ARE SYSTEMS OF INNOVATION IN CENTRAL AND EASTERN EUROPE INEFFICIENT?[1]

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DRAFT

Abstract

Paper explores the relationship between R&D and productivity through perspective of 'narrow' and 'broad' national systems of innovation (NSI). Based on OLS econometrics it examines the extent to which systems in CEE could be considered 'inefficient'. Our results suggest that the CEECs have lower levels of productivity than would be expected given their R&D capacities, innovation and production capabilities. However, 'inefficiencies' cannot be found within the 'narrow' national system of innovation but more likely within 'broad' national system of innovation. We than explore the extent to which current innovation polices of the CEECs meet requirements which follow from our analysis and we point to direction in which innovation policy in CEECs should be redirected.

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1. INTRODUCTION

European Commission (2004) recommendations on economic policies have for the first time included new Member States. These policy guidelines constitute the EU's medium-term economic policy strategy and focus on the contribution that economic policies can make to the fulfillment of Lisbon strategy. Among problems that are seen as important in improving productivity of the new members the EC states low investments in R&D and innovation and in retraining activities, low efficiency of education systems and vocational training, and in case of Slovenia and Czech Republic low efficiency of R&D and innovation. Recommendations to increase investments in business R&D and innovation and in vocational training stand as prominent mechanism to increase productivity for all new member states. From innovation studies perspective this problem could be expressed as problem of efficiency of and relationship between 'narrow' and 'broad' innovation systems of the CEECs.

In this paper we explore the relationship between R&D and productivity in CEECs and thus tackle some of the issues addressed by the EC (2004) recommendations. We approach to the issue of productivity and R&D through systems of innovation perspective and distinguish between 'narrow' and 'broad' national systems of innovation (NSI) (Freeman, 2004). The NSI in a narrow sense embraces those institutions which are directly involved in R and D and the dissemination of the results of R and D. The NSI in a broad sense embraces the social, economic and political context of technical and organisational innovation (ibid). We distinguish inefficiencies of narrow and broad innovation systems. Inefficiencies of narrow NSI are in conversion process from innovation inputs into innovation outputs. Inefficiencies of broad NSI are in conversion process of production and technology inputs in productivity.

The issue of 'inefficiencies' in NSI in CEE is controversial as productivity increases during the 1990s in these economies have been accompanied by declines in R&D. This suggests that productivity increases have been generated by non-R&D factors. Naturally, there is plethora of factors that affect productivity but we are particularly interested in impact of production and technology capabilities on productivity in these economies. Our analysis is based on OLS econometric testing of productivity related variables combined with descriptive statistics. In addition to R&D data, we use data on resident patents and ISO 9000 certificates as output indicators of technological and production capability respectively. By using these two indicators we generate new insights on the relationships between productivity, production and technology capability in CEE.

Our conclusions are fourfold. First, CEECs have lost advantages in terms of size of R&D which they inherited from the socialist period. Second, production capability in combination with technological capabilities explains satisfactory productivity differences among OECD and CEE countries. Third, CEECs have lower levels of productivity than would be expected given their R&D capacities, innovation and production capabilities. This may point to possible inefficiencies in conversion of R&D/innovation inputs into productivity. Fourth, we find that these inefficiencies cannot be found within the 'narrow' national system of innovation but more likely within 'broad' national system of innovation. Based on these conclusions we evaluate the extent to which current innovation policies of the CEECs are able to meet requirements which follow from our analysis.

In the next section we introduce the problem of productivity and R&D in CEE by drawing on broader evidence and by elaborating notions of production and technology capability which are essential to interpret data on R&D, patents and ISO900 certificates. In section 3 we test whether the size of R&D systems in CEECs correspond to their income levels given the inherited 'oversized' socialist R&D system. We also analyze process of downsizing of R&D systems in CEE. In section 4 we test the relationship between R&D, patents and ISO900 certificates on sample of OECD and CEE countries and point to specificity of CEECs. In section 5, we explore assumptions on 'inefficiency' of 'narrow' national systems of innovation in CEECs. Section 6 summarizes key conclusions and discusses policy implications of our findings based current innovation policy measures in CEECs.

2. PRODUCTIVITY AND TECHNICAL CHANGE IN CEE: INTRODUCTION AND CONCEPTUAL FRAMEWORK

In transition period, growth of the CEECs was mainly based on removing distortions and introducing macro - and micro-organizational innovations (see Havrylyshyn et al, 1998; De Mello et al, 1997; Berg et al, 1999; Christofferson and Doyle, 1998). In this period, reallocations and restructuring have been much more important for growth than factor accumulation. Factor expansion has not been significantly linked to growth in transition period. For example, aggregate investment ratios have not explanatory power. Efficiency gains appear to be the main, if not sole, source of growth (Zukowski, 1998). Extensive econometric work undertaken by World Bank and IMF staff shows that the major factors, which explain recovery and growth in CEECs, are initial conditions, macroeconomic policies, and structural reforms (For example see Havrylyshyn, Oleh (2001) Fischer, Sahay and Vegh (1998), Berg, Borensztein, Sahay, Zettelmeyer (1999)).

Macroeconomic policies and structural reforms seem to be the major determinants of recovery in transition period. Also, initial conditions have important explanatory power. Each of these individual factors is positively related to growth but the major problem is how they are mutually related. For example, policy choices are influenced by different initial conditions. Many institutional factors are omitted due to data problems.

With the institutional convergence to open market economies the emerging issue is what could be sources of long-term growth in CEE. In a long term, growth in CEE should depend increasingly on the expansion in physical and human capital, on total factor productivity, and especially on technology accumulation. Crafts and Kaiser (2004) show that during the 1990s the contribution of total factor productivity in three out of five central European economies was relatively high 2.3-2.4%[2]. In relative terms, in four out of five central European countries total factor productivity has contributed to GDP growth from 55% to 121%[3]. Literature on determinants of productivity suggests several proximate causes

[2] However, for period 1991-(95)97 Campos and Coricceli (2002) show that the contribution of TFP to growth was actually negative in four (Slovakia, Czech R, Croatia and Bulgaria) and positive in three CEE economies (Hungary, Poland and Slovenia). These differences in TFP are partly due to different periods which extend to 1995(1997) and 1999 respectively but also partly to assumed different shares of labor and capital. Campos and Corricelli (2002) have assumed shares of labor and capital of 0.7 and 0.3 respectively while Crafts and Kaiser (2004) have assumed shares of 0.65 and 0.35 respectively. Higher shares of labour in conditions of its radical reduction have possibly exaggerated the weight of TFP which in conditions of overall output decline have led to strong declines in TFP. However, these differences seem to be still too small to explain great differences in contributions of different components to GDP. This suggest that we should be cautious when drawing generalizations based on grow accounting exercises.

[3] Literature suggest that on average total factor productivity roughly half of cross country differences in per capita income (Lederman and Mahoney, 2003)

of productivity growth: increased capital intensity, human capital, technological change, and competition (OECD, 2003). The key problem when trying to explore determinants of productivity growth is whether it is appropriate to consider each of these individual components as separate factors, as their contributions are closely interrelated (ibid). One of the most important drivers of technological change is R&D. Hence, similar to other factors the issue is whether it is appropriate to isolate R&D as driver of productivity growth from other factors. Aggregate studies often find that R&D provides a positive contribution to productivity growth. For example, Verspagen (2001) found that in the last 10 to 20 years R&D has become a crucial part of the catching up strategy, i.e. R&D is no longer associated only with the world technology frontier. Second, differences among countries in terms of 'pure' technology competitiveness (patents) are becoming more and more important in explaining growth differences. At an aggregate level, R&D expenditures tend to show a statistically significant relationship to productivity growth, but only explain a relatively small part of overall annual movements in multi-factor productivity. This indicates the presence of other factors (OECD, 2002, p. 113).

As pointed out by the EC (2002) the supply of R&D is only a part of the overall process of innovation that leads to a finished product being placed on the market or to economic growth at the national level. The degree of technology and knowledge flows across public and private sectors strongly affects the impact of technology on the economy (OECD, 2002b). So, if we want to understand the effects of R&D and innovation on productivity we must look beyond the R&D sector to the diffusion of knowledge and new technologies[4].

