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SOURCES OF GROWTH IN SELECTED CENTRAL AND EASTERN EUROPEAN COUNTRIES

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ABSTRACT

In this paper we try to show the importance of the total factor productivity (TFP) in selected Central and Eastern European countries from 1991 to 2001 through two alternative approaches: (1) growth accounting using the Solow-Swan model, and (2) regression analysis. Although we can indicate general trend patterns across the country sample, there are certain differences between the countries. For that purpose, we divide them into three main regions: Central Europe, South-Eastern Europe, and Baltic States.

To study the sources of economic growth, we use an extended *Solow-Swan model* by incorporating the Lucas framework. Results show that the TFP has been a leading source of GDP growth throughout the observed period in Central Europe and Baltic States, whereas the physical capital stock was the main driving force of economic growth in South-Eastern Europe. Human capital contributions to the GDP growth have been negligible across all countries.

However, growth accounting cannot explain how the changes in inputs and improvements in the TFP relate to elements (such as government policies, technology, preferences) that can be understood as fundamentals.

For that reason, we use the *regression analysis* where we estimate an influence of selected state and control variables on the per capita real GDP growth. On the contrary with the growth accounting analysis, results show that human capital is the most important variable that explains economic growth in several sample countries, followed by the successful transition reforms (captured in so called transition index). Although we cannot estimate contributions of variables to the GDP growth, we can derive important policy implications.

Keywords: Central and Eastern Europe, total factor productivity, economic growth, physical capital, human capital, cross-country analysis

Contents

1 INTRODUCTION

In this paper, we analyze sources of growth in selected candidate EU countries (Slovenia, Hungary, Poland, Czech Republic, Slovakia, Bulgaria, Romania, Latvia, Estonia and Lithuania). We take two different approaches to economic growth. First, the *Solow – Swan growth model* that proposes the study of economic growth by assuming a standard neoclassical production function with constant returns to capital. Second, the *regression analysis* that estimates the effects of selected control and environmental variables on the real GDP growth.

The motivation of the research was the following. As a policy formulation tool, the analysis of "sources of growth" enabled us to demonstrate in a convincing manner the importance of investment in human capital and technological development, if selected sample countries want to increase its potential growth rate and speed up the process of real convergence with EU economies. Naturally, the research had to cope with severe limitations, including the non-availabity of some central data and methodlogical issues. We hope that further refinement of the analytical tools, and international comparisons that are to be made, will further increase not only the scientific, but also the practical value of the research.

To study the sources of economic growth, the growth accounting framework starts with an aggregate production function for the economy. We calculate sources of GDP growth on the basis of Solow-Swan model by incorporating the Lucas framework, where human capital is an additional source of growth. The rate of growth of aggregate output is the sum of four terms: *(1)* the rate of technological progress, *(2)* the rate of labor input, weighted by the share of labor in output, *(3)* the rate of growth of physical capital, weighted by the share of capital in output *(4)* the rate of growth of human capital, weighted by the share of human capital in output.

Results show that the TFP has been a leading source of GDP growth throughout the observed period in Central Europe and Baltic States, whereas the physical capital stock was the main driving force of economic growth in South-Eastern Europe. Human capital contributions to the GDP growth have been negligible across all countries.

However, the disadvantage of this approach is that the TFP is assumed to be the residual in the production function and therefore could include more unobserved effects on economic growth than just the TFP. Thus, growth accounting can provide a mechanical decomposition of the growth of output into growth of certain inputs and growth of the TFP. On the other hand, growth accounting cannot explain how changes in inputs and improvements in the TFP relate to elements (such as government policies, technology, preferences) that can be understood as fundamentals. Therefore, we use an alternative approach to estimate determinants of the economic growth.

We estimate the economic growth using simple regression equation. We divide variables that affect the real GDP growth on state variables and control variables, where state variables are stock of physical capital, augmented human capital index, and control variables are public spending on education as a ratio to *GDP*, investment ratio, and transition index. The level of TFP is then obtained as a residual from the regression equation and growth rates are calculated accordingly.

On the contrary with the growth accounting analysis, results show that human capital is the most important variable that explains economic growth in several sample countries, followed by the successful transition reforms (captured in so called transition index). Although we cannot estimate contributions of variables to the GDP growth, we can derive important policy implications.

The paper is organized as follows. Theoretical model of calculating sources of GDP growth is presented in Section 2. The detailed description of all variables and their calculations are given in Section 3 and empirical results are shown in Section 4. Section 5 explains regression analysis and empirical results are discussed in Section 6. Section 7 concludes.

2 GROWTH ACCOUNTING APPROACH

Standard growth accounting exercises provide a breakdown of economic growth into components that are associated with changes in factor inputs as well as residual, which is interpreted as a measure of technological progress. Therefore, growth accounting can be used for the analysis of fundamental determinants of economic growth. The analysis usually starts with the neoclassical production function, which is interpreted as a technical relationship between the level of output, Q, the level of inputs, capital, K, and labor, L, and the level of technology, A.

$$Q = Q(K, L, A) \qquad (1)$$

There are numerous mathematical formulations of production function, but the one used by farthest is a Cobb-Douglas production function. If we adjust the original form of Cobb-Douglas production function by adding the technology level parameter, it can be expressed as

$$Q = AK^{\alpha}L^{1-\alpha}, \quad with \ 0<\alpha<1 \qquad (2)$$

where α is a parameter of the production technology, with a value between 0 and 1. The most important assumptions that enter this specification of production function are the ones of constant returns of scale and a factor price elasticity which is equal to one. The unit elasticity assumption is consistent with the relative consistency of nominal factor shares. The output elasticities of capital and labor are represented by α and $1-\alpha$, respectively. Under the assumption of constant returns to scale and perfect competition, these elasticities can be estimated from the wage share.[1]

Growth accounts make it possible to decompose the change in output into the contribution of factor accumulation and a residual measure of gains in the efficiency with which the factors are used. Therefore, we can write down the growth rate of output, q_t, as the sum of the share-weighted growth of the factor inputs, k_t and l_t, and an index of growth in total factor productivity, a_t, broadly referred to as a Solow residual.

$$q_t = a_t+\alpha k_t+(1-\alpha)l_t \qquad (3)$$

Decomposing the output growth is important, because we are able to predict the growth of factor inputs and total factor productivity for a short-term period. Once these predictions are made, it is straightforward to observe the potential GDP growth in the economy.

According to traditional growth models (Solow model), only higher population growth and faster technological change can promote a permanent increase in a output growth rate. Therefore, in the early stages of empirical work on growth models, Solow residual (technological progress) accounted for the majority of the output growth. However, recent models of growth due to Romer and Lucas, suggest that the contribution of capital to growth is underestimated by the traditional economic growth models, because there exist externalities in the use of capital. In the new growth theories, productivity growth has a closer association with investment in human (investment in worker skills) rather than in physical capital. One of the Lucas's arguments is that the investment in a person does not only raise her own productivity, but productivity of others as well. Thus, there is a positive externality of investing in human capital. When the externalities related to human capital are strong, the country can achieve

[1] Refer to a discussion on measures of factor shares in Section 3.

sufficiently higher output as a result of its higher human capital endowment. Having this in mind, we introduce investment in human capital in the previously specified production function (*2*). In this case, the output (*Q*) is a function of physical capital (*K*), a skill-adjusted measure of the labor input (*L**)[2], and technology (*A*),

$$Q = Q(K, L^*, A) \qquad (4)$$

A skill-adjusted measure of the labor input, *L**, is defined as

$$L^* = HL, \qquad (5)$$

where *H* is an index of labor quality, therefore, a measure of human capital. Thus, a production function is simply expressed as

$$Q = AK^{\alpha} L^{*1-\alpha}, \quad with \;\; 0 < \alpha < 1 \qquad (6)$$

The output growth is now decomposed into the growth of physical capital, growth of skill-adjusted measure of labor input, and growth of total factor productivity.

$$q_t = a_t + \alpha\, k_t + (1-\alpha) l^*_t \qquad (7)$$

3 DESCRIPTION OF VARIABLES

Output Growth

The basic output measure is gross domestic product in 1995 national prices, from 1990 to 2001. The data source is World Development Report and “Countries in Transition 2002”, CD-Rom, issued by the Vienna Institute for International Economics (WIIW).

Figure 3.1 in Appendix shows the real GDP growth rates from 1991 to 2001 for the selected Central and Eastern European Countries. For the purpose of analysis, we divide countries into three groups: (1) Central Europe with Slovenia, Hungary, Poland, Czech Republic and Slovakia, (2) Southeastern Europe with Bulgaria and Romania, and (3) Baltic States with Latvia, Estonia and Lithuania. Data show a similar general pattern across countries and over the time. During the initial phase of transition (1991-1994) all countries managed to achieve positive real GDP growth rates. On the other hand, during the recovery phase (1995-1999) the real GDP growth slowed down, most significantly in Bulgaria and Romania. In 2000 and 2001, economies started to recuperate, thus showing increased real GDP growth. Similarly, estimates for 2002 show continuous positive trend in the real GDP growth.

[2] Detailed discussion on a skill-adjusted measure of the labor input is presented in Section 3.

