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TECHNOLOGICAL INNOVATION IN CENTRAL AND EASTERN EUROPE: WHAT'S THE CONTRIBUTION OF INNOVATION POLICY?

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ABSTRACT

If European Union member states are technologically lagging behind other member countries, especially Eastern European countries, it is important to analyze whether or not public policies contribute to the reduction of this gap. In this respect, our study examines the effect of public innovation policy on technological innovation in Central and Eastern European countries. The estimation of panel data model for 10 countries over the 1998-2013 period show that innovation policy in these countries is not efficient.

Contribution/Originality: This study contributes in the existing literature by showing in another manner the inefficiency of innovation policy in Central and Eastern European countries. It assesses public efforts by considering two periods: before policy implementation and after policy implementation.

1. INTRODUCTION

The countries of Central and Eastern Europe (CEE) originate from socialism, which attaches great importance to science and technology. However, in these centrally planned economies the output of innovation activities was relatively low in relation to the considerable input devoted to innovation (Hanson and Pavitt, 1987). In nearly all fields - except defense and space technology - these countries were technological followers, not leaders. That's why the socialist system does not approve a superior or even equal efficiency to the capitalist system.

In the late 1980s, these countries witnessed a change of regime: the collapse of socialism and the transition to the market economy. This passage, accompanied by other reforms, enabled them to join the European Union (EU) in 2004[1] and 2007[2].

The membership of the countries of Central and Eastern Europe in the European Union is forcing them to engage in a catching-up approach. Indeed, in 2000 the European Union launched the Lisbon Strategy, whose purpose was to make the EU the most dynamic and competitive knowledge-based economy in the world. Faced

[1] Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia are members in EU since 2004.

[2] Bulgaria and Romania are members in EU since 2007.

with the failure of this strategy, the European Commission launched in 2010 the Europe 2020 strategy for smart, sustainable and inclusive growth. To achieve the objectives of Europe 2020, well-developed innovation systems are required.

The Europe 2020 strategy is a major challenge for these countries. It enables them to move towards a knowledge-based economy based on new competitiveness factors, namely research, development and innovation. However, this shift to a new knowledge-based economy requires major reforms in their national innovation systems, as their innovation model is very different from that of the former member states of the EU, and their levels of innovation were low. At this level, public policies for promoting R&D and innovation activities have been designed to mitigate this technological gap with other European countries.

This paper aims to answer the following question: Does innovation policy contribute to spur technological innovation in Central and Eastern European countries? To answer this question, we will estimate a linear regression model on a sample of 10 countries over the period 1998-2013.

The rest of the paper is organized as follows: Section 2 describes innovation in CEE. Section 3 proposes the methodology to study the role of public policy in the production of technological innovation. Section 4 presents and interprets estimation results. Section 5 concludes.

2. INNOVATION IN CEE COUNTRIES

In this section, we describe innovation in Central and East European countries by distinguishing three periods: prior to the transition period: the socialist system, transition period and post transition period.

2.1. Innovation in Socialist System: State Has a Dominant Role

In the socialist economies the organization of innovation was largely oriented at the linear model of innovation. According to this linear model the different logical steps of the innovation process - e.g. invention, development, innovation and diffusion - had to be passed successively one after another (Meske, 1998).

However, the major disadvantage of this model is that it largely neglects feedback processes, i.e the impact of previous phases of the innovation process on future steps.

The centralized decision system in the socialist economies led to a dominant role of the state with regard to the generation and the selection of innovations.

The incentives to generate innovations remained relatively weak in these countries. On one hand, in all socialist countries the results of innovation activities were considered to be public goods, so that the main parts of the rents or profits generated by an innovation should not be appropriated by individuals. On the other hand, if an innovation project was started, there was relatively high pressure for this project to achieve the expected results, because otherwise, the economic agents had to overcome high bureaucratic obstacles for necessary changes of the plan. Moreover, such changes of the plan could lead to a considerable loss of reputation. Therefore, the incentives to accept risk and to engage in innovation activity were relatively low in these countries.

Moreover, Dyker and Perrin (1997) claim that there was nearly no effective R&D cooperation with organizations in other countries. Because the essence of innovation activities is the generation and combination of knowledge, these shortcomings of the centrally-planned economies had a negative impact on the efficiency of their innovation activities.

