The role of innovation in productivity growth in Central and Eastern European countries

KATERINA TOSHEVSKA-TRPCEVSKA, ELENA MAKREVSKA DISOSKA, DRAGAN TEVDOVSKI

THE ROLE OF INNOVATION IN PRODUCTIVITY GROWTH IN CENTRAL AND EASTERN EUROPEAN COUNTRIES

- The paper is accepted for publishing in Economics of Transition under the title **“What is the role of innovation in productivity growth in Central and Eastern European countries?”**
- Content of the presentation:
  - Introduction
  - Background Information
  - Literature Review
  - Model and Data Specification
  - Interpretation of Results
  - Conclusion

INTRODUCTION

- Ability to stimulate R&D spending and enhance the innovation activities of the companies is one of the most important factors to increase competitiveness and economic growth.
- We use CDM model based on Crepon et al. (1998) – structural model that directly links engagement and intensity to innovation outcomes measured either as process or product innovation. Then, it estimates the effectiveness of the innovative effort leading to productivity gains.
- We have added analysis of the factors driving knowledge production function as being marketing or organizational innovation.

INTRODUCTION

- The goal of the paper is to analyze the systems driving innovation and productivity in two CEE countries, Bulgaria and Romania, and compare them to highly developed and productive 'old' EU member countries, represented by Germany.
- The paper contributes to the literature in three ways:
  - It presents the role of innovation in productivity growth in two CEE countries.
  - It points out the innovation deficit in CEE countries in comparison to productive German companies.
  - It is based on Community Innovation Surveys 2008 (CIS 2008).

BACKGROUND INFORMATION

- 1950 -1973- ‘Golden age’ of growth, stability and social cohesion in Europe.
- Since then, the average GDP growth rate is declining: 1973-1995 it was 2,61 percent; between 1995-2013 it was 2,03 percent.

	Labor productivity indicators						
	GDP in PPS per person employed Index (EU27=100)			GDP in PPS per hour worked (EU27=100)			R&D (average 2002-2014, as percentage of GDP
	2002	2008	2013	2002	2008	2013	
EU28	99,8	99,8	99,9	99,8	99,9	99,9	1,880
CEE average	55,4	65,4	69,8	48,4	57,3	62,4	0,918
Germany	106	108	107	124	126	126	2,617
Bulgaria	34	39,7	43,4	34,6	39	43,2	0,525
Romania	29,4	49,1	51,7	26,5	43,5	45,1	0,442

BACKGROUND INFORMATION

- Europe 2020 Competitiveness Index: Bulgaria is at the 27th position, Romania is the worst performer in this field. Germany is ranked 4th.
- The latest Community Innovation Survey (CIS) 2012 shows that the proportion of innovative enterprises fell below 50 percent in the EU in 2010-2012, compared to previous periods: 2006-2008 and 2008-2010, and the pattern is observed in the majority of Member States (Eurostat, 2015).
- The highest proportion of enterprises with innovation activity were recorded in Germany (66,9 percent), Luxemburg (66,1 percent) and Ireland (58,7 percent), and the lowest proportion in Romania (20,7 percent), Poland (23 percent) and Bulgaria (27,4 percent).

LITERATURE REVIEW

- The relationship between R&D expenditures, innovation and productivity is not straightforward.
- Griffith et al. (2006) – the link between R&D and knowledge with process innovation is associated with higher productivity in France. Product innovation is associated with higher productivity in France, Spain and UK, but not Germany.
- Parisi et al. (2006) implies that process innovation has large impact on productivity.
- Loof and Hesmati (2006) - the relationship between innovation and productivity growth in service companies is independent from the degree of novelty in innovation.
- Martin and Nguyen-Thi (2015) - confirm that labor productivity is positively associated to technological innovation conditional to R&D expenditures and ICT use.
- Janz et al. (2004) – all linkages between innovation and productivity are positive based on Estonian service sectors analysis.

LITERATURE REVIEW

- For CEE countries there are only few studies:
- Kolasa (2008) provides evidence on factors driving productivity growth in the EU member states, focusing on Polish manufacturers.
- Friesenbichler and Peneder (2016) – focus on Europe and Central Asia and confirm positive effect of simultaneous competition and innovation on labor productivity.
- Hashi and Stojcic (2013 and 2014) estimate the impact of innovation activities on European firm performance, including firms from some CEE countries, using data from CIS in 2004 (CIS4) and 2006 (CIS6). Their results point to a gap in innovation behavior between firms from mature market economies of Western Europe and those from the new EU member states and candidate countries.
    - Kornai, 2010- the difference in technological progress can be explained by the basic attributes of the capitalism and central socialist economies.