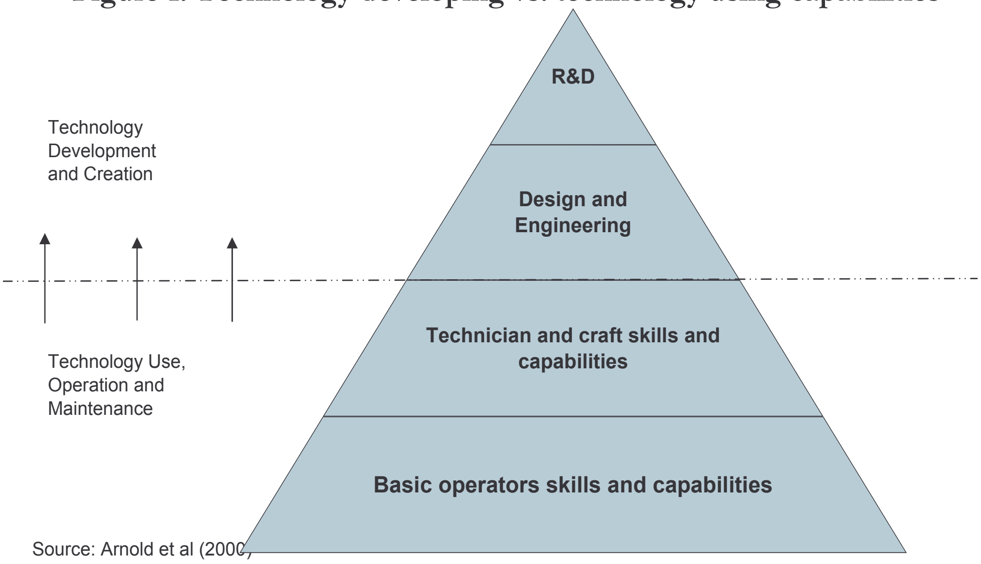
Socialist period was specific in a way that technology and R&D accumulation did not lead to increases in total factor productivity. In post-socialist period we have seen tendency towards increased total factor productivity but decline in R&D. Hence, CEE seems to be an interesting case which illustrates that technological change will not automatically follow from increases in productivity and vice versa. In this paper, we want to explore the issues related to decline of R&D and growth of productivity. We are aware that there are many drivers of productivity and we are not trying to account for different factors that drive productivity. We want to explore the role of technological change proxied by R&D and patents and their relationship to labour productivity. In addition, our hypothesis is that productivity growth in CEE is also driven by improvements in production capability.

We think that it is important to distinguish between technology developing and technology using capabilities. R&D and patents are proxies of technology developing or change generating capabilities. We use ISO900 certificates as proxies of technology using or production capabilities. These are capabilities to produce efficiently (at best practice level) on the existing equipment. Dominant focus of enterprises on mastery of production capability explains why growth is not automatically accompanied by recovery in R&D and domestic innovation. Moreover, disjunction between accumulations of production vs. technology capability of the CEECs may persist for quite some time not only because of weak of technological and R&D capabilities of enterprises but also because of weak systems of innovation unable to meet challenges of the emerging knowledge based economy. A shift from technology using to technology generating capabilities is not automatic and linear process but non-linear process of threshold nature i.e. which requires a new range of institutions and a new range of technological capabilities. Arnold et al (2000) have

[4] Elsewhere (see Radosevic, 2004) we analyzed the role of R&D in enlarged EU within the multidimensional national innovation capacity framework composed of 25 indicators.

graphically outlined the key elements of technology and production capabilities (see figure 1).

Figure 1: Technology developing vs. technology using capabilities

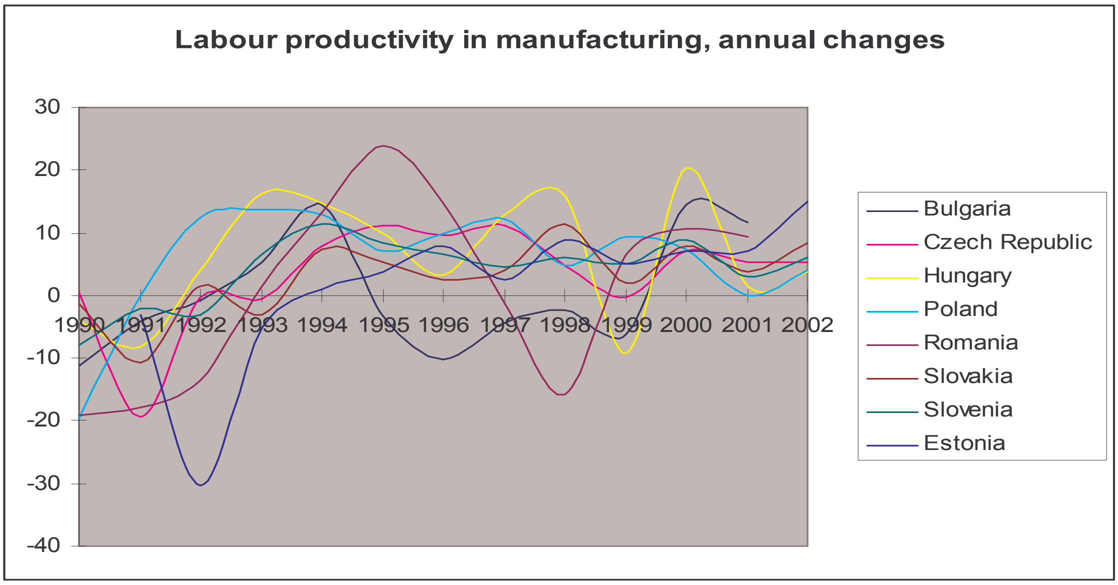


Source: Arnold et al (2000)

Innovation surveys in CEECs shows that the highest percentage of companies' innovators considers improving product quality as very important objective of their innovation activities (Radosevic, 1999). Elsewhere (Majcen, Radosevic and Rojec, 2004) we report on research based on 435 FDI subsidiaries in five Central European economies which suggest that quality (production capability) is the most important factors of competitiveness. FDI subsidiaries are the most productive firms in CEECs and hence this result has broader relevance which we want to explore in this context.

Before we explore relationship between productivity, production and technology capability we should analyze trends in labor productivity. A recovery and return of growth in CEE economies has been accompanied by trend of rising labor productivity in industry (see figure 3). However, strong fluctuations in rates of labor productivity growth in most of CEE economies (see figure 2) suggests that improvements are being driven more by uneven paths of layoffs, closure of unproductive lines of businesses and reactive restructuring than by continuous technological improvements.

Figure 2: Labor productivity in manufacturing, annual changes

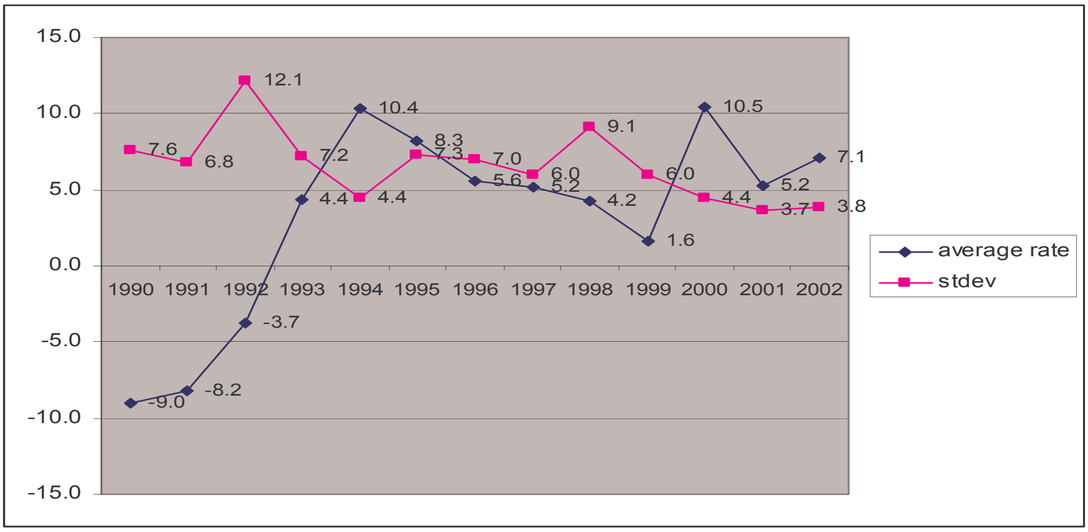


Bulgaria and Slovakia, figures are for industry.
Source: EBRD, Transition Reports, 2004, 1995, 2000 and 1999

In early transition productivity growth has been accompanied by big country differences. When measured by standard deviation differences in productivity rates between countries have fallen by three times from early 1990s to early 2000 (figure 2). This may suggest the emerging intra-regional convergence in productivity rates which may be far fetched conclusion given still very short period of recovery and growth. This would actually suggest the emerging 'convergence club' which by itself should be bad sign as 'catching up' of the CEE with the average would require much higher rates of productivity growth.