Physical Capital

To estimate the TFP growth according to our equation 3, we need to estimate the stock of capital. There are no accurate official computations of physical capital stock for the selected countries, which makes the analysis of growth components of GDP quite difficult. Authors try to solve this problem in several ways; for the purpose of our paper, we partially base the measure of the capital stock on Mrkaić (2002) approach, where he determines the stock of physical capital for Slovenia.[3] Usually, authors use gross fixed investment as a proxy for the change in the capital stock as shown in equation *(8)*.

$$K_{t+1} - K_t = I_{t+1} - \delta K_{t+1}, \qquad (8)$$

where K_t and K_{t+1} are the real stocks of capital in period t and $t+1$, respectively, I_{t+1} is gross fixed investment in period $t+1$, and δ is depreciation. However, to compute the stock of capital for each year it is necessary to have an estimate of initial stock. Mrkaić estimates initial stock of capital, K_0, as a share of GDP in the base year:

$$K_0 = \frac{\alpha}{r_0 + \delta} y_0, \qquad (9)$$

where α is the capital income share, r_0 denotes the real interest rate in the base year, and y_0 is the real GDP in the base year.

His calculations show that the initial stock of capital is between 0.6 and 2.3 times the value of real GDP in year zero (that is, in 1992[4]). However, his results are based on several assumptions, regarding the values of the real interest rate and depreciation rate. To obtain more accurate results, we relax his assumption on a wide range of rate of depreciation by fixing it at a 7.5 percent rate.[5] The data on real interest rates is taken from Central Bank statistics for each of the countries[6] and the capital income share can be calculated as shown in section on *Measures of Factor Shares*. Using equation *(9)*, we estimate the initial physical capital stock with respect to the real GDP in 1996 for each country. The size of initial physical capital stock varies across the sample countries; the highest

[3] Dobrinsky (2001) uses so called "permanent inventory method" to find a proxy for the true level of the physical capital stock. He obtains similar estimates for the capital stock as we do, with exception of Bulgaria.

[4] The stock of physical capital depends varies with the respect to the base year. For the purpose of this analysis, we use the base year 1996. The reason is that in 1996 all the sample countries adopted SNA methodology and thus adjusted theirs main statistical aggregates to an internationally compared level.

[5] We use the same depreciation rate as Dobrinsky (2001), where he defines the average rate of capital consumption of 7.5 percent (for the total economy) for the selected Central and Eastern European Countries.

[6] As Mrkaić, we use real interest rates on long-term capital. In general, Central Banks report this category as average commercial bank interest rates – lending long-term loans for capital assets. We capture lending interest rates on both long-term domestic and foreign capital assets by using a weighted average of the two (weights are the shares of capital assets in GDP).

is in Czech Republic where it amounts to 3.4 times the real GDP in 1996, and the lowest is in Bulgaria where it accounts for 0.6 times the real GDP in 1996. By applying equation *(8)*, we get the estimates of physical capital stock from 1991 to 2001. Results are shown in Figures 3.2 and 3.3 where we present growth rates of physical capital stock and physical capital stock as a share of GDP in the three groups of countries. It is interesting to see that in general, the stock of physical capital as a share of GDP was steadily declining during the observed period in all the countries. On the other hand, growth rates of physical capital were increasing until 1996 and then starting to decline. The exception is the Southeastern European region, in particular, Bulgaria. In 1997, the physical capital stock increased by more than 100 percent, which was due to a more than a twofold increase of real investment in the same year. Therefore, Bulgaria puts an upward bias on the total country sample in terms of physical capital stock growth rates. Finally, we use these values to obtain an estimate of the TFP growth in selected countries from 1991 to 2001.

Labor Inputs

For the purpose of this analysis, we measure the quantity of labor as actual employment in selected countries (defined as persons in paid employment and self-employed persons), which is a standard measure of labor inputs in industrialized countries. Data is obtained from the Countries in Transition 2002 CD-Rom, Vienna Institute for International Economics.

However, one needs to be cautious when using actual employment data as a measure of labor input. The more accurate measure of employment would be labor-hours, not a head count. This is important since both the business cycle and the secular trend often include variations in the average working week. Without a measure of labor-hours, these variations get captured into the estimate of TFP growth. Nevertheless, since the data on labor-hours is not available for all the selected countries, we use the "standard" measure of labor input, which is the number of employed persons.

Figure 3.4 shows employment growth rates in sample countries from 1991 to 2001. Again, we see similar trend across the countries. Due to restructuring of economies, there was an increase in employment in mid-90s, followed by a decrease after that period. However, favorable economic conditions after 1999 resulted in another increase of employment, with exception of Baltic States.

Human Capital

We follow the definition from N. Gregory Mankiw (2000). Human capital is defined as the knowledge and skills that workers acquire through education, from early childhood programs to on-the-job training for adults in the labor force. We assume that a well-trained labor force embodies a kind of human capital, since worker training raises the productive capacity of the labor force. A simple measure of labor force (or active population) treats all workers as if they were identical. However, worker characteristics clearly influence marginal productivity. Some previous growth studies included detailed adjustments by labor force groupings, including education, age, and gender. Nevertheless, we believe that the resulting indicators of human capital are best represented by available education. We measure this variable (education) as the employed population by school attainment during the period from 1990 to 2001.

Although we think that the active population by school attainment represents the best available educational data, there are a number of potentially serious measurement problems. Prior empirical studies have assumed enrollment rates as a proxy for changes in education. However, this assumption works only in the steady state.[7] That is, the enrollment rate that would be necessary to maintain constant average years of schooling in a country with an initially high stock would imply increasing years of schooling in a country with an initially low stock.

The other explanatory variable used for a proxy of human capital was the number of years of schooling. The disadvantage of this variable is that many studies[8] found no significant relationship between the change in years of schooling and economic growth. Most important explanation for such results is that years of schooling alone is a poor index of labor quality because it assigns workers with zero education a weight of zero and it implies disproportionate changes in labor quality for countries with low initial levels of schooling.

The more accurate approach of estimating human capital would be the one used in Collins and Bosworth (1996) where they apply the relative wage structure for workers with different years of schooling to construct weights for aggregating workers across education levels. However, data on wages with respect to educational structure is not available for all the countries, therefore we cannot construct a human capital variable in that way. Instead, we use data on educational attainment and life expectancy to obtain an estimate of human capital. Cross-country empirical studies (Barro, Sala-i-Martin, 1995) suggest that life expectancy is a good measure of quality of life and therefore should be

[7] Refer to Mankiw, Romer, and Weil (1992).
[8] For example, Behabib and Spiegel (1994), Pritchett (1995), Harrison (1996), and Judson (1996).

included in calculations of human capital.[9] Data is collected from Human Development Report, National Statistical Offices and Countries in Transition 2002 CD-Rom, WIIW.

The human capital index is constructed in the following way: we add up the variables on educational attainment of labor force (primary, secondary, and tertiary level) and life expectancy as deviations from the sample mean and then calculate changes across the period. Results are shown in Table 3.1 and Figure 3.5 Appendix.

As we can, human capital is extremely low in the selected countries and the growth rates are close to zero, although positive, during the observed period. On average, there was a 0.55 percent increase in human capital in 11-year period across the selected countries. We notice the same trend in both Central European and South-Eastern European regions. Baltic States, on the other hand, exhibited a drop in human capital between 1997-1999, which puts a downward bias on the full sample.

Table 3.1: Human Capital Index in selected Central and Eastern European Countries, 1991-2001

	Slovenia	Hungary	Poland	Czech Republic	Slovakia	**Central Europe**	Bulgaria	Romania	**Southeastern Europe**
1991-1993	100.15	99.72	100.49	100.69	100.49	**100.31**	100.19	99.71	**99.95**
1994-1996	100.76	100.51	100.42	100.78	99.44	**100.38**	99.87	100.22	**100.05**
1997-1999	100.48	100.06	100.47	100.81	100.37	**100.44**	100.15	100.56	**100.36**
2000-2001	100.62	100.73	101.01	100.51	100.37	**100.65**	100.62	100.92	**100.77**
1991-2001	**100.49**	**100.21**	**100.56**	**100.72**	**100.15**	**100.43**	**100.17**	**100.30**	**100.24**
	Latvia	Estonia	Lithuania	**Baltic States**	**All**				
1991-1993	100.40	101.10	100.32	**100.61**	**100.33**				
1994-1996	101.38	101.43	100.96	**101.26**	**100.58**				
1997-1999	100.41	100.34	100.91	**100.55**	**100.46**				
2000-2001	101.28	103.56	100.04	**101.63**	**100.97**				
1991-2001	**100.83**	**101.43**	**100.60**	**100.95**	**100.55**				

Source: Authors' calculations.

9 The potential problem with including this explanatory variable could be that changes in life expectancy probably do not embody valid information about changes in labor quality over such a short time frame (11-year period). Indeed, the main cause of changes in life expectancy in many countries is due to improvements in infant health care, which has little to do with the quality of the labor force in the near term. However, data for selected countries do not show a significant improve in infant health care across the observed period, while there has been improvement in life expectancy. For that reason we believe that it is proper to include this variable in estimation of human capital, even though we consider only a short-time period.