Model specification (first equation)

The model has structural form consisting of four equations. The first two equations depict the firm research behavior, where the first one presents the firm's decision to engage in R&D activity, and the second one presents the intensity of R&D activity. The third equation is knowledge or innovation production function, where knowledge takes two different forms: process and product innovation. The fourth equation deals with the impact of innovation output on productivity.

The first two equations are based on a generalized Tobit model (Heckman, 1976, 1979). The first equation is defined as follows:

$$g_i^* = \beta_0 x_{0i} + u_{0i} \qquad (1)$$

where g_i^* is an unobserved latent variable which accounts for firms' engagement in innovative activity, $\mathrm{x}_{0\mathrm{i}}$ is a vector of determinants of engagement in innovation activity, β_0 is a associated coefficient vector, $\mathrm{u}_{0\mathrm{i}}$ is random error, and $\mathrm{i} = 1, \dots, \mathrm{N}$ index firms. The observable binary variable r_i is used of whether or not a firm is engaged in innovation or not:

$$g_i = \begin{cases} 1 & if\ g_i^* > 0 \\ 0 & if\ g_i^* \le 0 \end{cases}$$

So, g_i is dummy variable which takes the value 1 if the firm reports continuous engagement in intramural R&D activities during the observed period and value 0 if not.

Model specification (second equation)

The second equation is conditional on firm i engagement in innovation activity. It accounts for the intensity of R&D activities:

$$k_i = \begin{cases} k_i^* = \beta_1 x_{1i} + u_{1i} & if\ g_i = 1 \\ 0 & if\ g_i = 0 \end{cases} \qquad (2)$$

where $\mathrm{k_i^*} = \mathrm{k_i}$ is actual R&D intensity per employee of firm i when the firm does research (both $\mathrm{k_i^*}$ and $\mathrm{k_i}$ are expressed in logarithms), $\mathrm{x_{1i}}$ is a vector of determinants of innovation intensity, β_1 is a associated coefficient vector, and $\mathrm{u_{1i}}$ is random error that summarizes omitted determinants and other sources of unobserved heterogeneity.

The explanatory variables in the equations (1) and (2) are international competition (dummy), cooperation (dummy), public support (three dummy variables), firm's size (less than 50, between 50 and 249 and above 250), sources for innovation (dummy for internal and external sources) and type of industry (set of dummy variables).

Model specification (third and fourth equation)

The third equation in the model is the knowledge or innovation production function (innovation outcome):

$$t_i = \alpha_k k_i^* + \beta_2 x_{2i} + u_{2i} \qquad (3)$$

where t_i is knowledge proxied by product, process, marketing or organizational innovation indicators, k_i^* is latent innovation intensity from equation (2), $\mathrm{x}_{2\mathrm{i}}$ is a vector of other determinants of knowledge or innovation function, β_1 is a associated coefficient vector, α_k and β_2 are associated coefficient vectors, and $\mathrm{u}_{2\mathrm{i}}$ is random error. The four different types of innovations in the firms – the product, the process innovation, the marketing and organizational innovation, are measured as indicator (dummy) variables. So product innovation takes the value 1 if the firm reports having introduced new or significantly improved products. And similarly, process innovation takes the value 1 if the firm reports having introduced new or significantly improved production processes.

Finally, the last equation of the model is the productivity equation. It relates the innovation output with the firm's performance, as an augmented Cobb-Douglas production function with labor, capital and knowledge input:

$$q_i = \alpha_t t_i + \beta_3 x_{3i} + u_{3i} \qquad (4)$$

where q_i is labor productivity (log of output per worker), t_i is estimation of predicted values of knowledge production function (3), $\mathrm{x}_{3\mathrm{i}}$ is a vector of other determinants of labor productivity, β_3 is a associated coefficient vector, α_t and β_3 are associated coefficient vectors, and $\mathrm{u}_{3\mathrm{i}}$ is random error.