Van Ark (1999) and van Ark and Piatkowski (2004) show that the reduction of labour inputs has made substantial contribution to labor productivity during the 1990s. Inefficient firms exited or laid off labor which enabled the remaining firms to restructure. This led to much larger declines in GDP per capita than in labor productivity. Van Ark and Piatkowski (2004) calculate that the relatively strong productivity convergence between the CEE-10 and the EU-15 is for only 20% driven by faster output growth in the CEE countries and for 80% by job cuts (p.5). This raises important issue what are the sources of further productivity growth as productivity driven mainly labour savings exhausts its potential.

Figure 3: Average rate of productivity change in eight CEE countries and standard deviation of annual changes



Source: Figure 1

Stagnation of CEE since mid-1970s was driven by ineffective investments in capital goods and technology so that extensive investments in capital inputs were accompanied by slow TFP growth (van Ark, 1999). In early transition period TFP has deteriorated but it seems that by the end of the 1990s the overall contribution of TFP has been significantly positive[5] and productivity growth was driven mainly by labour shedding. This might suggest that the initial sources of productivity growth may be soon exhausted and that the issue of technical change and innovation as the major source of long-term and sustainable growth needs to be addressed.

The link between industrial output and employment was not significant in the first five years of transition. Regressing gross industrial output on employment in industry in 1995 period (expressed as % of 1989 level) for 15 CEE economies produces insignificant results (see below). However, results for 2002 (expressed as % of 1995 level) produce significant results at 5% level with significantly higher coefficient.

Depend.var. IND, Industry Output
Indep.var. EMPL, Employment in industry
Number of observations: 15

Variable	**Constant**	**EMPL 89-95**	**R sq.**	**Adj. R-sq.**
Coefficient	10.14	0.687	0.331	0.110
Std. Error	37.12	0.543		
t-stat	0.273	1.267		
Prob.	0.789	0.228		
		EMPL 95-02		
Coefficient	0.0533	1.418	0.260	0.203
Std. Error	0.572	0.664		
t-stat	0.093	2.136		
Prob.	0.927	**0.052**		

[5] See footnote 2

This suggests that in the initial years of the post-socialist transformation, differences among countries in employment policies have not played a role in explaining trends in manufacturing productivity. However, after 10 years trends in employment started to broadly follow trends in industry output across CEE. Also, productivity differences rather than differences in wages are factors behind increasing differences in competitiveness. Table 2 shows that an increase in labor shedding is not reflected in relative wage rates, which vary much less than could be expected given differences in productivity across CEE. Bigger variation in productivity rates than in wages shares produce very different unit labour costs and thus big variation in cost competitiveness (table 2).

Table 2: Changes in productivity, unit labor costs (in %) and wage shares in manufacturing

	Productivity change		Wage share in output		Unit Labour Costs	
	1995-99	**1998-2000**	**1999**	**2001**	**1995-99**	**1998-2002**
Croatia	42.10	35.58	0.51	0.59	24.70	0.20
Czech Republic	45.90	15.72	0.25	0.38	20.00	18.57
Estonia	14.10	35.30	0.52	0.46	102.00	1.82
Hungary	41.40	40.34	0.29	0.26	-15.40	29.64
Latvia	66.10	27.23	0.48	0.41	129.00	6.05
Lithuania	34.50	48.18	0.33	0.35	125.00	2.77
Poland	51.20	23.02	0.34	0.37	12.30	24.55
Slovakia	27.70	27.38	0.29	0.36	18.80	3.88
Slovenia	29.60	25.20	0.35	0.34	12.40	-1.93
Average	*39.18*	*30.88*	*0.37*	*0.39*	*47.64*	*9.51*
Coef Var	*36.12*	*30.14*	*25.91*	*22.17*	*108.71*	*115.20*

* Coefficient of variation is calculated as standard deviation divided by the average.
Source: EBRD, Transition Report 1995, 2000, 2003

Landesmann (2000, p. 102) shows that this is also the case when wages are measured in absolute values. A smaller dispersion of wages manifests itself in big differences in productivity, and then in even bigger differences in unit labor costs. In this respect, the situation in the CEECs only confirms a stylized fact from growth theory which suggest that the wages tend to be relatively 'rigid', in the sense that they appear to adjust very slowly, if at all, to unbalances in the labor market. (Dosi et al, 1994, Jones, 1998). Hence, it is differences in labor productivity, and related to that difference in countries' ability to generate technical change, that will be crucial in determining speed and nature of catching-up process.

In continuation, we explore downsizing of R&D systems in CEECs and we test whether these systems are still 'oversized' given their current income levels.

3. R&D SYSTEMS IN CEE: ASSET THAT VANISHED

Socialist countries had invested disproportionably high shares of GDP into R&D. To a large extent this was due to closed nature of these economies where due to COCOM restrictions they often had to 'reinvent the wheel' as well as due to dominant orientation, especially of USSR, on defense technologies. Before we analyze pattern of downsizing of R&D system we want to find out whether CEECs still carry this heritage, i.e. whether they can be still differentiated based on their R&D investments from countries of similar income levels. If their R&D expenditures are still different from countries of similar level of development we would expect them to be outliers in regressions that link relative expenditures to GDP *per capita* levels.

Similar to Gross and Suhrcke (2000) we test the relationship between GERD/GDP as function of level of development. In order to capture possible outlying features of the CEECs we also test model with dummies for all transition economies, and than for CEECs and for CIS economies for 1990 and for 1999.

$$GERD/GDP = \alpha + \beta GDP\ pc + \beta DUMMY + \varepsilon$$

For 1990, our sample consists of 44 developing and developed countries and includes all transition economies for which R&D were available. For 1999, sample consists of 60 countries. Data are taken from World Bank Development Indicators 2003, Russian *Goskomstat* for CIS economies and from OECD Main S&T Indicators 2001 and 2003.
For 1990, simple regression of R&D on GDP per capita yield positive and significant results. Although per capita income explains only small proportion of variance in relative RD expenditures (1%) and its impact is very small (coefficient of only 0.00006) this impact is highly significant. Inclusion of transition economies for 1990 improves the overall fit with adjR2 rising to 24%. However, dummy variable for transition economies is on the border of significance at slightly above 5% level. When we break transition economies on CEE and CIS we get significant dummy variable for the CIS and insignificant for CEECs. These results suggest that in 1990 ex-socialist economies have not been 'overinvesting' in R&D as group. Socialist heritage is present only in the case of CIS economies which in 1990 were still part of the USSSR. Probably, if we could collect data on R&D for 19898 or earlier years the hypothesis on 'overinvestment' of socialist economies in R&D would have been confirmed. The drop in R&D funding has been very strong in all CEECs in between 1989 and 1990. Analysis of residuals for the CIS countries for 1990 shows that 'overinvestment' actually applies only to European CIS economies and Armenia. Data for 7 CEEC for which data are available shows that in 1990 only Bulgaria had R&D expenditures which were higher than one standard deviation from regression line.

Depend.var. R&D/GDP 1990
Indep.var. GDP per capita 1990
Dummy Transition Economies (TE)
Dummy CEE
Dummy CIS
Number of observations: 44

Variable	**Constant**	**GDPpc 90**	**DUM TE**	**DUM CEE**	**DUM CIS**	**R sq.**	**Adj. R-sq.**	**F-stat.**	**Prob (F-stat)**
Coefficient	0.859	0.00006 457				0.204	0.185	10.785	0.002
Std. Error	0.234	0.000							
t-stat	3.676	3.280							
Prob.	**0.001**	**0.002**							
Coefficient	0.450	0.00008	0.509			0.275	0.239	7.762	0.001

		518							
Std. Error	0.305	0.000	0.255						
t-stat	1.475	3.937	1.999						
Prob.	0.148	**0.000**	0.52						
Coefficient	0.338	0.00009323		0.498	0.713	0.302	0.249	5.763	0.002
Std. Error	0.314	0.000		0.320	0.323				
t-stat	1.075	4.149		1.556	2.209				
Prob.	0.289	**0.000**		0.128	0.33				

Regression for 1999 shows that GDP pc can explain 58% of variance in relative R&D expenditures which h is much higher when compared to 1990. However, coefficient is not significantly higher. Inclusion of dummy for transition economies is now highly insignificant. Also, model with separate dummies for CEE and for CIS are also highly insignificant. So, transition economies have lost their socialist heritage in R&D and have become in that respect 'normal' economies. Moreover, analysis of residuals for 1999 shows that among CEE economies relative expenditures for Poland, Romania, Hungary and Slovakia are now below of what would be expected given their income levels. However, these 'underinvestment' are not statistically significant as they are in the range of 0.02 to 0.4 standard deviations[6]. However, newly achieved 'normality' of CEE and CIS economies has now become cause for concern from the perspective of achieving knowledge economy objectives as well as from catching up perspective. Lederman and Maloney (2003) show that economies which have radically deviated from the predicted trajectory in terms of relative R&D expenditures (Finland, Israel, Korea and Taiwan) have also displayed high estimates of social rates of return from these investments which probably justify this effort. Also, they found that rates of returns from R&D investments are higher for less developed countries. All this suggest that the key issue is not size of R&D system *per se* but its contribution to productivity and growth.

