the European market or to other foreign markets is highly statistically important and of quite similar value among the firms operating in all three country settings.

Being part of a group and having previously abandoned innovation activities also increases the probability of deciding to innovate in all three samples and the coefficient is especially high for the companies in Central and Eastern Europe (the t-test for equality of the coefficients between CEE and SE and CEE and NE has p-value p = 0.000). This suggests that knowledge transfer from other parts of a group and knowledge accumulated from previous innovative activities motivates firms to engage in further innovation in all country groups.

Table 3. Decision to innovate

	CEE	NE	SE
Firm Size	0.056	0.099	0.079
	[0.009]***	[0.014]***	[0.008]***
Markets			
National	0.272	0.278	0.233
	[0.020]***	[0.036]***	[0.022]***
European	0.257	0.371	0.193
	[0.022]***	[0.038]***	[0.020]***
Other	0.149	0.199	0.303
	[0.023]***	[0.040]***	[0.020]***
Part of a group	0.225	0.392	0.108
	[0.021]***	[0.032]***	[0.018]***
Abandoned or ongoing innovations	3.109	0.837	0.618
	[0.182]***	[0.047]***	[0.028]***
Innovations			
Organizational innovations	0.759	0.445	0.568
	[0.026]***	[0.032]***	[0.018]***
Marketing innovations	0.805	0.595	0.723
	[0.025]***	[0.033]***	[0.019]***
_cons	-1.810	-1.247	-1.789
	[0.050]***	[0.198]***	[0.062]***
Observations	34295	10422	39066

Note: Dummy variables for industries according to NACE classification were included. Standard errors between brackets. ***: p < 0.01; **: p < 0.05; *: p <0.1.

Organizational and marketing innovations that measure the introduction of new business practices for organizing procedures, new methods of organizing work responsibilities and decision making, new methods of organizing external relations with other firms or public institutions, significant changes to the aesthetic design or packaging of a good or service, new media or techniques for product promotion, new methods for product placement or sales channels, or new methods of pricing goods or services, have a positive impact on the probability of the firm's decision to engage in innovation in all three samples of countries.

6.2. Innovation Input

In Table 4 the results for the estimation of the innovation investment equation are presented. The variables explaining the innovation input encompass the spending on all innovation activities mentioned in the previous sub-section. Moreover, three dummy variables on receiving different types of subsidies (from local, national and EU sources) are added. The natural logarithm of the overall amount spent on innovation between 2012 and 2014 indicates the Innovation input. The results in this stage are mostly positive and as expected for all three country groupings. Similar results were observed in Makrevska Disoska et al. (2020). However, they are quite different from the situation observed in the study of Toshevska-Trpchevska et al. (2019), where the authors found that innovation investment decreases with firm size and the effects of market orientation on the degree of innovation were rather confusing.

In this study we find high statistical significance for the positive effect of the size of the firms, of their orientation on the European, or other foreign markets; being part of a group or having previously abandoned innovation activities, on the innovation activity of the companies operating in all three country groupings. This finding may be explained by the notion that the economic crisis has had a significant effect on the innovation process and only big companies, companies that have been involved in the innovation process before (even if the activity was abandoned), or which were part of a group, were more eager to getting involved in the innovation process. The orientation towards the national market does not appear to be significant for the innovation activity of companies operating in CEE countries and is only significant at 10% level for the firms operating in Northern Europe.

Table 4. Innovation Input

	CEE	NE	SE
Firm Size	0.728	0.982	0.569
	[0.027]***	[0.027]***	[0.014]***
Markets			
National	0.037	0.176	0.210
	[0.075]	[0.102]*	[0.053]***
European	0.337	0.302	0.212
	[0.071]***	[0.094]***	[0.040]***
Other	0.270	0.437	0.189
	[0.060]***	[0.077]***	[0.036]***
Part of a group	0.530	0.524	0.559
	[0.058]***	[0.097]***	[0.030]***
Abandoned or ongoing innovations	0.374	0.264	0.220
	[0.094]***	[0.109]**	[0.035]***
Innovations			
Organizational innovations	0.398	-0.212	0.154
	[0.066]***	[0.076]***	[0.031]***
Marketing innovations	0.290	-0.142	0.019
	[0.070]***	[0.090]	[0.033]
Subsidies			
Local	0.306	0.428	0.491
	[0.114]***	[0.070]***	[0.032]***
National	0.729	0.650	0.742
	[0.062]***	[0.065]***	[0.029]***
European	0.812	0.668	0.497
	[0.067]***	[0.087]***	[0.041]***
constant	5.819	7.732	8.333
	[0.245]***	[0.434]***	[0.156]***
Observations	32869	9217	38407

Note: Dummy variables for industries according to NACE classification were included. Standard errors between brackets. ***: $p < 0.01$; **: $p < 0.05$; *: $p < 0.1$.

