GROWTH ACCOUNTING IN TRANSITIVE ECONOMIES

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Abstract:
The aim and probably the biggest contribution of this paper is to produce unique data series for the capital stock and an estimate of the depreciation rate (using microeconomic data) in the transitive economies in the period 1989 – 1999 and subsequently to try to calculate the growth accounting formula. The countries of primary interest are the Czech Republic and Slovakia, where the most complete data sources are available. The paper will prove that in the first years of economic transition Central and Eastern European countries show extremely high dynamics of growth that can be attributed to increases in productivity, that is very high Solow residual.

Keywords: growth accounting, capital stock, transition, Solow residual, Czech Republic

JEL Classification: O110, O300, O520

1. Introduction

In the standard growth accounting exercise, the main focus is on dividing the sources of growth between the contribution of increases in the quantity of the factor inputs and the efficiency with which they are used. Factor shares are used to decompose growth over time in a single country into a part explained by growth in factor inputs and an unexplained part – the Solow residual – which is usually attributed to technological change.

In another words, growth accounting breaks down the observed economic growth into components associated with changes in factor inputs and the “rest”, which reflects technological progress and the other elements. The focus is on obtaining quantity series for each input, which when multiplied by the inputs’ weights yield their contribution to changes in output.

In the textbook fashion, values of capital’s and labor’s share in output are imposed on the data and one can ask how much of the cross-country variation in income the model can account for. In practice, since the exact estimates of factor shares do not exist, it is necessary to use a plausible guess or to appraise their value from the statistical data. Even though the empirical calculation is not pursued very often, this study aims at producing reliable estimates of these shares.

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2. Total Factor Productivity

In growth accounting, the production function is most typically defined as the Cobb-Douglas production function in the familiar form

$$Y = AK^{\alpha} L^{(1-\alpha)}$$ [1]

where A is a measure of the level of technology called "total factor productivity", K represents the amount of capital and L the amount of labor used. Total factor productivity A grows over time (for reasons that are not entirely clear), capital stock grows over time due to investment and labor supply grows due to population growth, increases in participation rates or immigration. Thus, Y can be thought of as the product of three factors, so expressing through percentage changes gives us the so-called growth accounting formula

$$\Delta \%Y = \Delta\%A + \alpha\Delta\%K + (1 - \alpha)\Delta\%L$$

where α is the share of income going to capital. It is traditionally estimated to be about 0.3 in the case of the United States, but because the best of it is uncertain, it is common practice to assume it to be constant but to try a few different values. It is agreed that 0.2, 0.3, 0.45 cover the range of what most economists would think to be reasonable guesses (we will calculate our own "Czech" α later). Quite often $(1 - \alpha)$ is labeled as β. Both α and β are smaller than one due to the production function having diminishing returns to both capital and labor.[2] If we assume the production function to be linear homogeneous and markets competitive, then α equals capital's share in output and β equals labor's share in output, while $\alpha + \beta = 1$.[3]

According to Hall, roughly about half of the growth of output in the 20th century is not accounted for by growth in the input factors. This "unexplained" growth, namely total factor productivity, is often called the Solow residual or growth due to technical change and innovation.

Theoretically, improvements in education attainment of the population or higher and modern computers should be treated as parts of labor or capital respectively. Even though some researchers have aspired to do this by adjusting the labor input for increases in skills and the capital input for improvements in capital equipment, they could only confirm that in the United States at least, growth in the last century has been dominated by improvements in technology rather than by capital formation.

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1) Alternatively, Mankiw defines the production function as $Y(t) = K(t)^{\alpha}H(t)^{\beta}\,(A(t)L(t))^{(1-\alpha-\beta)}$ where H is the stock of human capital and all other variables are as defined above. This formulation is motivated by the conviction that education plays an independent role in the production process. Therefore, the production function incorporates three factors, capital, labor and education (usually measured by years of schooling). However, since years of schooling are only a very imperfect description of human capital and data are available only for a few years and a few countries, it is often rejected in empirical analyses.

2) A key assumption in growth accounting exercises is that factor prices coincide with marginal products. In other words, that each input factor is paid according to its marginal product. As Bosworth notes, if this assumption is violated, then the estimated value $\Delta\%A$ calculated from our growth accounting equation deviates from the true contribution of technical change to economic growth. Furthermore, the author understands a possible critique coming from the fact that transitive economies are not fully competitive, but as for the most developed Central European economies (the Czech Republic, Poland, Hungary), where the share of private sector highly exceeds that of the state, it is not a worse drawback than for developed economies (according to EBRD, share of private sector in GDP surpassed that of the government in 1993 in these countries and today constitutes about 85 % in Hungary, 80 % in the Czech Republic and 70 % in Poland).