Depend.var. R&D/GDP 1999
Indep.var. GDP per capita 1999
Dummy Transition Economies (TE)
Dummy CEE
Dummy CIS
Number of observations: 60

Variable	**Constant**	**GDPpc 99**	**DUM TE**	**DUM CEE**	**DUM CIS**	**R sq.**	**Adj. R-sq.**	**F-stat.**	**Prob (F-stat)**
Coefficient	0.118	0.00008043				0.588	0.581	82.866	0.000
Std. Error	0.135	0.000							
t-stat	0.873	9.103							
Prob.	0.386	**0.000**							
Coefficient	0.05619	0.00008279	0.102			0.590	0.576	41.074	0.000

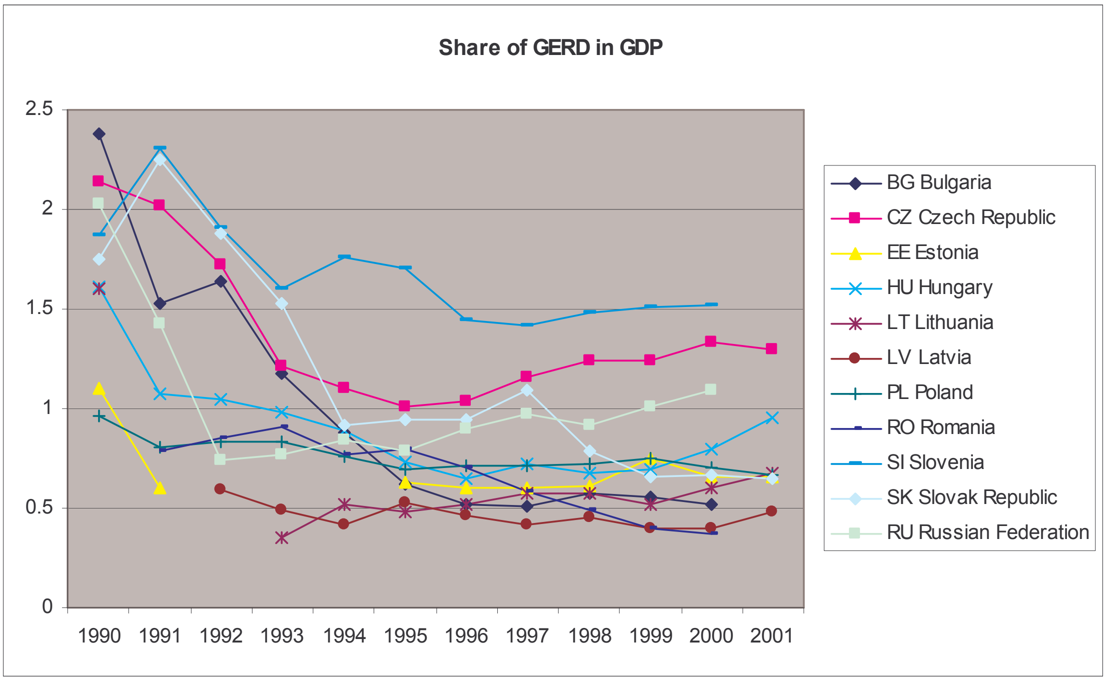
[6] Ukraine is the only economy among CEE/CIS countries whose relative R&D expenditures are at 1 standard deviation above regression line for 1999.

Std. Error	0.177	0.000	0.189						
t-stat	0.317	8.361	0.541						
Prob.	0.753	**0.000**	0.591						
Coefficient	0.01475			0.0216	0.270	0.597	0.575	27.618	0.000
Std. Error	0.177			0.241	0.253				
t-stat	0.083			0.090	1.068				
Prob.	0.934			0.929	0.290				

In the post-socialist period demand for R&D collapsed while budget squeeze could not compensate for fall in demand for innovation. As a result, relative expenditures for R&D fell from levels of between 1-2.5% in 1990 towards levels in between 0.5 and 1% in mid 1990s, with the exception of Slovenia where R&D has stabilized at the level of 1.5% of GDP (figure 5).

This downfall can be disaggregated into three distinct periods. First, in the period between 1990 and 1993/94, with the falling GDPs the share of expenditures for R&D also declined sharply leading to a very high absolute decline in funding of large R&D systems. This was followed by the period of stabilisation (1993/94 to 1996) in which decline continued but at significantly lower rate. From 1996, signs of recovery in some economies, in both absolute and relative funding of R&D, have emerged. After average annual decrease of 13% in 1991-96 period, the relative share of R&D in average grows by 3.2% annually in 1997-199 period and at even higher rates after 1999.

Figure 5: Share of GERD in GDP

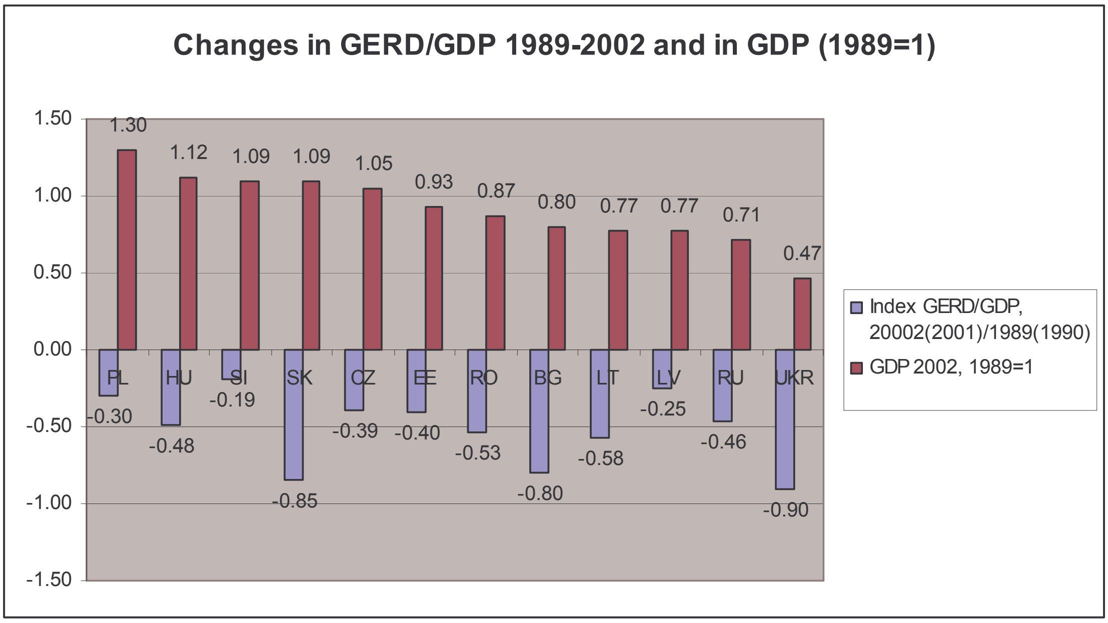


Source: New Cronos, OECD MSTI, Meske

This halving of relative R&D expenditures compared to 1990 has been accompanied by decline and than recovery of GDP which on average has approached to 90% of its 1989

level. This suggests that recovery in GDP has not been accompanied by parallel recovery in R&D. CEECs have come out of transition as significantly less R&D intensive economies. In addition, this decline has been led to reduced differences between CEECs, i.e. decline in R&D has led to convergence in relative expenditures. Standard deviation in relative expenditures has declined from 0.44 (1990) to 0.25 (2001)[7].
Figure 6 shows that big differences in recovery of GDP and growth have not been accompanied by similar differences in R&D expenditures. For example, Russia and Poland have similar declines in GERD/GDP (25% vs. 30% respectively) while their GDP recovery has been very different (130% vs. 71% respectively). Slovakian and Ukrainian relative R&D expenditures have declined to 15 and 10% respectively of their 1990 level. However, Slovak GDP is 9% higher while Ukrainian GDP is still at 47% of its 1989 level. Slovak and Slovenian GDP have recovered to the same level (109%) while their relative R&D expenditures differ greatly. Slovenian relative R&D expenditures have declined by 19% of their 1990 level while Slovakian expenditures have declined by 85%.

Figure 6: Changes in GERD/GDP 1989 and in GDP (1989=1)



Source: New Cronos, OECD MSTI, Meske (2004)

Correlation between growth rates of GDP and GERD/GDP in 1990-2002 period shows that the relationship is very much country specific. It ranges from highly negative correlation coefficients between changes in GDP and in GERD/GDP for Romania and Latvia to highly positive changes for Czech R and Estonia.