In CEE countries and Southern Europe organizational innovations have a significant positive effect whereas in Northern Europe their effect is reversed (p-values for the t-tests of NE versus CEE and SE is p = 0.000 and 0.000). This situation is quite similar with the one observed in Makrevska Disoska et al. (2020) for the companies operating in Western Europe. Marketing innovations appear to be significant only for the companies operating in CEE countries. A statistically significant and positive influence is observed from the results estimating the influence of subsidies on the innovation investment in all three country groupings.

6.3. Innovation Output

In the third and the fourth stage of the estimation procedure only the companies that reported positive amounts of innovation output were included. The third stage of the model measures the innovation output as natural logarithm of the share of sales of new products and services in total turnover of the firm. For this purpose explanatory variables that were taken into account were the following ones: firm size; innovation input from the second stage; natural logarithm of labor productivity; organizational and marketing innovations; and receiving different types of subsidies. We also included the inverse Mills ratio from the first stage to control for potential selectivity bias. In Table 5 the results of this stage of the estimation procedure are presented. The coefficient of the Mills ratio is statistically insignificant for all three samples suggesting the absence of selectivity.

Table 5. Innovation output

	CEE	NE	SE
Firm Size	0.224	-0.424	0.337
	[0.184]	[0.099]***	[0.191]*
Inverse Mills Ratio	-0.237	-0.190	-0.508
	[0.367]	[0.318]	[0.449]
Innovation input	-0.209	0.006	-0.732
	[0.273]	[0.173]	[0.421]*
Labor Productivity	-0.253	-0.395	0.119
	[0.208]	[0.351]	[0.396]
Innovations			
Organizational innovations	0.092	-0.114	0.141
	[0.144]	[0.129]	[0.078]*
Marketing innovations	0.273	0.277	0.074
	[0.120]**	[0.110]**	[0.081]
Subsidies			
Local	0.020	0.015	0.466*
	[0.091]	[0.102]	[0.244]
National	0.140	0.021	0.422
	[0.180]	[0.093]	[0.248]*
European	0.208	0.037	0.311
	[0.268]	[0.059]	[0.192]
Constant	1.272	-5.250	-5.170
	[0.537]**	[2.614]**	[1.401]**
Observations	401	769	1262

Note: Dummy variables for industries according to NACE classification were included. Standard errors between brackets. ***: $p < 0.01$; **: $p < 0.05$; *: $p < 0.1$.

One remarkable result for the Northern European firms is that the coefficient on firm size is significant but negative meaning that innovation output is higher for smaller firms. This illustrates the increasing role of entrepreneurs and small firms in innovation in modern economies (Vyas and Vyas, 2019). On the other hand, the same coefficient is positive but insignificant for the sample of Central and Eastern European companies and positive with small significance for Southern European firms (p-value for differences in coefficients between CEEC and North Europe p = 0.006, between CEEC and South Europe p = 0.364, and between North and South Europe p = 0.000).

In all three samples of companies, neither innovation input nor labor productivity seem to stimulate innovation output in the analyzed period 2012-2014. These findings are completely opposite to the ones that Toshevska-Trpchevska et al. (2019) have obtained for the period 2008-2010. A possible explanation for this result may be the decreased innovation activity in all three country settings in the period 2012-2014, i.e. in the aftermath of the 2008 financial crisis.

The dummy variable on organizational innovations appears to be not significant, except with a small significance for the firms in Southern Europe (p-value for differences between Southern Europe and CEEC: p = 0.763, and between Southern Europe and Northern Europe: p = 0.191). Marketing innovations, on the other hand, exhibit higher marginal effect for the companies operating in CEEC and in Northern Europe, even though with no statistical differences between the country groups (p-value for differences between Southern Europe and CEEC: p = 0.310, and between Southern Europe and Northern Europe: p = 0.264).

With respect to subsidies, the results indicate that they are not significant for increasing innovation output for the firms in Europe. Again, the results revealing the (lack of) influence of subsidies on innovation output in the analyzed period 2012-2014 are completely opposite to those for the period 2008-2010 (Toshevska-Trpchevska et al., 2019), but almost the same as for the period 2010-2012 (Makrevska Disoska et al., 2020).

6.4. Labor Productivity

The last stage of the model measures the labor productivity as a natural logarithm of the ratio of the firm's total turnover and total employment in 2014. The variables that were taken into account to estimate the productivity function were firm size; innovation output from the third stage; organizational and marketing innovations; and two plus two dummy variables indicating whether sources of process and product innovations were developed within enterprises or through cooperation with other firms and institutions. In Table 6 the results of the labor productivity estimation are presented.