Data/Summary statistics/Mean value of the variables

Variable	Bulgaria	Romania	Germany	Variable	Bulgaria	Romania	Germany	Variable	Bulgaria	Romania	Germany
Observations	3817	2489	5270	Health and Safety Aspects				Other			
Knowledge/Innovation				High	0.234	0.305	0.123	Cooperation	0.167	0.193	0.225
R&D engagement	0.089	0.289	0.460	Medium	0.298	0.341	0.168	International competition	0.129	0.196	0.170
R&D intensity	6.673	5.632	8.195	Low	0.157	0.175	0.167	Size			
process innovation	0.104	0.162	0.270	Not relevant	0.311	0.179	0.541	250+	0.035	0.134	0.261
product innovation	0.113	0.170	0.417	Sources of information				50-249	0.196	0.427	0.321
labour productivity	9.687	10.308	12.047	Internal	0.248	0.474	0.382	0-49	0.769	0.438	0.418
Investment intensity	6.112	5.935	7.461	University	0.029	0.058	0.056				
Public support				Government	0.020	0.061	0.024				
Local funding	0.005	0.039	0.098	Suppliers	0.209	0.343	0.090				
National funding	0.059	0.077	0.114	Competitors	0.129	0.168	0.114				
EU funding	0.051	0.078	0.034	Customers	0.224	0.280	0.313				

R&D engagement and R&D intensity

	R&D Engagement			R&D Intensity		
Dep. Var.	**Engage in R&D continuously**			**R&D intensity**		
Sample	**Bulgaria**	**Romania**	**Germany**	**Bulgaria**	**Romania**	**Germany**
Observations	3817	2489	5270	3654	2460	4690
International	**0.026****	**0.019**	**0.170*****	**0.337**	**-0.428****	**0.205***
Competition	**[0.011]**	**[0.022]**	**[0.015]**	**[0.308]**	**[0.209]**	**[0.117]**
Cooperation				**0.145**	**0.197**	**0.475*****
				[0.276]	**[0.181]**	**[0.093]**
Funding						
Local	**-0.010**	**-0.080**	**0.221*****	**-0.822***	**-0.209**	**0.061**
	[0.051]	**[0.053]**	**[0.024]**	**[0.471]**	**[0.414]**	**[0.131]**
National	**0.172*****	**0.236*****	**0.373*****	**1.459***	**0.332**	**-0.006**
	[0.012]	**[0.033]**	**[0.023]**	**[0.770]**	**[0.336]**	**[0.149]**
EU	**0.048*****	**0.120*****	**0.172*****	**-0.540**	**0.036**	**1.164*****
	[0.015]	**[0.035]**	**[0.051]**	**[0.419]**	**[0.286]**	**[0.210]**
Size						
Medium	**0.045*****	**0.021**	**0.074*****			
	[0.011]	**[0.019]**	**[0.013]**			
Large	**0.069*****	**0.153*****	**0.219*****			
	[0.018]	**[0.025]**	**[0.017]**			
W-demand pull				**0.702**	**0.040**	**0.129**
W_sources				**0.998**	**0.147**	**0.000**
W_industry	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rho				**0.530**	**0.008**	**-0.666*****
				[0.262]	**[0.262]**	**[0.068]**
Log-likelihood	**-870.78**	**-1269.946**	**-2580.48**	**-794.574**	**-2675.416**	**-5389.552**

Knowledge production function: Process and product innovation

	Process Innovation			Product Innovation		
Sample	Bulgaria	Romania	Germany	Bulgaria	Romania	Germany
Observations	1426	2097	1937	3817	2487	4918
R&D	0.145	-0.107	0.243***	0.498***	0.430***	0.820***
Intensity	[0.103]	[0.104]	[0.067]	[0.100]	[0.100]	[0.102]
Investment	0.074***	0.064***	0.114***			
Intensity	[0.020]	[0.014]	[0.017]			
Sources						
Suppliers	0.169*	0.069	-0.096			
	[0.090]	[0.065]	[0.090]			
Competitors	-0.335***	0.394***	0.053	-0.053	-0.072	0.091
	[0.109]	[0.092]	[0.082]	[0.118]	[0.094]	[0.092]
Customers				0.194**	0.374***	0.201**
				[0.096]	[0.074]	[0.079]
Demand pull						
Health high	0.339***	0.801***	0.320***	0.534***	0.312***	-0.207*
	[0.121]	[0.124]	[0.101]	[0.112]	[0.116]	[0.111]
Health medium	-0.333***	0.594***	0.228***	0.488***	0.248***	-0.054
	[0.096]	[0.097]	[0.088]	[0.101]	[0.094]	[0.092]
Health low	-0.109	0.244**	0.123	0.351***	0.178*	0.089
	[0.125]	[0.098]	[0.086]	[0.130]	[0.096]	[0.093]
Size						
Medium	0.247***	0.023	0.360***	0.076	0.041	0.154**
	[0.087]	[0.071]	[0.073]	[0.085]	[0.069]	[0.076]
Large	0.303**	0.194**	0.438***	0.242*	0.228***	0.311***
	[0.135]	[0.087]	[0.085]	[0.132]	[0.085]	[0.095]
W_industry	0.000	0.000	0.000	0.000	0.000	0.000
Log-likelihood	-2986.274	-4835.515	-4311.000	-2986.274	-4835.515	-4311.000