3) Mankiw notes that although there are decreasing returns to physical-capital accumulation when human capital is held constant, the returns to all reproducible capital (human plus physical) are constant.

What results can we expect from studying the total factor productivity among transitive economies in Central and Eastern Europe? Can we state any concrete hypothesis at all? By looking at total factor productivity in various continents from the period of 1965 – 1990, we see that developing economies like Latin America or Africa registered zero growth from technological improvements. Based on this logic, we might assume that Central and Eastern European (CEE) countries will be no exception and will show a minimal or zero contribution of technology to economic growth.

However, since the economic system of communist regimes was very ineffective, we might also assume that simply by removing the basic obstacles, CEE countries should register economic growth stemming from other sources than capital or labor accumulation. This would, on the other hand, resemble more developed economies with their high percentage of growth explained by total factor productivity. As we will see later, CEE countries really – and quite surprisingly indeed – show a very high total factor productivity contribution to economic growth in the transition period of the 1990s.

3. Problems with Data

While growth accounts have long provided a useful framework for analyzing economic growth in the industrial economies, their use for a broader group of developing countries has been limited by the lack of available data on the major inputs. Most previous studies have been restricted to select only a few countries where the researcher was able to obtain the required information from national statistical sources.

As far as the author is aware, nobody has tried to compute the growth accounting for Central and Eastern European countries. Because data were available to the author only for a very limited number of countries, he had to concentrate on the empirical study of the Czech Republic above all and in a restricted and incomplete extent of Slovakia, Poland, Hungary, Slovenia and Estonia. All these countries belong to the so-called fast reformers group with the relatively highest level of living standard and liberal reforms' achievements among CEE countries and former Soviet Union Republics.

By far, the most complications arise while trying to estimate the capital stock data. Usage of numbers from statistical yearbooks poses immense difficulties because the composition of stock differs from year to year, there are troubles with accounting in base historical prices or with speculatively unknown rate of depreciation for the whole economy.

4. Depreciation Rate

The key task, which must be overcome in order to be able to calculate the capital stock data series, is an estimation of the depreciation rate for the whole economy.[4)] When a proxy of δ can be estimated, the capital stock series – using a benchmark value of K, annual percentage change of real investment and depreciation δ – can be produced. Mankiw (1992) assesses that in the USA δ is about 0.03, that is 3 %. Romer (1989) presents a calculation for a broader sample of developed countries and concludes that δ is around 3 – 4 %.

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4) The majority of economists trying to calculate growth accounting formula usually do not bother with estimating average depreciation rates for the whole economy and simply take a guess value of 3 – 4 %.

From the taxable profit standpoint, depreciation is treated as a cost of production. Replacement costs of capital, i.e. depreciation, are considered a part of the production costs in the Czech accounting system, or more rigorously, a part of the tax-deductible costs. According to the accounting and tax laws, depreciation costs are defined as a certain percentage of the book value of capital each year. In the case of a strictly linear scheme, for example, 20 % of capital depreciation each year means that after 5 years the capital is fully depreciated and financial resources to replace it should be available in the replacement fund. In the Czech Republic, the life span of capital varies from 4 years (for most electronics) up to 30 years (for real estate like buildings). This translates into a depreciation rate ranging from 2.2 % per annum for long-life capital to 25 % per annum for computers. Thus, the common view is that heavy industry firms have long-life capital resulting in a lower average depreciation rate, while firms operating in electronics or light industry have a capital structure containing higher portion of a short-life capital, with outcome being a higher average depreciation rate. Also, larger firms are more likely to have a higher portion of long-life capital, like real estate, resulting in a lower depreciation rate.

While estimating the average depreciation rate for the Czech Republic in transitive period in the 1990s, the author was fortunate to use the calculations from a mutual project between the Czech National Bank and the CERGE (Center for Economic Research and Graduate Education of Charles University, the Czech Republic), which was headed by L. Lízal from the CERGE. Their estimations deal with individual microeconomic industry-sector depreciation rates based on a linear scheme. They researched in a great detail quarterly accounting documents of companies that were available at the Czech Statistical Office. The aim of their work was to evaluate and discuss hypotheses about different depreciation rates in various sectors (because the composition of capital in heavy industry should be quite different from the composition, for example, in textiles or electronics) and speeds of restructuring among Czech industries in transition.