Measures of Factor Shares

The final step is the choice of weights for aggregating the factors inputs. As we already mentioned, under the assumption of perfect competition, those weights can be represented by the shares of income earned by capital and labor, respectively. One way of estimating factor shares is to use the underlying production function, and regress log output on log capital (physical and human), and log labor. Nevertheless, it is important that factor shares are truly independent from the underlying production function. For that reason, weights should vary freely across countries and time. The problem associated with this is that there are no reliable measures of factor income shares available for developing countries or countries in transition. However, Dobrinsky (2001) presented a measure of capital income share for countries in transition. According to him, the capital income share can be calculated as the share of gross operating surplus and gross mixed income compared to total factor incomes.[10]

Following Dobrinsky approach, we use the data on gross operating surplus and gross mixed income for selected Central and Eastern European Countries from 1990 to 2001. Data on gross operating surplus and gross mixed income are taken from the UNECE statistical database.[11] The capital and labor income shares for selected countries varied through the observed period. However, most of empirical studies average the coefficient to eliminate cyclical noise, not because there is a presumption that the coefficient is stable on a year- to-year basis. By using annual values we would embed a large cyclical element into the computation of contribution of inputs and thus distort the estimated growth of TFP.

4 EMPIRICAL RESULTS

In this section, we estimate the extended form of production function, where human capital is added. Given the growth rates of real GDP, real physical capital, labor input and human capital we can calculate contributions of TFP to the GDP growth.

[10] Total factor incomes can be calculated as the difference between the nominal GDP and net indirect taxes.
[11] For some of the countries in the sample we were able to get data on gross operating surplus and gross mixed income from national statistics. However, these data is not comparable with the one taken from the UNECE statistical database. Therefore, we use the UNECE database for the full country sample in order to be consistent with the analysis.

When TFP is calculated as a residual, it captures also the short run fluctuations in the GDP, which are the results of the short run demand fluctuations. Therefore, we divide the TFP residual in two components: (1) structural component, which is calculated as the difference between the potential GDP growth (HP-filtered series of actual real GDP growth) and contributions of inputs in a given year, and (2) cyclical – short run component, which is calculated as the difference between the actual real GDP growth rate and contributions of inputs and structural TFP component in a given year. In this way, the structural component of TFP is clear of the impact of real GDP fluctuations, which are not due to supply side factors. On the other hand, the cyclical component of TFP would capture these fluctuations explicitly.

Before discussing contributions of individual components to the GDP growth, we present estimates of the TFP level and its growth from 1990 to 2001. We use annual data to calculate the TFP level according to the equation *(6)*. The dynamics of the TFP level as well as of both components expressed as an index (where 1990 = 1) is shown in Figures 4.1a, 4.1b, and 4.1c Appendix. After an initial decrease in the TFP, we observe an upward trend for the full country sample. The highest TFP was exhibited in Central European region, while South-Eastern Europe (Bulgaria and Romania) indicated a drastic decrease in the TFP level.[12] However, the structural component of TFP shows an initial increase, followed by the decrease in the TFP level. Therefore, fluctuations are captured in the cyclical component of the TFP.

Growth rates of both structural and cyclical components of TFP are presented in Figures 4.2b and 4.2c, and of the total TFP in Figure 4.2a Appendix. We see that they are extremely volatile and not due to cyclical short-term movements (note that the growth rate of the cyclical TFP component is closely to zero). This is worrisome result because it means that during observed period countries did not manage to develop proper policy instruments that would enable them to reach sustainable TFP growth rates.

The growth of output, divided into contributions of increases in physical capital, human capital, labor input and total factor productivity, is reported in Table 4.1 for selected Central and Eastern European countries from 1991 to 2001. Although available data series is too short to perform any detailed time-series analysis, the results are interesting in several aspects.

[12] This is probably due to the significant increase of the physical capital stock in Bulgaria from 1997 on.

The TFP estimates show a similar general pattern across group of countries (Central Europe, South-Eastern Europe and Baltic States) over the time. During the initial phase of transition (1991-1994) all the countries experienced a substantial decrease in the TFP. However, in the recovery phase (1995-1999), most countries started to experience higher TFP contributions to the GDP, with exception of South-Eastern Europe (Bulgaria, Romania). In these two countries, the GDP growth was mainly due to high physical capital stock contributions. After 1999, we observe a substantial increase in TFP contributions in Baltic States, followed by the Central Europe, while the TFP contributions in South-Eastern Europe were still negative. Thus, in general we can say that Central European countries were the most successful during the observed period because they experienced relatively moderate changes (and also positive) in the TFP contributions. Baltic region made a significant progress in terms of TFP, only South-Eastern Europe registered a limited improvement.

Table 4.1: Sources of Growth in Candidate Countries

in %		Contribution by Component						Contribution by Component			
Slovenia	**Growth of Actual Output**	**Physical Capital a)**	**Labor Input b)**	**Human Capital c)**	**TFP d)**	**Bulgaria**	**Growth of Actual Output**	**Physical Capital a)**	**Labor Input b)**	**Human Capital c)**	**TFP d)**
1991-93	-3.83	0.65	-3.93	0.10	-0.66	1991-93	-5.73	-0.39	-3.64	0.24	-1.94
1994-96	4.30	0.80	-0.41	0.08	3.84	1994-96	-1.82	4.17	0.32	-0.12	-6.18
1997-99	4.43	1.03	0.49	0.09	2.82	1997-99	-0.38	26.91	-0.98	0.00	-26.31
2000-01	3.80	0.48	0.88	-0.14	2.58	2000-01	4.70	8.16	-1.16	0.20	-2.50
1991-2001	2.17	0.74	-0.74	0.03	2.15	**1991-2001**	-0.81	9.71	-1.37	0.08	-9.23
Hungary						**Romania**					
1991-93	-5.18	-0.41	-1.47	0.05	-3.35	1991-93	-6.72	-0.22	-0.97	0.13	-5.66
1994-96	1.93	3.53	-0.95	0.16	-0.81	1994-96	4.99	1.99	-0.91	-0.05	3.96
1997-99	4.64	1.49	0.89	-0.04	2.30	1997-99	-4.89	4.10	-1.40	0.14	-7.72
2000-01	4.50	1.25	0.38	0.01	2.86	2000-01	3.45	8.51	0.68	-0.08	-5.65
1991-2001	1.47	1.47	-0.29	0.04	0.25	**1991-2001**	-0.79	3.59	-0.65	0.03	-3.77
Poland						**Latvia**					
1991-93	-0.20	-0.39	-2.10	0.25	2.04	1991-93	-20.05	-0.73	0.82	-0.04	-20.10
1994-96	6.07	3.44	0.80	0.00	1.82	1994-96	1.06	3.04	0.32	0.66	-2.97
1997-99	5.23	1.87	0.41	-0.10	3.06	1997-99	4.19	0.59	0.39	-0.15	3.35
2000-01	2.50	-0.02	-0.66	0.15	3.03	2000-01	7.25	0.72	-0.12	-0.61	7.27
1991-2001	3.40	1.23	-0.39	0.07	2.49	**1991-2001**	-1.89	0.90	0.35	-0.03	-3.11
Czech Republic						**Estonia**					
1991-93	-4.02	-0.44	-1.68	0.10	-2.01	1991-93	-12.51	-0.13	-3.23	0.02	-9.16
1994-96	4.33	2.80	0.69	0.05	0.78	1994-96	2.07	1.29	-2.37	0.11	3.03
1997-99	-1.16	0.08	-1.24	-0.14	0.14	1997-99	4.75	0.30	-1.45	-0.07	5.98
2000-01	3.30	0.36	0.34	0.02	2.58	2000-01	5.95	0.53	-0.16	-0.33	5.91
1991-2001	0.61	0.70	-0.47	0.01	0.37	**1991-2001**	0.07	0.50	-1.80	-0.07	1.44
Slovakia						**Lithuania**					
1991-93	-8.33	-0.33	-2.90	-0.07	-5.03	1991-93	-14.39	-0.33	-2.42	-0.01	-11.62
1994-96	5.95	3.34	7.36	0.20	-4.96	1994-96	-0.59	1.85	5.13	0.23	-7.80
1997-99	4.07	0.37	-0.69	-0.04	4.44	1997-99	2.72	0.48	0.89	-0.11	1.47
2000-01	2.75	0.72	-0.09	-0.09	2.21	2000-01	4.90	0.55	-2.14	-0.12	6.62
1991-2001	1.11	1.02	0.92	0.00	-0.84	**1991-2001**	-1.84	0.64	0.36	0.00	-2.83

a) The contribution of physical capital is calculated as the growth rate of physical capital multiplied by capital's income share (α).
b) The contribution of labor input is calculated as the growth rate of labor input multiplied by labor's income share ($1-\alpha$).
c) The contribution of human capital is calculated as the difference between the contribution of skill adjusted labor input (L^*) and labor input (L).
d) The contribution of total factor productivity is calculated as the difference between the growth rate of output and contributions of physical capital, labor input and human capital.

Source: Authors' calculations.

Another interesting observation is that human capital had a marginal effect on the real GDP growth across the countries in the observed 11-year period.[13] This is a concerning result, which means that a special attention should be devoted to stimulate labor force to achieve higher levels of education.

[13] In order to get contributions of human capital to the real GDP growth, we first estimate contributions of skill-adjusted labor input, L^*,through equation *(7)*. Factor shares are again calculated as shown in Dobrinsky (2001). Namely, compensation of employees, which is used to calculate the share of L^* in output, depends on skills that people have. Then it is intuitive to calculate contributions of skill-increases (or contributions of human capital).