Table 3: Correlation of GDP growth rates and GERD/GDP 1990 – 2002

CZ	0.79
EE	0.68

[7] The highest decline in GERD was from 1989 to 1990 but we do not have complete and reliable data.

SK	0.53
PL	0.48
LT	0.18
RF	0.17
SI	-0.09
BG	-0.21
HU	-0.66
UKR	-0.66
LV	-0.97
RO	-0.98

Source: New Cronos, OECD MSTI, Meske (2004)

As we analyzed elsewhere, (Radosevic and Auriol, 1999) downsizing of the R&D systems in CEE was not systematically linked to a specific individual factor on the demand or supply side. Probably, it is the combination of demand side factors (annual changes in GDP and investments) and supply side policies (budgetary R&D policy) that in the end have shaped trends in R&D spending. Neither government nor market demand for R&D could buffer this fall.

Our analysis suggests that R&D system plays a relatively small direct role in the current performance of the CEE economies. However, we should not ignore the importance of R&D system just based on its current role. The role of R&D is likely to increase with return to growth. In fact, restructuring of R&D is one the key preconditions for further industrial upgrading. In addition, its role cannot be evaluated only through its direct contribution to innovation but also through its contribution to education and transfer of research methodologies and techniques (Pavitt) and as an important factor of absorptive capacity (Cohen and Levinthal, 1989, 1990).

This means that we have to shift focus of analysis from R&D as stand alone aggregate towards R&D as a component of technological and production capabilities of the CEE countries. R&D and innovation are not synonymous concepts, especially in countries which are not operating at technology frontier. In section 5 we analyze through descriptive analysis structure of business R&D expenditures, resident patents and quality certificates. In next section, we analyze the relationship between productivity and R&D, patents as outcomes of technological activity and ISO9000 certificates.

4. PRODUCTIVITY, PRODUCTION AND TECHNOLOGICAL CAPABILITY

Early 1990s have shown weak competitiveness of the CEECs. Improved competitiveness could not be achieved based on their technological capabilities (R&D and patents) but primarily based on significant improvements in productivity based on production capability.

In continuation we want to test our conceptual model from section 2. We want to examine whether technological capabilities (R&D and patents) and production (ISO900 certificates) capabilities could explain differences in productivity (income per capita) across sample of countries. Specifically we want to test the following relationship:

$GNI\ pc = \alpha + \beta\ RDPRSN\ pe + \beta\ RESPAT\ pc + \gamma\ ISO9000\ pc\ CORR + \delta CEEDUMMY + \varepsilon$

Where:

GNI pc = Gross National Income per capita in $PPP, 2002
BESRDPRSN pe = Business R&D personnel per 000 employment (alternatively: RDPRSN pe = R&D Personnel per 000 employment), 2002 or nearest available year
RESPAT pc = Resident patents per capita, 2000
ISO9000 pc CORR = Number of ISO 900 certificates per capita (2002) corrected by share of FDI/GDP (2002 or nearest available year)
CEEDUMMY = Dummy variable for CEE countries

Sources of data are:

- for GNI pc, World Bank Development Indicators 2003
- for RDPRSN pe and BESRDPRSN pe, OECD Main S&T Indicators Data Base, 2003
- for RESPAT pc, WIPO CD ROM
- for ISO9000 pc, ISO CD ROM
- for FDI, UNCTAD World Investment Report

Our sample includes 33 OECD/CEE countries (7) with the full model data available for 28 countries. These are: Australia, Austria, Belgium, Canada, Czech R, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

R&D Personnel per 000 employments measures the R&D intensity of labor force and is proxy for generation of new knowledge. As alternative, we use business sector R&D personnel. For output of R&D and innovation activities we use resident patent data. National patents have not been used extensively as an indicator for international comparisons of national innovation capabilities[8]. Instead, US patent data are most commonly used. However, the relevance of the US foreign patenting is much less clear in the case of 'catching up' economies. The technology effort of these economies is mostly not at the world innovation frontier. This results in relatively small numbers for these economies and creates the danger of over-interpreting small differences in patent numbers, especially over time. In addition, we expect that resident patents may capture imitative innovative effort which is dominant share of innovative effort in 'catching up' economies. Our sample of 30 economies encompasses technology frontier as well as 'catching up' economies of CEE, Turkey, Russia, Mexico and Korea.

However, productivity is affected not only by innovation activities but also by non-innovation or activities related to improvements in production capability. ISO9000 certificates are imperfect but available proxy for this kind of activities. With spread of new business model based on contract manufacturing and fragmented value chains quality standards have become 'entry tickets' to global production networks. Especially for CEECs, ISO standards are indispensable for exporting and for integration into MNC networks. Hence, we control number of ISO900 certificates for the degree to which FDI are present in

[8] We are actually unaware of any large comparative study based on national patent data. It is still assumed that i) differences in national patent systems, and ii) in quality of national patents are big and do not justify this analysis. We think that the first of these arguments is not justified any more as the process of harmonization in patent legislation has advanced so much that meaningful comparisons are possible today. Differences in quality of resident patents are supposedly present although we have not come across a systematic analysis, which would look at this issue.

the economy. This variable also captures differences in size of economies and thus relatively smaller presence if FDI in large economies.

We want to explore whether CEE economies 'under-perform' or 'over-perform' in terms of productivity given their levels of R&D, innovation and quality related activities. For that purpose we run regressions with and without CEE dummy variable.

Model is tested in logarithmic and non-logarithmic forms. Here we report results in logarithmic form which gives better fit for very low and very high levels which is often the case in our sample. In order to analyze if the relationship between productivity and our technology/production capability variables is specific in the case of the CEECs we run regressions with and without CEE dummy.

Table 4:

Depend.var. GNI pc

Number of observations: 28

Variable	Const.	BESRD PRSN	RESPAT	ISOFDI	CEE-DUMMY	R sq.	Adj. R-sq.	F-stat.	Prob (F-stat)
Coefficient	10.36	0.285	-0.000447	- 0.02299		0.637	0.591	14.014	0.000
Std. Error	0.155	0.082	.054	0.044					
t-stat	66.849	3.459	-0.008	-0.473					
Prob.	**0.000**	**0.002**	0.640	0.993					
Coefficient	9.040	0.454	-0.000168	0.00675	-1.069	0.928	0.837	35.614	0.000
Std. Error	0.187	0.099	0.065	0.053	0.172				
t-stat	48.273	4.854	-0.003	0.127	-6.205				
Prob.	**0.000**	**0.000**	0.998	0.900	**0.000**				

The overall model with BES R&D Personnel is highly significant, the coefficient on R&D is also significant and the overall model explains 60% of variation in GNI per capita. However, both ISO certificates and patents are highly insignificant and with opposite sign of expected which suggest that there is multicolinearity among variables. Indeed, variance proportions show that these two predictors have most of their variance loaded into different eigenvalues which confirms multicolinearity. Colinearity statistics (tolerance and VIF values) also confirms this problem.

Model with R&D personnel, whose results we do not report here, is in overall also significant but with lower F test and R2 values, it has similar problem of multicolinearity but none of coefficients is significant which points to lesser relevance of the overall size of the R&D system as variable to explain productivity levels. Businesses enterprise sector R&D seems to be better proxy for exploring determinants of productivity than the overall R&D manpower proxy. However, we should bear in mind that in the CEE countries data on BES R&D are not without problems. A high share of extra-mural R&D which is inconsistently grouped as either BES R&D or GOV R&D makes the use of only BES data problematic. In addition, use of ISO900 certificates data would require use of the overall R&D manpower proxy rather than only BES as high share of ISO certificates are issued in services including public organizations.

Model with CEE Dummy variable yields even more overall significance with coefficient determination reaching 83% and highly significant F test. Importantly, CEE dummy and BES R&D variables are highly significant but patents and ISO variables are highly insignificant which point to problem of multicolinearity and thus to problem with the specification of our model. Negative coefficients for patents support conclusion as well as

inspection of multicolinearity statistics. High variance proportions between patents and BES R&D personnel variables on identical dimensions of eigenvalues points to multicolinearity between these two variables. In other words, these two variables capture the same part of variation in productivity and make our model 'overspecified'.
However, despite these problems high significance of the CEE dummy variable with negative sign point to important specificity of the CEEC in terms of relationship between technology/production capability variables and productivity which we want to explore.

Usual advice for resolving multicolinearity problem is to either drop one of variables or create multiple of variables. In order to explore the problem we run 3 simple regressions between our dependent and each of three independent variables as well as models with different pairs of variables. First, we report on regressions with individual technology/production capability variables with and without CEE dummy variable.