The depreciation rates that are used in calculation of the average depreciation rate for the Czech economy, are based on the above mentioned mutual project (and for a few categories not covered by Lízal from the EBRD, 1999), as follows.

Table 1
Annual Depreciation in Industry and Elsewhere (in %)

Machinery	6.61	Furniture	7.10
Mining	5.79	Recycling	6.74
Food	6.89	Water utilities	2.06
Textiles	5.29	Trade	6.01
Wood	5.02	Restaurants	3.98
Publishing	8.32	Transportation	10.02
Chemicals	5.27	Financing, insurance	6.80
Plastics	7.93	Construction	6.60
Ceramics	6.21	Real Estate	4.03
Metals	4.82	Defense, state administration	4.97
Electronics	7.50	Recreation, sport activities	5.01
Medical	6.49	Non-weighed average	6.29
Vehicles	11.55		

Source: Lízal, 1998, p. 17.

It can be easily seen that the machinery's depreciation of roughly 6.6 % annually, which Lízal uses as a benchmark, seems to be more-or-less identical to that for food, medical goods, furniture, recycling, ceramic production industry, financing and construction. Another noticeable fact is the extremely low depreciation rate of capital in the water utility industry (only about 2 %), which signals that water producers' capital consists mainly of long-life real estate like water dams and pipelines. Also, as expected, heavy industry (mining, chemical production and metal production) has a significant share of long-life capital. A similar situation exists in the wood processing, restaurants, state administration or recreation facilities sectors, showing the higher share of buildings and other long-used equipment.

A little surprisingly, relatively low depreciation rate is also revealed in textile industry. One plausible explanation for this could be that the labor-intensive textile industry did not undergo any modernization yet. On the other hand, as one would expect, the depreciation rate is higher in the electronics and publishing industries and extremely high in the automotive industry and transportation.

Then, using the above depreciation rates, I utilized the data from the statistical yearbooks (various issues, the Czech Statistical Office) and calculated the average Czech depreciation rate for individual years.[5)] I applied the weighed method and assigned the corresponding depreciation rate to the value of fixed assets in individual years. Weights are the shares of industries in total national annual value of fixed assets in current prices.[6)] The results are as follows.

Table 2
The Czech Aggregate Depreciation Rate (in %)

Year		Year	
1985	6.31	1994	5.49
1988	6.33	1995	5.48
1989	6.34	1996	5.49
1990	6.33	1997	5.48
1991	5.84	1998	5.48
1992	5.83	1999	5.48
1993	5.82		

Source: Author's calculations, 1999 value supposed to be the same as in 1998 since no data were yet available.

In comparison with 3 – 4 % rate of depreciation typical for developed economies, transition depreciation rate is a little higher. It marginally decreases with time (from 6.34 % in 1989 to 5.48 % ten years later), as the economies move closer towards standard developed economies and replace old equipment with new machines. Since depreciation rate and productivity of foreign owned companies in the Czech Republic have grown up, one possible explanation of this phenomenon might be that the remaining mammoth state or quasi-state owned companies have done nothing or very little in changing their long-life obsolete heavy-industry like capital stock (whose depreciation rate is lower).

5) The used data tables were – for 1994 – 1998: Czech Statistical Yearbook, 2000, Table 11-9, Gross tangible fixed capital stock: buildings and structures, machinery and equipment, current prices at Oct-Dec prices of current year. For 1991 – 1993: Czech Statistical Yearbook, 1995, Table 11-12, Gross tangible fixed capital stock: buildings and structures, machinery and equipment, actual prices. For 1989 – 1990: Czech Statistical Yearbook, 1993, Table 10-7, Fixed assets by branch.

6) Weights of sectors not encompassed in this calculation include only 0.04 % of the total value of tangible assets represented by the "others" sector.

What has to be distinguished here is a concept of economic (theoretical) vs. tax (calculated) depreciation rate. Economically, it is plausible to speculate that due to a very old capital stock of communist enterprises at the rebirth of capitalism at the beginning of 1990, the economic depreciation rate was very high (some "unwritten and unpublished" estimates in the academic sphere in the Czech Republic speak even about 40 %). With time and with increases of effectiveness and living standards in transitive economies, the economic depreciation should go down and one day come close to 3 – 4 % of the U.S. economy.