5 REGRESSION ANALYSIS

This section considers the empirical determinants of growth. Our sample includes data for 10 countries over a 12-year period (1990-2001). Thus, we are able to obtain 120 observations for each variable included in the regression analysis.

We use an empirical framework where the real GDP growth rate is related to two groups of variables: (1) initial levels of state variables, such as the stock of physical capital, labor input and the stock of human capital,[14] and (2) control or environmental variables such as public spending on education, investment ratio, and transition index.

The real GDP per-capita growth rate in time t, y_{gt}, can be determined as a function of the following variables:

$$y_{gt} = f\,(k_{t-1}, h_{t-1}; \ldots), \quad (10)$$

where k_{t-1}, h_{t-1} represent lagged levels of stock of physical capital per person and stock of human capital per person. The variables, denoted by …, represent range of control and environmental variables.

5.1 Effects from State Variables

According to Solow – Swan and Ramsey models, the increase of the initial period stock of physical and human capital per person would result in a lower real GDP per-capita growth rate, assuming everything else constant. Thus, richer countries with high levels of k and h tend to grow slower (absolute convergence). The steady-state level of per-capita GDP is then determined by control and environmental variables.

In order to represent the rate of convergence, we enter the initial level of per-capita GDP, y_{t-1} (in the log form), in the growth regression equation. The coefficient on this variable represents the responsiveness of the real GDP per-capita growth rate in time t to a proportional change in per-capita GDP in time $t-1$.

The difference between contributions of skill-adjusted labor ($(1-\alpha)l^*$ from equation *7*) and only labor ($(1-\alpha)l$ from equation *3*) is the actual effect of a skill increase in growth (contributions of H).

[14] Definitions of human and physical capital are explained in Section 3.

Along with theories of technological diffusion, more human capital increases the ability of the country to absorb new technologies (Barro, Sala-i-Martin, 1995). Therefore, a higher level of human capital rises the responsiveness of the growth rate to reductions in the initial level of per-capita GDP. In other words, the speed of convergence is higher the higher is h_{t-1}. We capture this effect by including the level variables log(y_{t-1}) and log(h_{t-1}), as well as an interaction term, log (y_{t-1})*(h_{t-1}). We expect a negative coefficient on the interaction term.

5.2 Effects from Control Variables

In the basic regression equation (1), the control and environmental variables are public spending on education as a ratio to *GDP*, denoted as *E/Y*, investment ratio, denoted as *I/Y*, and transition index, *T*.[15]

The educational spending variable, *E/Y*, is a proxy for variations in school quality during the observed period. We expect that higher ratio of educational expenditure to *GDP* will increase a *GDP* per-capita growth rate for the given values of the state variables.

The investment to *GDP* ratio, *I/Y*, shows an increase of physical capital stock during the observed period and therefore it should have a positive effect on the per-capita *GDP* growth rate. Even though the stock of physical capital is included in the regression equation as the state variable, we want to see the effect of a rise in capital stock on the *GDP* growth.

Transition index, *T*, is a variable constructed by the EBRD and represents a development of macroeconomic and structural reforms in Central and Eastern European countries in transition.[16] Therefore, an exogenous increase in *T* will positively affect the per-capita *GDP* growth rate, for given values of the state variables.

[15] We tried to include in the regression analysis other control variables, such as government consumption as a share of GDP, educational attainment of labor force, fertility rate, population growth rate and terms of trade. All these variables are usually used in cross-country regression analyses, presented by Barro, Sala-i-Martin (1995). However, Slovenian time series data has only 9 observations and including more explanatory variables in the regression analysis produces inaccurate results. We decided to choose explanatory variables that best explain economic growth and which coefficients are significant at least at 10 percent level.

[16] Transition index is calculated as a simple mean of the following indices: price liberalization, forex trade liberalization, small-scale privatization, large-scale privatization, enterprise reform, competition policy, banking sector reform and reform of non-financial institutions.

6 REGRESSION RESULTS

Table 6.1 shows regression results for the growth rate of real per capita GDP. Due to short time series, results should be interpreted with caution. Table 5.1 in Appendix illustrates the means, standard deviations and minimum and maximum values of the variables that are included in various regressions.

Column 1 of Table 6.1 shows estimates that are obtained when only state variables are included in the regression analysis. This finding applies to the standard Solow-Swan exogenous growth model where physical and human capital are the two inputs that contribute to the real GDP growth. We include the initial value of real GDP per capita to control for the conditional convergence.

Table 6.1: Regression Results for the real per capita GDP Growth Rate

Explanatory Variables	(1)	(2)	(3)	(4)
log GDP per capita	-0.023* (0.006)	-0.027** (0.011)	-0.026** (0.013)	-0.023** (0.009)
log Physical Capital per capita	0.047* (0.014)	0.069* (0.082)	0.054** (0.022)	0.041** (0.012)
log Human Capital	-2.798 (5.329)	-1.547 (1.218)	-1.472* (0.589)	-1.671* (0.692)
log Saving/GDP		0.003 (0.056)		
log Taxes on Corporate Income and Profit/GDP		-0.053 (0.068)		
Interaction Term (log GDP*log h)			-0.315* (0.105)	-0.280** (0.105)
log E/Y			-0.016* (0.009)	-0.023* (0.010)
log I/Y			0.035** (0.003)	0.028** (0.004)
log Transition Index			0.072** (0.006)	0.081** (0.009)
dummy (South-Eastern Europe)				0.035** (0.014)
R^2	0.58	0.51	0.54	0.60
No. of observations	120	120	120	120

** and* indicate significance of coefficients at 5 and 10 percent level, respectively. Standard error on coefficients is reported in brackets.
Source: Authors' calculations.

Results are somehow surprising. We see that the estimated coefficient on initial per capita GDP (significant at 10 percent level), *-0.23*, shows the conditional convergence. That is, the sample countries' real GDP per capita growth rate is slower if the countries start up with the higher GDP per person. The magnitude of the coefficient implies that convergence in the country sample occurs at the rate of *0.1* percent per year.[17]

On the other hand, the coefficient on physical capital per person (significant at 10 percent level) is positive which is opposite from predictions of Ramsey and Solow-Swan growth models. Positive coefficient of *0.05* implies that a one percent increase in an initial capital stock would increase per capita GDP growth by *0.05* percent. It is true that greater availability of resources enables an economy to produce more and therefore increase in resources can have a positive impact on economic growth. However, this effect does not coincide with diminishing returns of reproducible factors. The possible explanation could be that there are some other unobservable factors that affected the steady-state level of GDP per capita in selected country sample. As we discussed in previous sections, South-Eastern region (Bulgaria and Romania) exhibited a large increase in the stock of physical capital after 1997. This probably results in biased regression coefficient. We try to solve the problem by including a dummy variable for South-Eastern region.[18] However, including the dummy in the first regression equation does not change results. The coefficient on the capital stock is still positive and the coefficient on the dummy is positive but not significant.

Coefficient on human capital is in accordance with predictions of Ramsey and Solow-Swan growth models, it is negative but not significant. Thus, observing only the effect of state variables on real GDP per capita growth does not produce satisfactory results.

For that reason, we add more explanatory variables in the regression equation. Data for the full country sample show that in general both savings as well as taxes on corporate income and profit as a share of nominal GDP were increasing during the observed period.

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[17] The average growth rate of per capita output, *y*, over an interval from an initial time *0* to any future time $T \geq 0$ is given by

$(1/T)\log[(y(T)/y(0)] = x + \frac{(1-e^{-\beta T})}{T}\log[\hat{y}^*/\hat{y}(0)]$, where *x* stands for the steady-state growth rate and *β* indicates convergence speed. Thus, this equation implies that the coefficient on *log (yt-T)* for the average growth rate, *(1/T)log (yt / yt-T)*, is *–(1-e- βT),* that is, the convergence speed coefficient. This expression tends to *β* as T tends to 0 and tends to 0 as T approaches infinity.

[18] We include the dummy variables also for other two regions, Central Europe and Baltic States, but they do not affect the regression results. Coefficients on dummies are positive and not significant.

Including these two variables in the regression equation (column 2 of Table 6.1) shows predicted effects. However, it does not improve regression results. The coefficient on the initial per capita GDP is now *–0.03* (significant at 5 percent level) and shows even stronger conditional convergence. The coefficient on physical capital per person is still positive, *0.07*, and significant at 10 percent level (a one percent increase in the physical capital stock would increase real per capita GDP growth by 0.07 percent) but its positive effect on economic growth is now justified by increased saving in the selected Central and Eastern European Countries. On the other hand, the coefficient on saving as a share of GDP is positive but not significant. The coefficient on taxes on corporate income and profit is negative and also not significant. The coefficient on human capital is again negative but not significant.

Thus, including saving as a share of GDP in the regression equation does not improve results. Namely, both state variables, stock of physical and human capital have extremely low effects on economic growth. Therefore, the next step in explaining sources of economic growth is to extend the regression equation with above described control or so called environmental variables.

Results are shown in column 3 of Table 6.1. Basically, signs of the coefficients on state variables do not change The coefficient on the initial real GDP per capita indicates conditional convergence. The coefficient on initial per person initial capital stock is again positive, *0.05*, and significant at a 5 percent level, and the coefficient on human capital stock is negative and significant at a 10 percent level.