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2.2. Innovation in Transition Period: Science and Technology are neglected

After the end of the socialist regime in 1989, the countries of Central and Eastern Europe faced a recession, followed by a return to positive growth rates in the mid and late 1990s (Jude and Pop, 2011).

Some countries found quickly the growth path, while others (such as Romania and Bulgaria) experienced long periods of recession and reached a dynamic level of growth only in the period 1997-1998.

During the transition period, the largest share of economic growth was achieved by the increase in total factor productivity (TFP). Although traditional sources of TFP growth are technical progress and innovation, growth at that time was largely explained by improvements in efficiency of the use of capital and labor (Havrylyshyn, 2001). During this period, the increase in productivity was accompanied by a decrease in R&D investments. Thus, economic growth was driven by factors other than R&D (Radosevic, 2005).

According to Chataway (1999) the profound changes that have taken place in the countries of Central and Eastern Europe during the transition period have led to fragile systems of science and technology. The crisis of the old system, trade liberalization accompanied by privatization policies, as well as significant decreases in public funding, had a detrimental effect on innovation in these countries.

Science and technology have been largely abandoned for various reasons. The countries of central and eastern Europe experienced a high level of brain drain on both internal and external levels. On the one hand, individuals move away from science and technology to focus on other areas. On the other hand, the most skilled individuals move to other countries.

In addition, the research equipment was present with poor quality. Public spending has declined dramatically. Large firms in restructuring and privatization phases have reduced R&D spending. In Poland, the share of total R&D expenditure in GDP fell from 1.3 in 1989 to 0.92 in 1992. Over the same period, 15% of R&D institutes closed and 22% of researchers Lost their jobs.

In the Czech Republic and Hungary, R&D expenditure decreased by 64% and 70% respectively over the 1989-1996 period. This decline reached a level of 89% in Slovakia during the period 1989-1994.

During the period 1994-1996, a large number of R&D institutes closed in Poland, Slovakia, the Czech Republic and Romania. The majority of those still operating were under pressure and reduced their workforce (Chataway, 1999).

The crisis in science and technology system was linked to general difficulties associated with the transition to market economies. Moreover, the accumulation of economic and social problems explain why science and technology are not a top priority.

2.3. Innovation in Post Transition Period: An Innovation Policy is implemented

In the post transition period, Kattel *et al.* (2009) distinguish two periods: 1998-2004 and 2004-2013:

- Harmonization with the European Union, 1998-2004

Many CEE countries started to develop first strategic documents and policies related to innovation and R&D proper. During this period EU's influence on funding and administrative schemes brought creation of novel governance structures that play up to today key part in innovation policy in CEE. However, according to Radosevic (2004) national innovation capacities were by 2000 underdeveloped in all CEE countries compared to the old member states.

- Awakening, since 2004

Kattel *et al.* (2009) claim that CEE innovation policies emerging in early and mid 2000s tend to concentrate on high technology sectors, on commercializing university research, technology parks for start-ups and similar efforts. In contents, an overwhelming number of policy measures concentrate upon innovation programmes and technology platforms.

The innovation policies in CEE countries attempt to imitate those of industrial economies. They focus on improving infrastructure, building and/or strengthening collaborations between public research institutes and private companies, increasing investment in research and development, promoting education, science and technology by increasing the number of scientists and engineers (Tiits *et al.*, 2008).

3. ROLE OF INNOVATION POLICY IN SHAPING INNOVATION IN CEE COUNTRIES: METHODOLOGY

3.1. Sample description

This study includes 10 central and eastern european countries[3]. The study uses data for the period of 1998-2013.

3.2. Data

3.2.1. Dependent variable

The dependent variable in our model (PAT) is defined as the number of patent applications filed by residents of a country in the USPTO for a given year.

As the level of international patenting is observed with a time lag, our empirical work requires a lag of 3 years between explanatory variables and the dependent variable. Therefore, data for independent variables are for the period 1998-2010, and patent applications relate to the period 2001-2013.