Table 5:

Depend.var.	GNI pc								
Variable	**Const.**	**BESRD PRSN**	**RDPRSN**	**RESPAT**	**ISOFDI**	**CEE-DUMMY**	**Adj. R-sq.**	**F-stat.**[9]	**Prob (F-stat)**
Coefficient	8.790	0.524					0.622	42.708	0.000
Std. Error	0.159	0.080							
t-stat	55.164	6.535							
Prob.	**0.00**	**0.000**							
No of obs	28								
Coefficient	9.054	0.456				-1.069	0.850	77.358	0.000
Std. Error	0.106	0.051				0.163			
t-stat	85.059	8.999				-0.500			
Prob.	**0.000**	**0.000**				**0.000**			
No of obs	28								
Coefficient	7.773		0.832				0.380	18.771	0.000
Std. Error	0.426		0.192						
t-stat	18.263		4.333						
Prob.	**0.000**		**0.000**						
No of obs	30								
Coefficient	8.321		0.702			-1.373	0.773	50.480	0.000
Std. Error	0.269		0.117			0.195			
t-stat	30.953		5.976			-7.043			
Prob.	**0.000**		**0.000**			**0.000**			
No of obs	30								
Coefficient	9.344			0.343			0.395	21.933	0.000
Std. Error	0.128			0.073					

[9] The F statistics is equal to the square of the t statistics and the critical value of F, at any given significance level, is equal to the square of the critical value of t. However, we report on F test in simple regression as we want to compare the overall robustness of simple regression with regression which contains CEE dummy.

t-stat	73.166	4.683					
Prob.	**0.000**	**0.000**					
No of obs	33						
Coefficient	9.667	0.257		-1.272	0.729	44.000	0.000
Std. Error	0.100	0.051		0.203			
t-stat	96.798	5.053		-6.253			
Prob.	**0.000**	**0.000**		**0.000**			
No of obs	33						
Coefficient	8.999		0.260		0.122	5.290	0.029
Std. Error	0.312		0.113				
t-stat	28.481		2.3				
Prob.	**0.000**		**0.029**				
No of obs	32						
Coefficient	9.432		0.169	-1.427	0.558	20.569	0.000
Std. Error	0.242		0.082	0.258			
t-stat	39.029		2.069	-5.534			
Prob.	**0.000**		**0.048**	**0.000**			
No of obs	32						

Simple regression results show that R&D and patents are highly significant explanatory variables of country's productivity at 1% level. ISO certificates are significant at below 5% level but not at 1% level.

Residuals for all CEECs (bolded), except for Bulgaria for three variables, are negative in all four models with simple regressions which suggest that for the given level of technology/production capability indicators levels of productivity in CEE are lower than would be expected.

Table 6: Standardised residuals in simple regressions on productivity

R&D personnel		BES R&D personnel		Res patents		ISO 9000	
mex	1.31	mex	1.55	el	1.43	lux	1.82
nor	1.07	nor	1.16	irl	1.19	us	1.19
lux	0.89	ch	0.85	nor	1.08	nor	1.14
ch	0.86	it	0.77	ice	1.01	**bl**	**1.07**
irl	0.85	el	0.76	p	0.96	dk	1.02
a	0.84	lux	0.70	lux	0.94	ch	0.76
it	0.76	p	0.66	us	0.74	aus	0.73
uk	0.73	uk	0.65	**bl**	**0.73**	s	0.73
jpn	0.71	aus	0.63	can	0.70	irl	0.64
can	0.53	a	0.61	mex	0.65	nl	0.61
dk	0.48	jpn	0.60	ch	0.55	can	0.56
nl	0.44	irl	0.51	dk	0.49	nz	0.55
d	0.24	can	0.40	it	0.40	fin	0.52
aus	0.22	nl	0.31	a	0.40	d	0.47
e	0.15	dk	0.28	e	0.39	fr	0.45
bl	**0.15**	e	0.15	fr	0.33	uk	0.40
p	0.13	d	-0.03	uk	0.30	a	0.34

fr	0.10	nz	-0.08	nl	0.27	jpn	0.13
s	0.08	fr	-0.11	fin	0.20	e	-0.20
el	0.01	**bl**	**-0.23**	s	-0.03	it	-0.29
tk	-0.25	s	-0.33	aus	-0.05	mex	-0.30
nz	-0.29	fin	-0.54	jpn	-0.12	p	-0.30
kor	-0.38	tk	-0.71	d	-0.13	el	-0.47
fin	-0.42	**pl**	**-1.13**	**si**	**-0.42**	kor	-0.60
si	**-0.53**	kor	-1.22	nz	-0.66	**si**	**-0.66**
hun	**-1.01**	**hun**	**-1.46**	tk	-0.72	**pl**	**-0.98**
pl	**-1.03**	**sk**	**-2.18**	**cz**	**-0.81**	**rus**	**-1.02**
sk	**-1.46**	**cz**	**-2.58**	**hun**	**-1.05**	**cz**	**-1.27**
ro	**-1.80**			**pl**	**-1.10**	**hun**	**-1.34**
rus	**-3.39**			**sk**	**-1.15**	**sk**	**-1.51**
				kor	-1.57	tk	-1.97
				ro	**-2.25**	**ro**	**-2.21**
				rus	**-2.69**		

All regressions with CEE dummies which take into account this problem have significantly better results. Moreover, inclusion of CEE dummy in regression with ISO certificates improves regression so that the overall regression becomes significant though coefficient of ISO certificates is significant at below % level.

In multiple regressions CEE dummies are negative which suggest that with the given capabilities CEEC achieve lower results in productivity than would be expected. This is also confirmed by residuals from simple regressions of individual technology/production capability variables on productivity levels.

These results points to possible 'inefficiencies' in process of conversion of the existing 'potential' into higher productivity. However, a positive interpretation of this would be that negative dummies show a high potential for catching up provided that countries are able to exploit advantages in their technology/production capabilities. Within that context, 'Bulgarian puzzle' may suggest either Bulgarian R&D system is not any more 'inefficient' or that Bulgaria has lost potential advantages which could be exploited in future in terms of technology outputs.

In continuation, we want to explore whether these inefficiencies are within the R&D and 'narrow' innovation system or within 'broader' national system of innovation. However, before that we want to explore reduced model which best explains differences in levels of productivity in our sample of OECD/CEECs. For that purpose we run regressions with pairs of variables.

Table 7: Reduced form of model: regressions with pairs of variables

Depend.var.	**GNI pc**								
Variable	**Const.**	**BESRD PRSN**	**RDPRSN**	**RESPAT**	**ISOFDI**	**CEE-DUMMY**	**Adj. R-sq.**	**F-stat.**	**Prob (F-stat)**
Coefficient	8.892	0.436		0.0668			0.598	21.120	0.000
Std. Error	0.222	0.155		0.100					
t-stat	39.990	2.815		0.667					
Prob.	**0.000**	**0.009**		0.511					
No of obs	28								
Coefficient	9.055	0.455		0.0007357		-1.068	0.844	49.509	0.000

Std. Error	0.141	0.097		0.063		0.169			
t-stat	64.138	4.703		0.012		-6.336			
Prob.	**0.000**	**0.000**		0.991		**0.000**			
No of obs	28								
Coefficient	8.454		0.456	0.186			0.408	10.994	0.000
Std. Error	0.610		0.310	0.122					
t-stat	13.473		1.473	1.526					
Prob.	**0.000**		0.152	0.139					
No of obs	30								
Coefficient	8.633		0.525	0.08979		-1.329	0.777	34.602	0.000
Std. Error	0.376		0.190	0.076		0.197			
t-stat	22.971		2.755	1.179		-0.610			
Prob.	**0.000**		**0.011**	0.249		**0.000**			
No of obs	30								
Coefficient	8.789	0.524			0.0002935		0.591	20.533	0.000
Std. Error	0.238	0.086			0.084				
t-stat	36.986	6.119			0.004				
Prob.	**0.000**	**0.000**			0.997				
No of obs	28								
Coefficient	9.040	0.454			0.006739	-1.069	0.844	49.550	0.000
Std. Error	0.152	0.054			0.052	0.166			
t-stat	59.438	8.391			0.130	-6.429			
Prob.	**0.000**	**0.000**			0.897	**0.000**			
No of obs	30								
Coefficient	7.825		0.108		0.268		0.471	13.914	0.000
Std. Error	0.345		0.025		0.088				
t-stat	22.658		3.058		3.058				
Prob.	**0.000**		**0.000**		**0.005**				
No of obs	30								
Coefficient	8.045		0.672		0.132	-1.273	0.808	41.579	0.000
Std. Error	0.273		0.109		0.055	0.184			
t-stat	29.471		6.164		2.410	-6.907			
Prob.	**0.000**		**0.000**		**0.023**	**0.000**			
No of obs	30								
Coefficient	8.962			0.311	0.156		0.437	13.028	0.000
Std. Error	0.251			0.074	0.094				
t-stat	35.762			4.219	1.663				
Prob.	**0.000**			**0.000**	0.107				
No of obs	32								
Coefficient	9.399			0.240	0.103	-1.209	0.745	31.189	0.000
Std. Error	0.184			0.051	0.064	0.201			
t-stat	51.164			4.719	1.613	-6.003			

Prob.	**0.000**			**0.000**	0.118	**0.000**
No of obs	32					

Exploration of the most robust model which can explain different level of productivity has generated few interesting conclusions:

First, the only satisfactory model is the one where productivity is determined by the overall R&D employment and ISO9000 certificates. Both variables are significant at 1% and model explains 47% of variation in levels of productivity. This result confirms our conceptual model which points to the importance of technological and production capability for explaining levels of productivity.