Coefficients on explanatory variables perform as predicted with exception of coefficient on education as a share of GDP. The positive effect of physical capital on the real GDP growth is due to the fact that an increase in physical capital stock is now represented by an investment ratio variable *(I/Y)*. The coefficient on this explanatory variable is positive, *0.04*, and significant at a 5 percent level. Thus, a one-percent increase in an investment ratio would increase the real GDP per capita growth rate by 0.04 percent.[19]

The coefficient on human capital shows that if the initial human capital stock across the countries would be greater by 1 percent, the real GDP growth per capita would be lower by *1.47* percent. Thus, among the selected explanatory variables, human capital has the biggest effect on economic growth.

[19] We do not include variables on GDP shares of saving and taxes on corporate income and profit in the regression analysis because an investment ratio variable indirectly shows effect on increased savings in the economy. Moreover, saving to GDP ratio and investment ratio variables are perfectly correlated and including both variables in a regression analysis would produce spurious results.

As explained above, the interaction term between initial per capita GDP and human capital is included in the regression analysis. The estimated coefficient on the interaction term is significantly negative, -*0.32*. The negative coefficient means that the growth rate is more sensitive to log GDP when overall human capital (the total effect from educational structure, returns on education and life expectancy) is higher.

It is surprising to observe that the coefficient on the educational spending variable, *E/Y*, is negative, -*0.02*, and significant at a 10 percent level. Generally, the educational spending is a proxy for the quality of schooling. However, the positive effects of education are already captured in human capital index. Moreover, the GDP share on educational spending was basically constant during the observed period and therefore it is not expected to see a large positive effect of this variable on the economic growth.[20]

The last explanatory variable that we include in the regression equation is transition index. The coefficient on this variable is positive, *0.07*, and highly significant. Thus, a one-percent change in transition index would reflect a *0.07* percent increase in the real per capita GDP growth.

Although the country sample is quite homogeneous, there are certain differences across the regions. Since South-Eastern Europe exhibits biggest deviations from the country sample, we also run the regression by including the dummy variable just for this region. We capture the region specifics by including dummy variables in the regression equation. Results are shown in column 4 of Table 6.1.

We expect that controlling for the region specifics would alter regressions results. However, regression coefficients on previously determined explanatory variables do not change in sign or significance, even though the coefficient on the dummy is positive and highly significant.

The error term in the regression equation captures all unobserved effects on economic growth. According to Ramsey and Solow-Swan growth models, the difference between the observed growth rate of output and the part of growth explained by labor and capital (physical, human) weighted by the share of each production factor in output can be explained by so called Solow residual, or exogenous technological progress. Thus, a a residual in a regression equation where the dependent variable is a real GDP growth per capita, and independent variables stock of physical capital per capita and human

[20] We run the regression equation (3) without including an education variable. This does not affect the sign and significance of other regression coefficients.

capital stock would represent a proxy for technological progress (or TFP). We run this regression and plot the residual in Figure 6.1 Appendix.

In order to compare these results with the ones obtained from a growth accounting analysis, we calculate the TFP index (where 1990 =1) for three country regions and for the full country sample. It is interesting to see that the TFP index for the full country sample follows the same trend as the one estimated from the Cobb-Douglas production function. Also South-Eastern European countries and Baltic States exhibit similar TFP performance as in the previous analysis. The only noticeable difference is in Central European region. The TFP estimated by the growth accounting analysis shows much more volatile behavior than the one calculated on the basis of the regression analysis.

However, we cannot use other set of regression equations to estimate the TFP. When more explanatory variables are added, they pick up the TFP effects and thus a residual is not a proper measure of the TFP growth. In particular, the transition index variable proxies structural reforms performed in the country sample. Hence, structural reforms should reflect higher productivity and thus higher TFP growth.

Thus, the regression analysis where economic growth is not only explained by state variables can be used as a policy advice measure. The size of the coefficients on explanatory variables shows which determinants of economic growth are the most important for the region.

7 POLICY IMPLICATIONS AND CONCLUSIONS

Main empirical findings can be summarize in the following points:

- Although the country sample is relatively homogenous, we observe differences between the three regions: Central Europe, South-Eastern Europe, and Baltic States. After the initial phase of transition Central Europe was the region with the most stable real GDP growth. Baltic States was the fastest growing region, while positive effects from structural reforms in South-Eastern Europe were noticed only after 1999.

- Growth accounting analysis shows that the relatively fast recovery in the country sample was due to improvement in total factor productivity. However, this is not true for South-Eastern Europe, where economic growth was mainly driven by increased stock of physical capital.

- One of the concerning observations is that human capital stock hardly contributed to the real GDP growth in the observed period. Moreover, on average, contributions were negative in Baltic States and South-Eastern Europe, but positive (although not significantly different from zero) in Central Europe.

- Regression analysis is a useful tool to identify the most important determinants of economic growth and derive policy implications for a sustainable and long-term growth.

- Cross-country analysis shows that the human capital has the biggest effect on economic growth, followed by the transition index, which indicates structural reforms in economies and thus increases productivity (TFP) in the country sample.

On the basis of these findings we can derive important policy implications. It is necessary to increase the stock of human capital across the countries, which can be done by an increased investment in education. Candidate countries have prepared so-called national programs for promoting education, where the main stress is put on the importance of human capital for a sustainable and long-term economic growth. An increase in the total factor productivity can be enabled by the adjusted industrial policy measures.

Moreover, education as well as technology have important “spillover” effects on economic growth. Thus, countries would be able to reach important synergy by adopting a coordinated policy in both areas (for example, transfer of innovations among research and entrepreneurial sphere).

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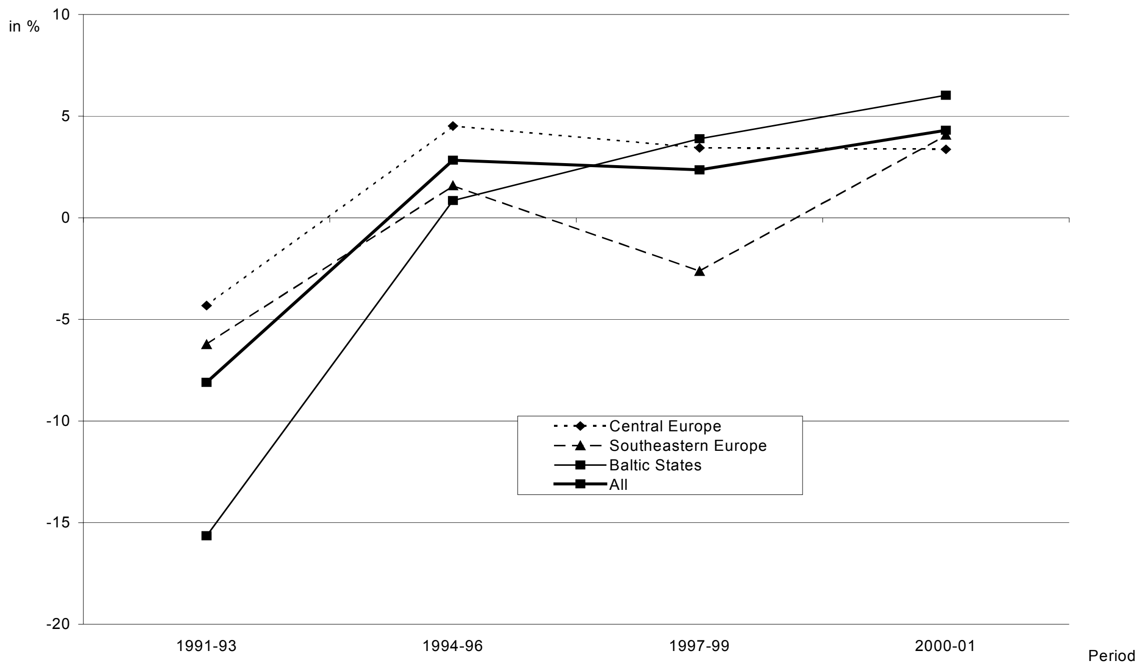
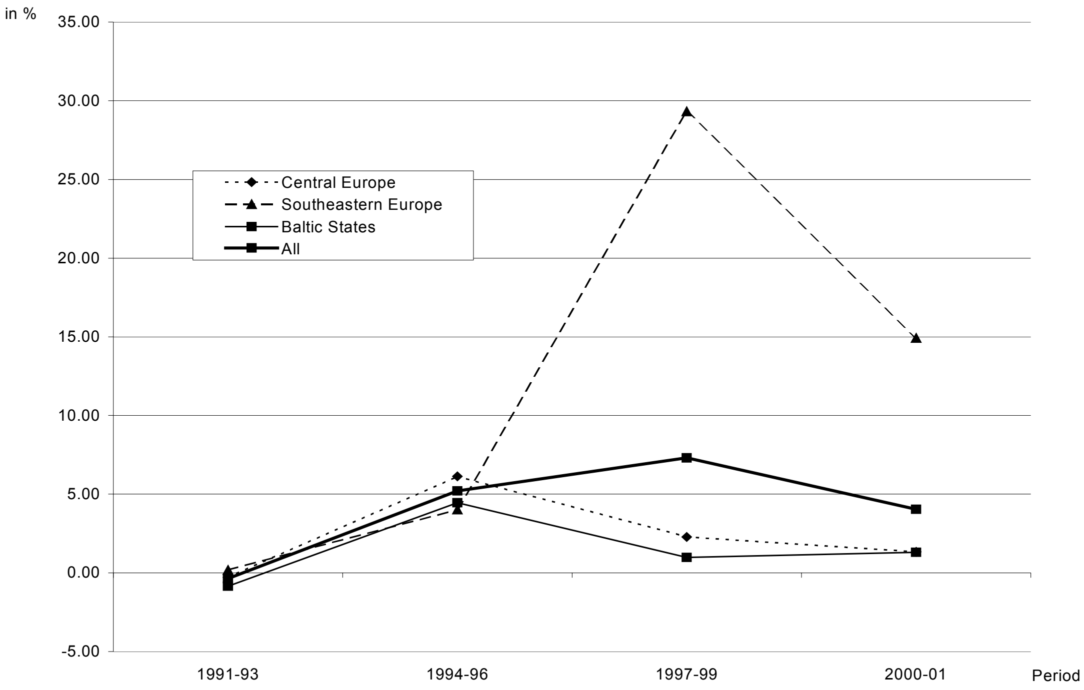
APPENDIX