3.2.2. Independent Variables

A. The Innovation Policy

According to the previous section, serious efforts devoted to implement innovation policy in CEE countries began in 2004. So, we introduce a dummy variable (IP) to measure the public policy.
IP takes the value of 1 if t = > 2004, 0 otherwise.

B. R&D Human Capital

This variable reflects the human capital employed in R&D activity. The data represent the number of R&D personnel in full time equivalent (Data source: EUROSTAT).

C. R&D Physical Capital

R&D physical capital is measured by the share in GDP of R&D expenditures (ERD). (Data source: EUROSTAT).

D. Foreign Direct Investment

CEE countries are emerging countries. To create new technologies, they depend on foreign knowledge. FDI measure the inflows of foreign direct investment as share to GDP. Data are from World Development Indicators.
Variables, except IP, are transformed in natural logarithm. Summary statistics for the variables are given in Table 1.

Table-1. Summary statistics

	Mean	Median	Stand. dev	Minimum	Maximum
PAT (t + 3)	76.3	47.5	86.4	1	403
HRD (t)	23524.02	15514.5	21474.41	3710	84510
ERD (t)	0.77	0.65	0.36	0.35	2.06
FDI (t)	6.26	4.81	7.38	-16.07	50.74

Source: Calculation of the author

3.3. Presentation of Models

The general form of the linear model is the following:

[3] Bulgaria-Czech Republic-Estonia-Hungary-Latvia-Lithuania-Poland-Romania-Slovakia-Slovenia

$$PAT_{it+3} = \beta 0 + \beta 1\ IP + \beta 2\ HRD_{it} + \beta 3\ ERD_{it} + \beta 4\ FDI_{it} + \varepsilon_{it} \quad (1)$$

In this paper, two models are tested :

$$PAT_{it+3} = \beta 0 + \beta 1\ HRD_{it} + \beta 2\ ERD_{it} + \beta 3\ FDI_{it} + \varepsilon_{it} \quad (2)$$

$$PAT_{it+3} = \beta 0 + \beta 1\ IP + \beta 2\ HRD_{it} + \beta 3\ ERD_{it} + \beta 4\ FDI_{it} + \varepsilon_{it} \quad (3)$$

PAT = number of patent applications filed in the USPTO; HRD= human resources devoted to R&D (in full time equivalent); ERD = R&D expenditures (%GDP); FDI = foreign direct investment inflows (%GDP); ε is regression residuals All variables, except IP, are transformed in natural logarithm.

4. EMPIRICAL RESULTS AND ANALYSIS

When we have a sample of panel data, the homogeneous or heterogeneous specification of the data generating process should be verified.

If the test carried out (test for the presence of individual effects) shows that there are specificities to each country, the Ordinary Least Squares (OLS) method is not appropriate. In this case, we should apply the Hausman test to determine whether the coefficients of the two estimates (fixed and random) are statistically different.

4.1. Tests for the Presence of Individual Effects

The tests (Fisher in the case of a fixed effects model and Lagrange multipliers in the case of a random effects model) permit verification of the presence of individual effects. The null hypothesis of these tests is the absence of individual effects.

Table-2. Test for the presence of individual effects

	Model 1	**Model 2**
Test of Chi (2)	43,41***	101,06***

***: Correlations are significant at the 0.01 level
Models 1 and 2 are respectively related to (2) and (3) defined in section 3.

Table 2 shows that the p-value associated with the Lagrange multiplier test is less than the 1%. Then, the null hypothesis of the absence of specific effects is rejected and it is necessary to introduce individual effects. After the validity assumption of the random effects model is met, the next decision is to either rely on the random effects model or the fixed effects model results. The decision to choose an appropriate model is based on the Hausman specification test by Hausman (1978).

4.2. Hausman Test

A significant value for the chi-square statistic of the Hausman test indicates the existence of correlation between the composite error term and the independent variables in the model.

In this study, the probability of the Hausman test in Model 1 is equal to 0.066 > 1% and it is 0.0003 < 1% in Model 2. Then, the Hausman test allows us to choose random effects model for Model 1 and fixed effects model for Model 2.