Second, inclusion of CEEC dummy greatly improves the overall robustness of model though coefficient for quality certificates is significant only at 5 % level. However, this model explains 80% of variation in levels of productivity.

Third, all models with added CEE dummies significantly improve the overall robustness of models as confirmed by F-tests. This is expected based on results of simple regressions and it points to important specificity of the CEEC related to possible 'inefficiencies' or potentials within 'broad' or 'narrow' NSI which we want to explore in the rest of this paper.

Fourth, use of business enterprises R&D employment in combination with ISO9000 certificates yields negative results for ISO certificates. Partly, this may reflect problems with use of BES data for the CEECs due to high share of extra-mural R&D which is inconsistently recorded as business or government R&D. However, we think that this also reflects different functions of the overall R&D as compared BES R&D as well as nature of quality indicators. Namely, ISO Certificates are registered in a large number of non-industry sectors while BES R&D is to a great extent confined to industry, in particular in less developed OECD and CEECs. Overall R&D system could be used as a proxy for the overall absorptive capability while BES R&D seems to be better proxy of innovation activity.

Fifth, model with BES R&D and resident patents show that these indicators are capturing similar parts of variance in productivity levels which generates high collinearity between these variables. As a result of this we get high coefficient of determination and insignificant results for resident patents. As still majority of patents are generated within industry the high significance of BES R&D employment may be expected. When patent data are used in combination with the overall R&D employment size and significance of coefficients for patents improves though they still remain insignificant.

Sixth, combined use of output proxies – patents and ISO certificates – generates similar problems of multicolinearity.

In conclusion, reduced model which explains differences in levels of productivity by differences in technological (R&D employment) and production (ISO9000) capabilities generate satisfactory results. This model points to need to expand our understanding of determinants of productivity to non-innovation areas i.e. issues of production capability. In addition, our analysis points to problems of the CEECs to generate levels of productivity which would be expected given their levels of investments in R&D and given their levels of production capability related activities. This suggests that problems may be related to 'broad' rather than 'narrow' system of innovation. However, before we embark on this conclusion we would like to explore hypothesis on possible inefficiency of narrow NSI in CEECs.

5. TESTING (IN)EFFICIENCY OF NARROW NATIONAL SYSTEM OF INNOVATION IN CEE

Due to the multifaceted nature of science and technology (S&T) inputs and outputs, the issue of productivity of countries' narrow innovation systems is extremely complex. Outputs of innovation activities are not only in the form of products, such as patents, papers, or tangibles, such as machinery and equipment, but even more important, in the form of a wide range of know–how capabilities and skills. We should bear this in mind when trying to understand the issue of productivity of innovation activities. Any indicator is inevitably very partial and can be understood only in a specific national context.

One way to explore the issue of inefficiency of narrow NSI is to relate S&T outputs to inputs. For example, for Czech R EC (2004) writes 'Despite a relatively high level of expenditure on R&D in comparison with the new members, the resulting innovation activity as measured by the number of patents, is very low, pointing to low effectiveness of R&D' (p. 24).

Table 9 shows the ratio between resident patents and S&T journal articles per $1mn GERD (PPP) and per 1000 Research Scientists and Engineers (RSE). This indicator measures in extremely crude and primitive form 'productivity' of the R&D system. However, we consider it to be more useful as an indicator of the relative orientation of formal R&D activities, in particular, whether they are more research oriented (S&T journal articles) or more innovation/invention oriented (resident patents).

Table 9 - Relative orientations and productivity of R&D systems, 1998 or latest available

Country name	Resident patents/GERD[10]	Resident patents per 1000 R&D personnel	S&T journal articles/GERD	S&T journal articles per 1000 R&D personnel
Latvia	8.13	44	5.88	30
Lithuania	2.45	11	3.6	20
Slovak Republic	1.44	14	6.09	60
Bulgaria	4.32	15	13.79	50
Romania	7.11	25	4.08	10
Estonia	0.76	4	7.64	50
Slovenia	1.3	37	2.27	60
Hungary	2.64	37	6.03	80
Czech Republic	1.02	27	3.21	90
Poland	2.36	29	3.93	50
Average productivity	***3.15***	***24.30***	***5.65***	***50.00***
Greece		4		110
Portugal	0.2	6	1.86	50
Spain	0.66	32	2.39	120

[10] Expressed in PPP$

Average productivity	***0.43***	***14***	***2.13***	***93.33***
Austria	0.89	97	1.01	110
Belgium	0.48	41	1.19	100
Denmark	0.97	82	1.32	110
Finland	1.44	103	1.17	80
France	0.72	66	0.94	90
Germany	1.54	147	0.82	80
Ireland	1.24	100	1.16	90
Italy	0.29	22	1.52	120
Netherlands	0.85	67	1.62	130
Sweden	1.07	126	1.03	120
United Kingdom	1.26	104	1.69	140
Average productivity	***0.86***	***71.93***	***1.42***	***102.38***
Relative productivity				
DEU12=100 avg.	1	1	1	1
SEU-3 avg.	0.50	0.19	1.50	0.91
CEE-10-avg.	3.67	0.34	3.99	0.49

Source: Calculations based on WB CDROM World Development Indicators 2001, OECD MSTI 2000, Slovenian Statistical Office data, and for Estonia on Hernseniemi (2000).

As measured by both patents and S&T journal articles, the relative productivity of CEECs-10 R&D systems is high in relation to their gross expenditures on R&D (GERD) (Table 9). However, when measured in terms of patents per full-time equivalent (FTE) researcher, the 'productivity' of CEE-10 is significantly lower than in the high-income EU economies. 'Productivity' in the CEE-10 also lags in relation to Southern EU economies in terms of papers but not in terms of patents.

Differences in 'productivity' in terms of papers and patents suggest that the orientation of the R&D systems of CEEC-10 may be different from those of the other EU economies. When compared with the developed EU economies CEECs are lagging more in terms of patenting than in terms of papers. This stronger science orientation of CEECs is to be expected given the very low capital intensity of their R&D systems. However, in relation to the Southern EU economies CEECs exhibit a stronger technology (patents) orientation but a weaker science (papers) orientation. This intermediate position of the CEE in terms of S&T orientation corresponds with the intermediate position of CCs in terms of industry structure. Urban (1999) shows that CEECs have higher engineering sector shares than the EU South but smaller than the EU North while the opposite position apply to labour intensive industries. In this respect, the intermediate position of CEECs in terms of orientation of their R&D systems may reflect the intermediate position of CEECs in terms of industry structure.

This suggests that the problem of productivity of R&D system is complex issue as it is highly sensitive on orientation of R&D systems and thus criteria of efficiency should be clearly spelled out. Narrow NSI may be very efficient from science perspective and inefficient from innovation perspective. Or, it could be efficient from generation of new knowledge (science, know how) perspective but weak from diffusion perspective.

In order to explore this problem further we run regression which tests the relationship between resident patents as output variable and BES R&D employment as input variable. We would expect that there is positive relationship, i.e. similar number of BES R&D employment per employee should generate similar numbers of resident patents per capita. If CEECs R&D systems were 'inefficient' we would expect that the CEE dummy variable would be significant and negative as we have seen above.

Regression results (table 8) show that there is positive and strong relationship between inputs (BESR R&D employment) and output (resident patents per capita). R&D coefficient is highly significant and explains 71% of variation in resident patents. However, CEE dummy is not significant i.e. CEECs do not seem to be 'inefficient' in converting BES R&D employment into resident patents[11][12].