Figure 3.1: Real GDP Growth Rates in percent, 1991-2001



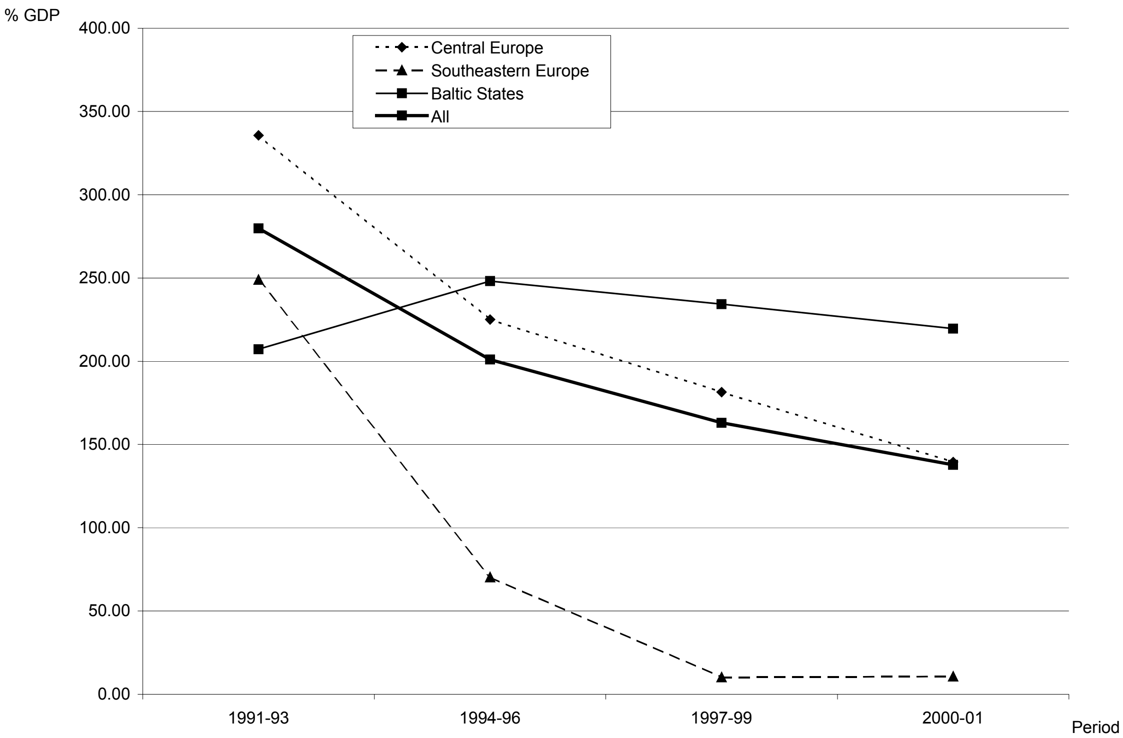
Source: World Development Report, Countries in Transition 2002 CD-Rom.

Figure 3.2: Physical Capital Stock Growth Rates in percent, 1991-2001



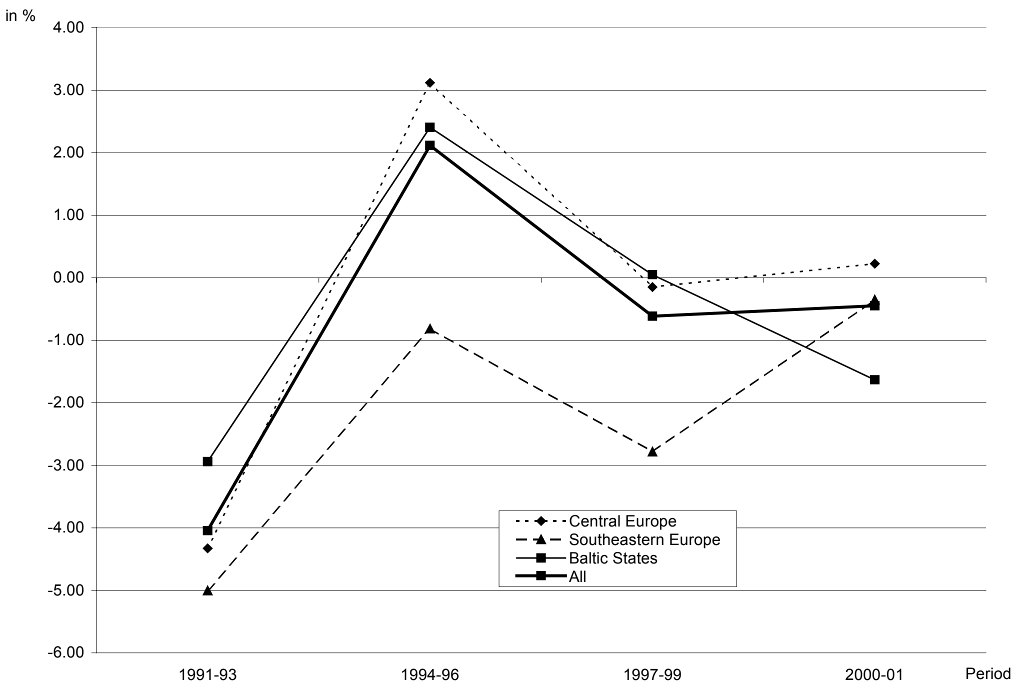
Source: Authors' calculations.

Figure 3.3: Physical Capital Stock as a Share of GDP in percent, 1991-2001



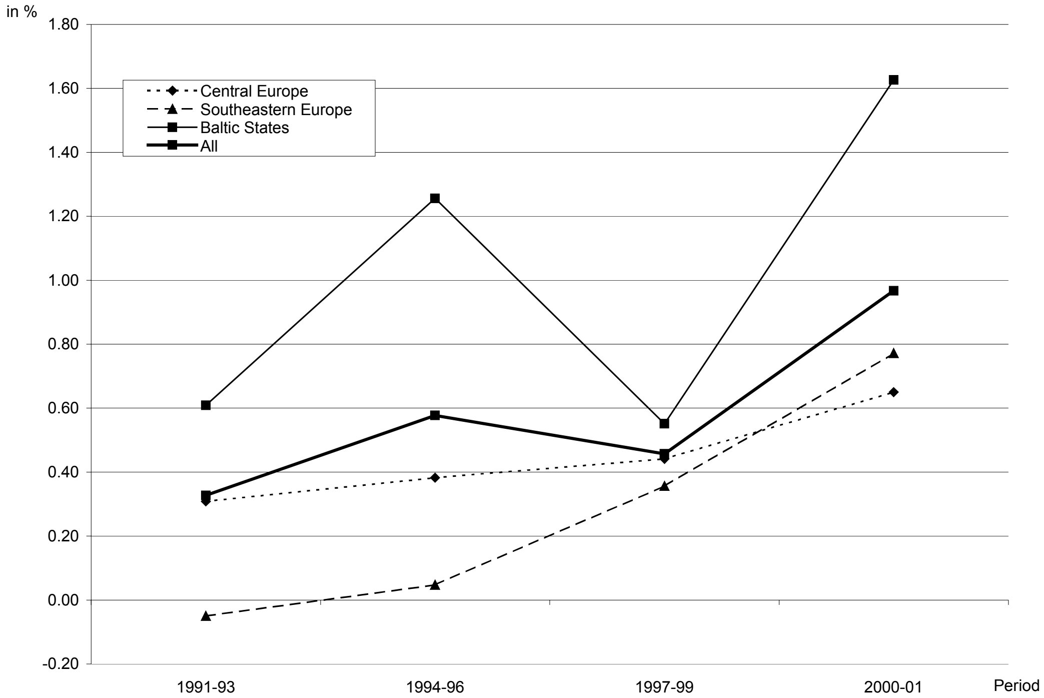
Source: Authors’ calculations.