Knowledge production function: Marketing and Organizational Innovation

	Marketing Innovation			Organizational Innovation		
Sample	Bulgaria	Romania	Germany	Bulgaria	Romania	Germany
Observations	1426	2097	1937	3817	2487	4918
R&D	0.319***	0.356***	0.218***	0.598***	0.292***	0.360***
Intensity	[0.100]	[0.099]	[0.070]	[0.105]	[0.098]	[0.071]
Investment						
Intensity						
Sources						
Suppliers				0.098	0.066	0.047
				[0.079]	[0.057]	[0.090]
Competitors	0.141	0.199**	0.191**	0.115	0.194**	0.008
	[0.116]	[0.087]	[0.086]	[0.108]	[0.087]	[0.084]
Customers	0.159*	0.039	0.003			
	[0.084]	[0.064]	[0.069]			
Demand pull						
Health high	0.520***	0.556***	0.197*	0.531***	0.538***	0.105
	[0.115]	[0.117]	[0.101]	[0.115]	[0.115]	[0.102]
Health medium	0.307***	0.332***	0.031	0.298***	0.306***	0.230**
	[0.106]	[0.096]	[0.086]	[0.098]	[0.093]	[0.090]
Health low	0.143	0.098	0.073	0.179	-0.012	0.081
	[0.137]	[0.099]	[0.086]	[0.128]	[0.095]	[0.087]
Size						
Medium	0.231***	0.018	0.000	0.497***	0.149**	0.215***
	[0.088]	[0.067]	[0.072]	[0.083]	[0.068]	[0.072]
Large	0.287**	0.156*	0.112	0.595***	0.366***	0.471***
	[0.129]	[0.083]	[0.087]	[0.128]	[0.085]	[0.090]
W_industry	0.000	0.000	0.000	0.000	0.000	0.000
Log-likelihood	-2986.274	-4835.515	-4311.000	-2986.274	-4835.515	-4311.000

Output production function: Process and Product Innovation

Dep. Var	Labour Productivity		
Sample Observations	Bulgaria 1426	Romania 2097	Germany 1999
Investment Intensity	0.123*** [0.020]	0.183*** [0.016]	0.129*** [0.021]
Process Innovation	0.238** [0.101]	0.130 [0.120]	1.145*** [0.121]
Product Innovation	0.295*** [0.075]	0.489*** [0.120]	0.326*** [0.073]
Constant	10.364*** [0.392]	9.222*** [0.503]	11.510*** [0.259]
R^2	0.340	0.313	0.414

Output production function: Marketing and Organizational Innovation

Dep. Var	Labour Productivity		
Sample	Bulgaria	Romania	Germany
Observations	1426	2097	1999
Investment Intensity	0.144***	0.193***	0.243***
	[0.019]	[0.013]	[0.017]
Marketing Innovation	-0.517*	-2.129***	-0.368*
	[0.283]	[0.277]	[0.222]
Organizational Innovation	0.628***	2.569***	1.970***
	[0.198]	[0.268]	[0.133]
Constant	9.658***	9.049***	9.783***
	[0.448]	[0.512]	[0.231]
R^2	0.339	0.338	0.458

CONCLUSION

- Different processes drive firms’ decision to engage in R&D in these three European countries. Factors that are the same drivers to continuous engagement in R&D in all three countries are receiving national or EU funding and being a large firm.
- Greater R&D effort per employee in all three countries makes them to be more product innovators, and process innovators only in Germany. This has also been important for marketing and organizational innovations.
- Setting high environmental standards is important for product, process, marketing and organizational innovations.
- The effects of the other factors over the production function are mixed.

CONCLUSION

- The results for labor productivity are quite similar in all three countries.
- Process innovation is associated with higher productivity in Germany and Bulgaria, but not in Romania.
- Product innovation is associated with higher labor productivity in all three countries.
- Organizational innovation may lead to higher labor productivity in all three countries, and that can’t be declared for marketing innovation.

THANK YOU FOR YOUR ATTENTION!