Table 8: Testing efficiency of R&D in CEE

Depend.var.	**Resident patents per capita**					
Variable	**Const.**	**BESRDPRSN**	**CEE-DUMMY**	**Adj. R-sq.**	**F-stat.[13]**	**Prob (F-stat)**
Coefficient	-1.529	1.316		0.716	68.928	0.000
Std. Error	0.315	0.159				
t-stat	-4.853	8.302				
Prob.	**0.000**	**0.000**				
No of obs	28					
Coefficient	-1.421	1.289	-0.437			
Std. Error	0.342	0.163	0.524			
t-stat	-4.150	7.907	-0.833			
Prob.	**0.000**	**0.000**	-.413			
No of obs	28					

Inspection of standardized residuals and of scatter diagram fully confirms this result. Czech Republic, whose inefficient R&D system has been pointed by the EC (2004), has negative residual in simple regression which does confirm that its number of patents is lower than would be expected given its number of BES R&D employment. However, this residual is still within the normal range and is somewhat higher than negative residual of Ireland.

Table 10:
Standardised residuals in regression of patents on BES R&D employment

	StResid		**StResid**
Korea	1.86	Denmark	-0.12
Japan	1.63	Norway	-0.15
New Zeal	1.50	Spain	-0.39
Australia	1.28	France	-0.40
United Kingdom	0.67	Luxembourg	-0.43
Germany	0.67	Canada	-0.53

[11] Similar results are generated for total R&D employment as input variable.

[12] We also explored the relationship between ISO900 certificates as inputs and patents as output indicators. Underlying model is that mastery of production capability is closely related to mastery of technology capability. Results are not statistically significant which pints that the relationship between these tow capabilities is non-linear and fraught with different threshold levels and feedbacks. Addition of the CEE dummy is also insignificant.

[13] The F statistics is equal to the square of the t statistics and the critical value of F, at any given significance level, is equal to the square of the critical value of t. However, we report on F test in simple regression as we want to compare the overall robustness of simple regression with regression which contains CEE dummy.

Poland	**0.66**	**Slovak R**	**-0.64**
Switzerland	0.55	Finland	-0.66
Italy	0.49	Portugal	-1.10
Mexico	0.45	Belgium	-1.39
Austria	0.40	Ireland	-1.44
Netherlands	0.27	**Czech Rep**	**-1.74**
Hungary	**0.19**	Greece	-1.93
Sweden	0.13		
Turkey	0.13		

A higher 'efficiency' of Polish R&D system does not seem to make much difference in terms of contribution of 'narrow' NSI to Polish economic growth. In fact, in many respects Polish R&D system is mush less reformed and its higher 'productivity' may be merely a symptom of the degree to which it is not restructured. For example, Ukraine and Russia are countries where resident patenting has fallen the least among the CEECs which makes striking comparison with the central European economies. However, this seeming 'efficiency' of Russian and Ukrainian narrow NSI does not seem to translate into industrial productivity.

Our analysis suggests that narrow NSI of CEECs do not seem to be 'inefficient' in terms of conversion of BES employment into patents. Inefficiencies do not seem to exist within 'narrow' national system of innovation but within 'broad' national innovation system. CEECs have not yet achieved levels of productivity which would be expected given their technological and production capabilities. Inefficiency of broad national systems of innovation is complex issue which cannot be handled properly even through much more sophisticated econometrics and data sets available than we have used here. Nevertheless, our analysis has identified several issues which are of importance in improving 'efficiencies' of both broad and narrow NSI and which we discuss these in the last section.

6. CONCLUSIONS AND POLICY IMPLICATIONS

Innovation and technical change are the main drivers of economic growth though the link between them is difficult to show empirically[14]. Differences in countries' ability to generate technical change will be crucial in determining speed and nature of catching-up process in new members' states. In this paper, we tried to address some of the factors behind differences in productivity by primarily looking at the impact of production and technology capacities of the CEECs.

Our analysis shows that the CEECs have lost advantages in terms of size of R&D which they inherited from the socialist period. Policy problem has now reversed as the EC (2004) recommendations point to low R&D investments in most of the countries, low efficiency of R&D systems (Czech R, Slovenia), and of education and vocational training systems.

Production capability in combination with technological capabilities explains satisfactory productivity differences among OECD and CEE countries. In this way, our results point to importance of quality and intra-firm productivity enhancing activities for growth and catch-up.

[14] See OECD, 2000 for an overview of different approaches

CEECs have lower levels of productivity than would be expected given their R&D capacities, innovation and production capabilities. This may point to possible inefficiencies in conversion of R&D/innovation outputs into productivity. We find that these inefficiencies cannot be identified within the 'narrow' national system of innovation but more likely within 'broad' national system of innovation. The problems are not only in the narrow S&T systems itself but in the broader issues of demand for technology. This particularly applies to the relationship between small and large firms and integration of foreign firms into local economy.

These findings when interpreted from the perspective of technology using vs. technology developing conceptual model (figure 1) and from national systems of innovation perspective have several policy implications.

First, they point to importance of production capability i.e. intra-firm productivity or non-R&D activities. This aspect of policy which is addressed only through vocational training is essential for improving absorptive capabilities of the CEECs. By improving absorptive or technology using capabilities firms can move to technology adopting and developing activities.

Second, key productivity challenge of CEEcs at firm level is how firms can make transition from mastery of production to technological capabilities. This process is not automatic and linear and requires not only changes within firms but also changes in narrow NSI or innovation infrastructure.

Third, this requires re-orientation of R&D systems from current exclusive knowledge generation orientation to knowledge diffusion and absorption orientation. The capacity to diffuse knowledge throughout economy becomes essential for catching-up in knowledge based economy. By embracing additional functions of knowledge diffusion (supply side) R&D systems could better match changing demand requirements for innovation and technology which are generated through broad NSI.

The issue is to what extent innovation policies of the CEECs have embodied these factors into their policy instruments. Table 11 summarizes state of innovation policy mechanisms in CEECs by classifying individual instruments according to which aspects of innovation/production capability they address. We group individual instruments according to four components of innovative capacity: absorptive capacity, R&D, diffusion and demand capacities[15]. This summary illustrates a variety of policy mechanisms across the CEECs. It does not tell us anything about the financial weight of individual instruments. For that we would have to find correct number of instruments by some measure of their financial weight. Nevertheless, data gathered in this form correspond conceptually to our distinction between production (absorptive, diffusion oriented instruments) and technology (R&D) capabilities and it includes demand oriented instruments which operate as signals for R&D and innovation within broad NSI.

Table 2: Number of innovation policy mechanisms of the CEE acceding and candidate countries (end of 2003)

[15] For quantitative analysis of the CEECs in the enlarged EU based on this four elements of innovative capacity see Radosevic, Slavo (2004)

	Absorptive capacity and human capital	Generation of new knowledge (R&D)	Diffusion of knowledge and networking	Demand for innovation	Total
Bulgaria		1	1	1	3
Czech R		**4**	4	3	**11**
Hungary		3	3	**4**	**10**
Estonia	1	3	**5**	1	**10**
Latvia		1	2	1	4
Lithuania	1	2	1	1	5
Poland	1	3	1	3	8
Romania		2	2	**4**	8
Slovakia		2	2	1	5
Slovenia	**3**	**4**	**5**	2	**14**
Total	6	25	26	21	78

Source: compiled based on Trendchart Database

Table 11 shows, first, that the policy is much more focused on generation of new knowledge and diffusion (networking) than on absorptive capacities. A largest number of instruments are oriented towards R&D through traditional R&D programs oriented towards scientific excellence. Instruments oriented towards diffusion of knowledge and networking are most often support to different bridging institutions like science and innovation parks whose effectiveness is still unclear.

Second, if we rank countries based on the scope of their operating policy mechanisms i.e. in terms of coverage of all four components than Slovenia, Czech R, Hungary and Estonia are situated at the top of the list. In the middle of the range we find the rest of the CEECs with Bulgaria clearly at the bottom end. This shows very different degrees of development and orientation of innovation policies among CEECs. Slovenia has the most diversified innovation policy in terms of mechanisms that address different components of innovation policy. Hungary, Czech R and Estonia belong to the group with relatively large number of policy mechanisms. Bulgaria has very limited number of innovation policy mechanisms.

Third, demand oriented instruments are surprisingly quite numerous in CEECs. These are mainly tax incentives which currently seem redundant and with limited effects given sharp reductions in corporate tax rates in the run-up to accession. Hungary and Romania have the biggest number of tax measures which try to induce demand for innovation.

Fourth, absorptive capacity is the area which is the least often addressed by innovation policy. Yet, innovation studies suggest that the production capability or capability to efficiently use existing technologies is the key first step in closing productivity gap. Slovenia is the only country which has more than one measure for promoting absorptive capacity.

In conclusion, our analysis points to the gap between production and technology determinants of productivity in CEECs and innovation policy to support closure of this gap. Policies that can assist in closing this gap cannot be confined only on narrow NSI and oriented only towards generation of new knowledge but also have to embrace knowledge absorption and diffusion functions of R&D systems and assist integration of narrow and broad NSI through effective demand oriented measures.

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