Table 6. Labor Productivity

	CEE	NE	SE
Firm Size	0.237	0.644	0.053
	[0.121]*	[0.611]	[0.076]
Innovation output	-2.293	1.377	-1.484
	[0.968]**	[1.821]	[0.357]***
Sources of product innovation			
Within enterprise	-0.084	0.267	-0.124
	[0.167]	[0.332]	[0.110]
With other enterprise	0.089	0.625	0.074
	[0.114]	[0.782]	[0.069]
Sources of process innovation			
Within enterprise	0.056	0.141	0.026
	[0.092]	[0.211]	[0.105]
With other enterprise	0.188	-0.022	0.150
	[0.338]	[0.134]	[0.095]
Innovations			
Organizational innovations	0.078	0.186	0.271
	[0.265]	[0.301]	[0.122]**
Marketing innovations	0.621	-0.489	0.127
	[0.327]*	[0.486]	[0.128]
Constant	3.692	11.933	8.753
	[2.477]	[1.198]***	[1.875]***
Observations	401	769	1262

Note: Dummy variables for industries according to NACE classification were included.
Standard errors between brackets. ***: $p < 0.01$; **: $p < 0.05$; *: $p < 0.1$.

From the results presented in Table 6 one can observe that firm size has a positive and significant influence on labor productivity only in CEE countries. It seems that in the Northern and Southern European samples of companies, smaller and larger firms are equally productive, ceteris paribus, whereas in the CEE countries, larger firms are more productive than small firms, as one would expect.

The results indicate that innovation output has a negative and significant effect on labor productivity for the companies in Central and Eastern Europe and in Southern Europe, while the effect is not significant in Northern Europe. Although a non-significant or even negative relationship between innovation output and productivity seems counterintuitive, it is not unusual in CDM research (see Table 1).

For all three country groupings the results suggest that neither process nor product innovation are significant for increasing labor productivity. The situation is the same with the effect of organizational and marketing innovations over labor productivity except for the impact of organizational innovations on labor productivity in the Southern European sample of countries.

7. Conclusion

The main goal of this paper is to look at the effectiveness of the innovation systems in Europe by applying a comparative perspective. The group of Central and Eastern European countries stand out as a primary source for our analysis as the innovation systems of these countries are trying to catch up the developed, so-called "old" and already established, European innovation systems. The national innovation systems of Germany and Norway were grouped and used as a benchmark innovation system, as their innovation systems have proved to be stable over time. And the other European innovation systems were classified as the Southern European group comprising of the still vulnerable national innovation systems of Greece, Spain and Portugal.

The first result that should be annotated is that the proportions of firms involved in innovative activities in Europe in the period 2012-2014 remained the same as in the period 2010-2012 or just after the financial crisis: about 25% in CEE countries and between 40 and 50% in other European countries (see Table 2). Although it may look like these levels of innovation activity are stable, they are still below the levels recorded in 2006-2008 or the pick recorded in 2008. This decreased innovative activity of the European firms expectedly has an effect on the results for innovation output and labor productivity.

The most important results in this paper are presented in the last stage of the model where the influence of innovation variables is measured over labor productivity. Only the size of the companies appears to have a significant and positive relationship with labor productivity, for Central and Eastern European countries.

The results have shown a negative and significant relationship between innovation output and labor productivity for the firms operating in Central and Eastern Europe and in Southern Europe. Higher levels of innovation output are associated with lower labor productivity in these two country settings. We believe that the inverse relationship between innovation output and labor productivity may be explained by the low absorption capacity of the firms operating in these country settings (presence of human capital, size of the enterprise, infrastructure, business environment, and size of the local economy, among others). These results, although counterintuitive at first sight, may be explained also by the crowding out effect from the process of globalization driven by Trans National Companies (TNCs). Notwithstanding positive spillover effects, foreign capital can inhibit the establishment of local technology and innovation activities. More research is needed to be able to pinpoint the exact causes of this inverse relationship though.

From the analysis that we have undertaken, we can't recognize improving and strengthening of the innovation systems in Europe, or convergence between the different parts of Europe. In all three groups of countries, during our observation period, which fell in the aftermath of the 2008 financial crisis, the links between innovation inputs, innovation outputs and productivity were found to be rather weak. These findings also indicate that in most European countries policy makers should set back, reshape and work on their innovation policies and consider how to enhance the interactions among the main actors and strengthen the innovation settings.

The main limitation of this paper is the time frame. We are elaborating the innovation systems in Europe in a period of two years. Further research progress in this area will be made by creating long time series, for the common aspects that are present in the CIS surveys. That can bring us to more profound conclusions regarding the structure, innovation strategies and innovation performance of the firms for specific institutional settings in Europe.

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