Figure 3.4: Employment Growth Rates in percent, 1991-2001



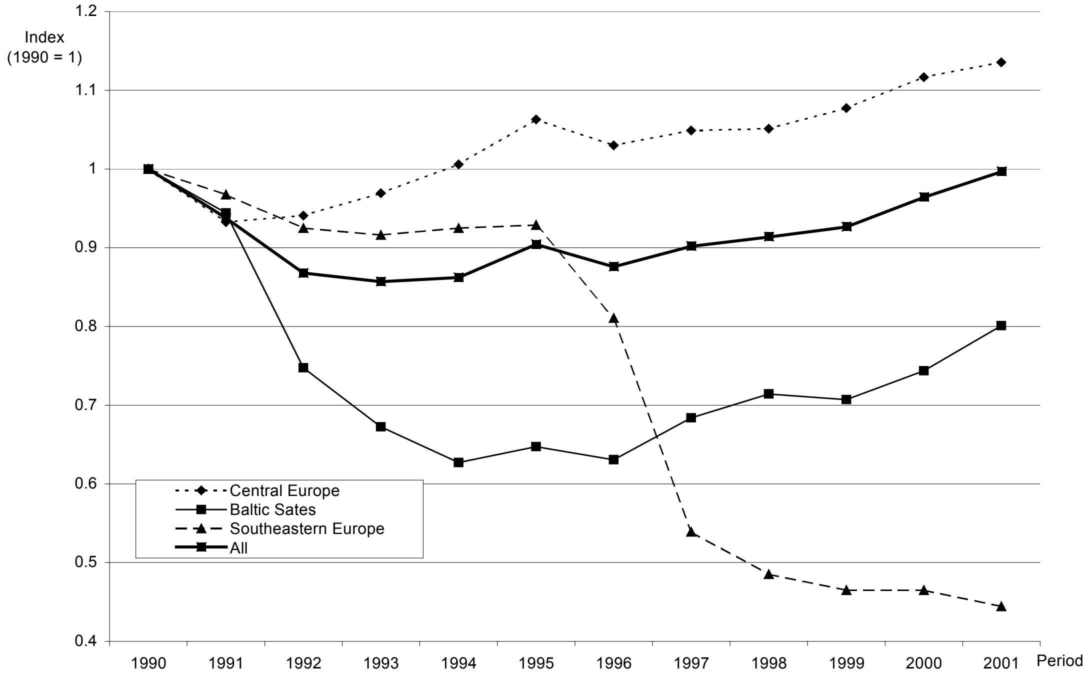
Source: Countries in Transition 2002, CD-rom, WIWW.

Figure 3.5: Human Capital Growth Rates in percent, 1991-2001



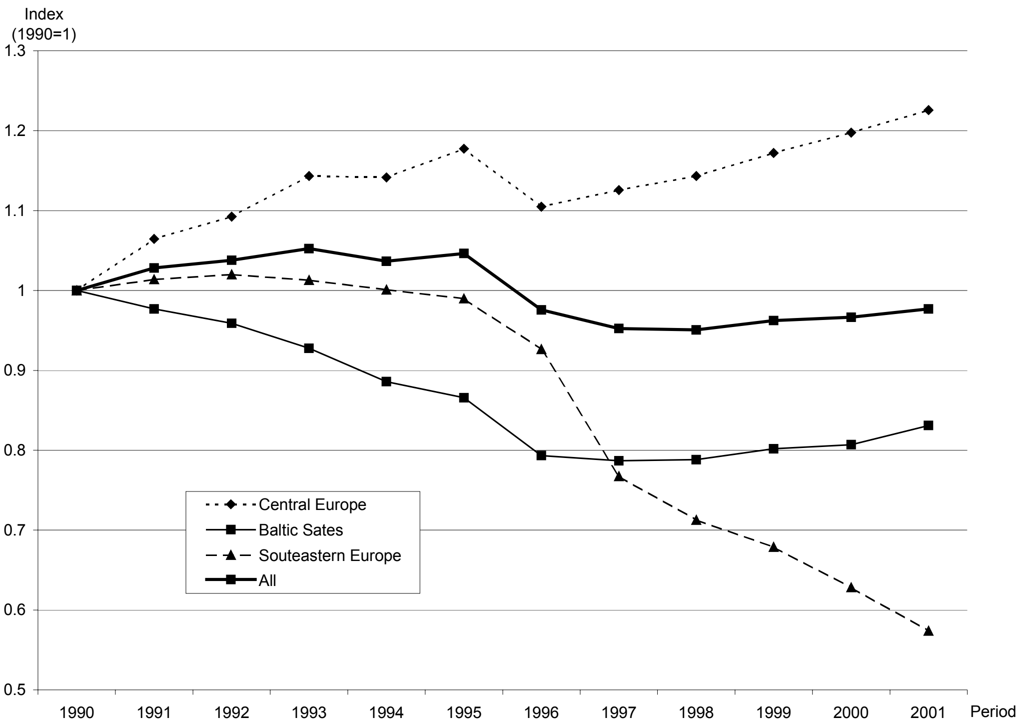
Source: Authors' calculations.

Figure 4.1a: The dynamics of the TFP level (1990=1)



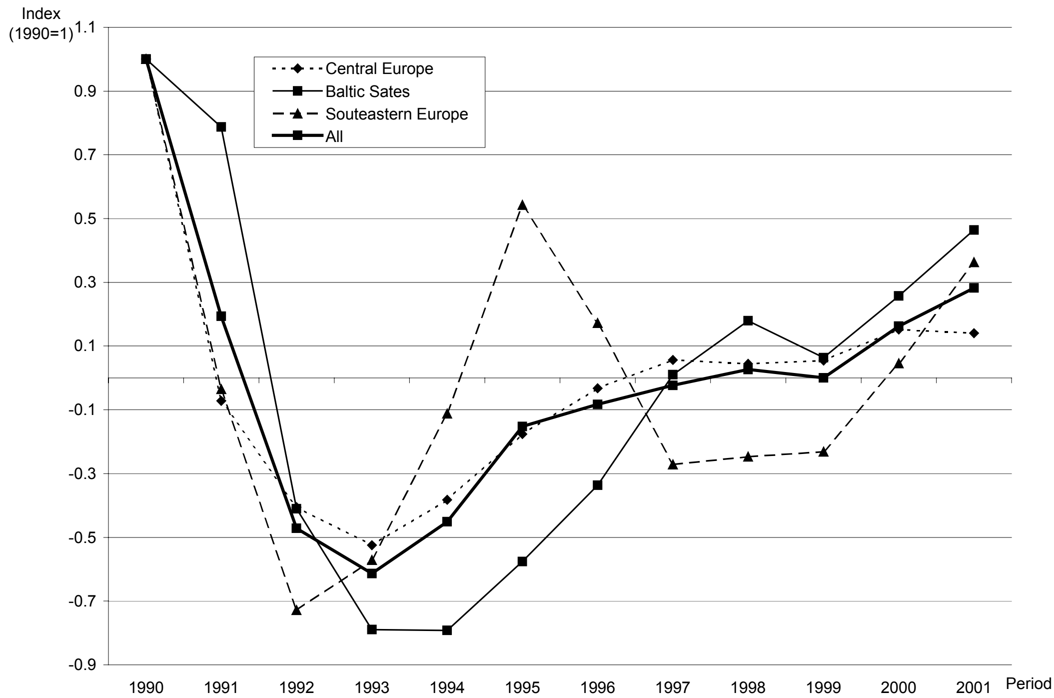
Source: Authors' calculations.

Figure 4.1b: The dynamics of the structural TFP level (1990=1)



Source: Authors' calculations.

Figure 4.1c: The dynamics of the cyclical TFP level (1990=1)



Source: Authors' calculations.