4.3. Test of Heteroscedasticity

Test of Breush-Pagan allows us to detect heteroscedasticity. In our study, probabilities of the test in Models 1 and 2 are respectively equal to 0,001 < 1% and 0,860 > 1 %. So, we reject the null hypothesis of absence of heteroscedasticity problem for the Model 1 and we accept it in Model 2.

4.4. Test of Error Auto Correlation

Test of Wooldrigde allows us to detect auto correlation. In our study, probabilities of the test in Models 1 and 2 are respectively equal to 0,0093 < 1% and 0,0107 > 1%. Thus, the test confirms the presence of auto-correlation problem in Model 1 and its absence in Model 2.

4.5. Linear Regressions

After correction of heteroscedasticity and auto-correlation problems in the Model 1, we obtain the following results[4] (see Table 3).

Table-3. Regression results of Models 1 and 2

Independent variables	Model 1		Model 2	
	Coefficients β	SE	Coefficients β	SE
Constant	-4.66	0.79***	6.75	2.99**
IP			1.03	0.09***
HRD	0.9	0.08***	-0.34	0.3
ERD	1.29	0.15***	0.63	0.29**
FDI	0.006	0.04	-0.05	0.05
Number of observations	130		130	
F / Chi2	214.17***		44.24***	

Coefficients and standard errors are given in this table.

*, **, *** : coefficients are significant at 10 %, 5 % and 1 %.

All variables, except IP, are in natural log.

Models 1 and 2 Are Respectively Related to Equations (2) and (3) Defined in Section 3.

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According to regression results, Chi-square statistic in Model 1 and Fisher statistics in Model 2 testing the joint significance of explanatory variables are significant at 1% in the two models. They permit rejection of the null hypothesis that the regression coefficients β are zero.

The results of multiple regression Model 1 show that human resources devoted to R&D have a significant positive effect on the level of technological innovation. Interpreting the coefficients as elasticities, Model 1 implies that, all things being equal, a 10% increase in the share of researchers in total labour force is associated with an increase of 9% in the level of international patenting. This result corroborates the findings of Furman *et al.* (2002) and Ulku (2007). It allows us to show the importance of R&D human capital in the innovation process.

Findings show also that R&D expenditures have a positive and significant sign at 1% level. An increase of 10% of physical capital in R&D leads to an increase of 12.9% in the number of patents. This result is consistent with the results found by Teixeira and Fortuna (2010).

Foreign direct investment inflows have no significant effect on innovation in central and eastern european countries. To assess the role of public innovation policy, we introduce the variable IP in Model 1 and we re estimate the model.

Estimation of Model 2 provides us with some contradictory results. Indeed, the coefficient of IP is positive and significant at 1% level, suggesting that innovation policy is efficient. However, looking at the coefficients of the other variables, especially HRD and ERD, we recognize that the introduction of innovation policy variable in the model disturbs their positive effect on innovation. Findings show that R&D human capital has a negative and non significant effect on technological innovation in CEE countries. R&D physical capital still has a positive effect, but less than in model 1. The coefficient of ERD is equal to 0.63 and is significant at 5% level. This result suggests that

[4] We use the software STATA 10 for estimation of the models.

an increase of 10% of R&D expenditures leads to an increase of 6.3% only (this percent was 12.9% in Model 1) in the number of patents. We note that the effect of R&D expenditure decreases relatively to Model 1.

FDI still has no significant effect on international patents.

Our findings show that the main inputs of innovation process, namely R&D physical and human capital, are not positively influenced by innovation policy. They suggest that public measures aimed at spuring innovation in CEE countries are not efficient. Our findings support the arguments of Von Tunzelmann and Nassehi (2004) who warned that the EU innovation policies were appropriate for conditions of core countries in the EU, but will probably not work in CEE.

Regarding the positive effect of IP, we can interpret it as a positive effect of all economic, social and institutional environment which is improved since 2004 thanks to many reforms implemented to join the European Union.

5. CONCLUSION

The objective of this paper was to evaluate the role of public measures in technological innovation in Central and Eastern European countries. The application of a linear model to a sample of 10 countries over the period 1998-2013 shows that innovation policy does not improve the effect of R&D physical and human capital on technological innovation. We conclude that the public innovation policy is not efficient in CEE countries.

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