Figure 4.2a: TFP Growth Rates in percent, 1991-2001

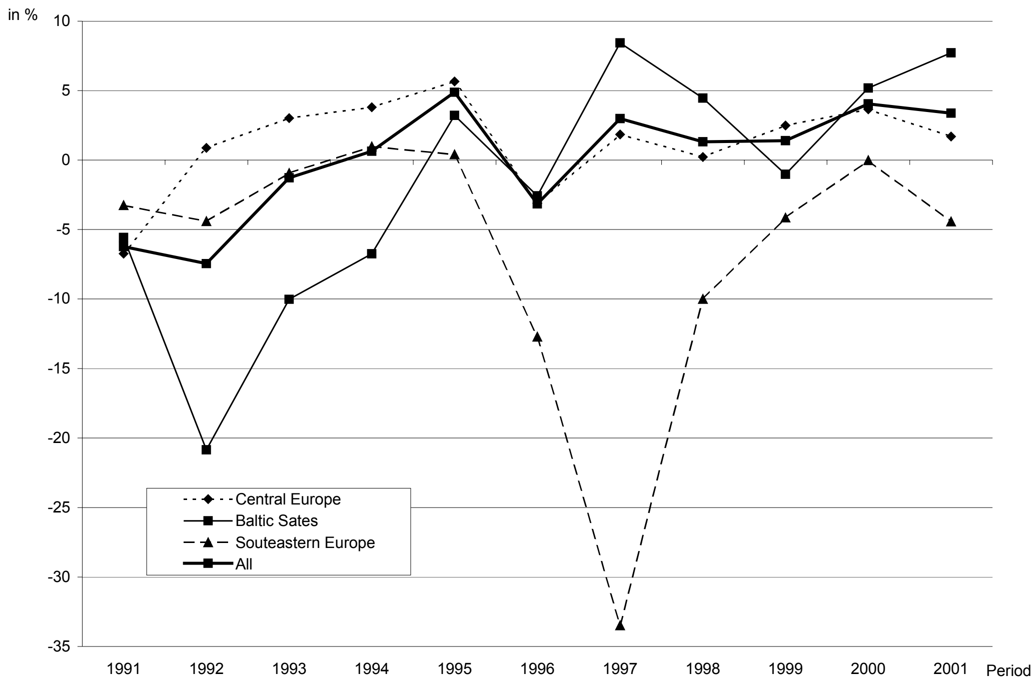
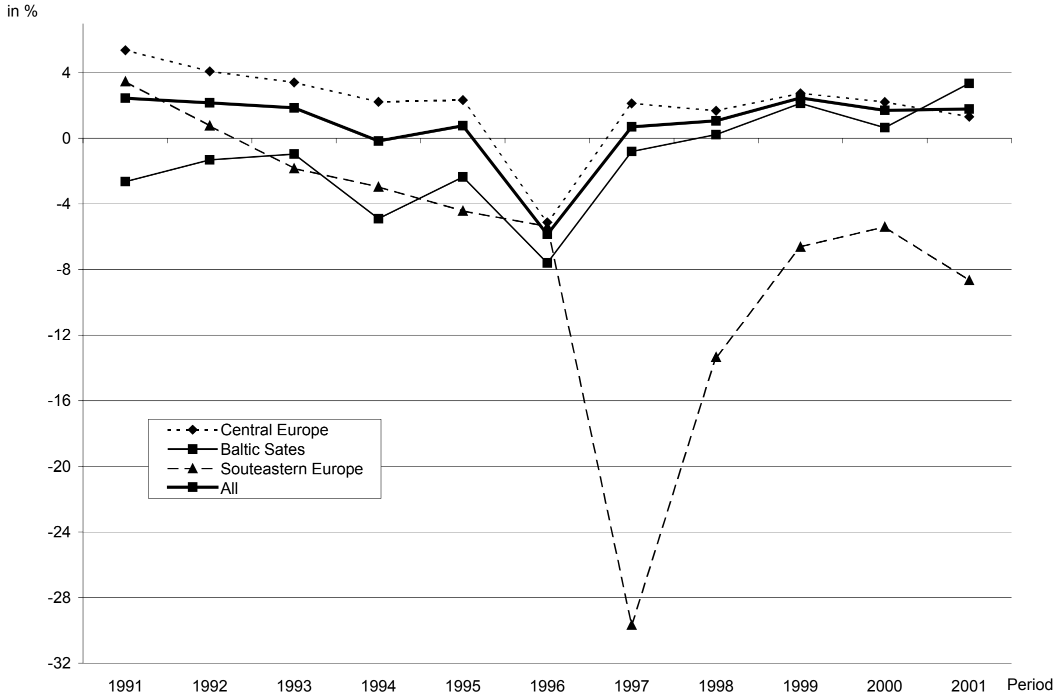
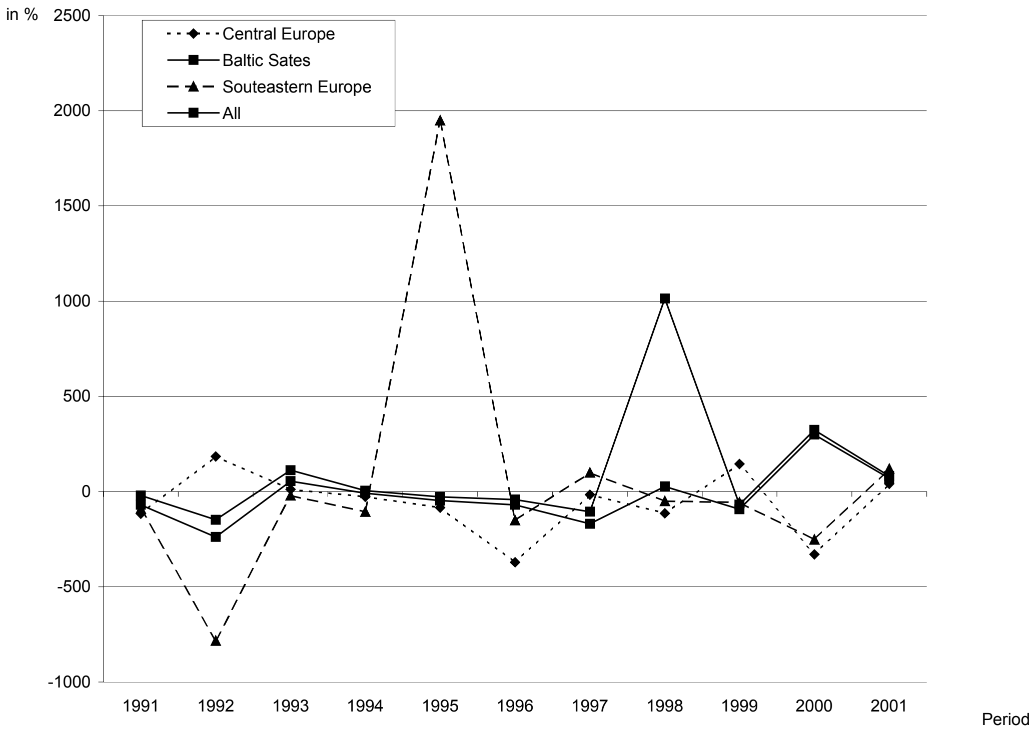


Figure 4.2b: Structural TFP Growth Rates in percent, 1991-2001



Source: Authors' calculations.

Figure 4.2c: Cyclical TFP Growth Rates in percent, 1991-2001



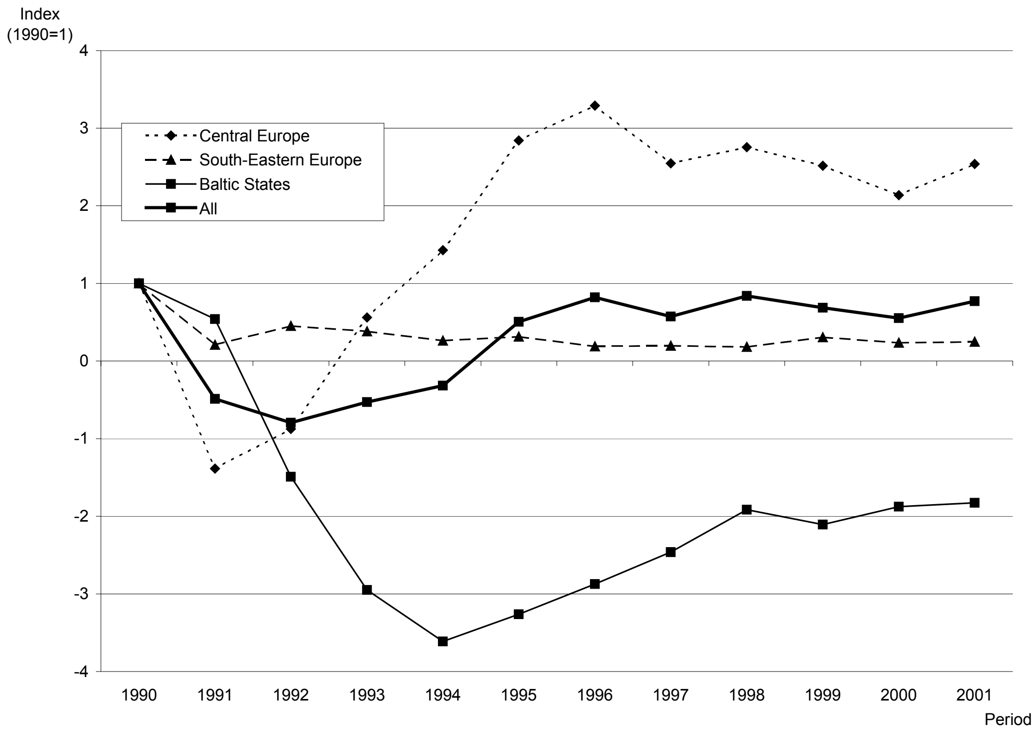
Source: Authors' calculations.

Table 5.1: Description of State and Environmental Variables

	Mean 1990-2001	Std. Dev. 1990-2001	Min	Max
GDP (mio USD)	31270.91	32207.54	4591.85	143582.21
log GDP	23.70	0.98	0.98	25.69
GDP per capita (USD)	3479.64	2121.33	859.00	8699.00
log GDP per capita	7.99	0.57	6.76	9.07
Human Capital (index)	100.49	0.97	97.90	100.87
log Human Capital	4.61	0.01	4.58	4.61
Physical Capital per capita (USD)	1846.97	4423.97	1234.67	12299.60
Log Physical Capital per capita	3.91	3.72	-2.10	9.42
Saving/GDP (%)	27.60	0.91	21.89	32.68
log Saving/GDP	3.16	0.05	3.09	3.28
Taxes on Corporate Income and Profit/GDP (%)	0.88	0.33	0.21	1.52
log Taxes on Corporate Income and Profit/GDP	-0.21	0.57	-1.20	0.39
Interaction Term (log GDP*h)	2.38	0.11	2.19	2.55
E/Y (%)	5.11	1.23	2.80	6.10
log E/Y	1.60	0.26	1.03	1.81
I/Y (%)	36.94	4.06	12.01	44.77
log I/Y	0.74	3.35	2.49	4.92
Transition Index growth rate (%)	2.94	0.58	1.10	0.00
log Transition Index	1.05	0.25	0.10	0.00

Source: Authors' calculations.

Figure 6.1: The dynamics of the TFP level according to the regression analysis (1990=1)



Source: Authors' calculations.