On the condition that Lízal's estimates of industry depreciation rates are the same also in the case of Slovakia (which is very reasonable and easy to defend, as by January 1993 both countries were part of the same Czechoslovak federation and even after that have very similar depreciation, tax and accounting laws), we can assess the average Slovak depreciation rate of 5.61 %.[7] Because of the insufficiency of official statistical data, it will be assumed in the further text that depreciation for the years 1989 – 1992 was identical with the Czech Republic and afterwards stayed the same at 5.61 %.

5. Capital

After estimating the average annual depreciation rate for the whole economy, it can be proceeded to the assessment of the capital stock and its changes.[8] The basic relationship between capital and depreciation used in the literature is an idealization of an accounting identity on an aggregate level. In our case, $D_t = \delta K_t$, where D is the depreciation value, K is the book value of the capital at the time of purchase, δ is the depreciation rate and subscript t denotes time. However, as mentioned earlier, since data about D are not available either in the case of the Czech Republic or other transitive European economy, this easy formula to derive capital stock series could not be used.

The first best ideal alternative would be to have the series of K data expressed in actual buying price, reflecting different annual composition and quality upgrades. However, this theoretically ideal data is not at hand for transitive economies and other estimates of the capital stock are normally viewed as unreliable. It is because of lack of information about the initial benchmark capital stock and the rate of depreciation that is, thus, a main obstacle to calculating the growth accounting equation. The key condition for any kind of capital stock series estimation is the right assumption about the initial benchmark capital stock.

The second best alternative, reflecting skepticism about any estimate of the capital stock, simply involves using the gross investment rate (i.e. flow variable) as a proxy for the change in the capital stock. Indeed, that is the route taken by most of the past studies. The change in the capital stock is given by

$$\Delta K = I$$

However, the autor thinks that using the investment (I) as a proxy seems quite unreasonably in the case of transitive economies. Many of these countries have had a growth experience both over the communist decades and the transition period that was very far from the conditions of anything close to a steady-state. As a result, it

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7) Data were taken from the Statistical Yearbook of Slovakia, 1999, Table III.4-12, Gross tangible fixed capital assets stock as of Dec 31, 1997, by industry groups.

8) It should be noted here that K expressed in Statistical Yearbooks of the Czech Republic represents both public and private capital. Therefore, the capital stock of big state-run companies is also included.

can be suspected that the investment rate appeared to be a very poor proxy for the rate of capital accumulation.[9)]

To test this hypothesis, a regression analysis of the function GDP % = f(*L*, INV), where GDP % denotes real annual percentage changes of GDP in the Czech Republic between 1991 – 1999, *L* is civilian employment annual changes (from OECD, see below) and INV are percentage changes of gross investment, was conducted. As we will see later, intercept measures technological change, and the coefficients of the labor and investment growths represent β and α, respectively. It can be noticed that even though R^2 is very high, the model is not very good. First, INV coefficient is significant only at 90% level of significance, but most importantly – both intercept and coefficients are nonsense values. Intercept's negative number would mean that total factor productivity's contribution to growth in transition period is negative (it will be proved later that quite the opposite is true) and shares of capital and labor in total income are absurd (recall α is roughly 0.3 – 0.4 and β is about 0.6 – 0.7).

Equation 1 (1991 – 1999, Czech Republic)

	Coefficient	Stand. dev.	*t*-value	*P*-value
Intercept	-0.17	1.02	-0.17	0.8742
Labor	**0.99**	0.45	2.20	0.0705
INV	**27.38**	8.37	3.27	0.0170

# of obser	9
R^2	88 %

Therefore, the author concluded that a capital stock value data series have to be estimated because INV as a proxy of capital stock does not show satisfactory results. The so-called capital accumulation constraint has been employed and used for further derivation of capital stock in the form of

$$K_t = K_{t-1} + I_t - \delta_t \cdot K_{t-1}$$

where K_t describes capital stock value in *t*, K_{t-1} denotes the value of stock at the end of the previous year, δ_t is depreciation rate in *t* and I_t real investment in *t*. This capital accumulation constraint utilizes the assumption of linear dependency of depreciation on the capital. The author used depreciation in period *t* instead of *t*-1 because of depreciating capital stock value from Dec 31 of the period *t*-1, which in fact means starting to write off in the period *t*.

As a benchmark capital stock it was used the datum from the year 1994 (in 1994 prices) from the latest Statistical Yearbook of the Czech Republic 2000, Table 11-10 Gross Tangible Capital Stock. The year 1994 was the most recent capital stock in the same year's prices available and since there were some quite substantial changes in relative prices and inflation at the beginning of the transition process, the later data were given preference.

For the years 1995 – 1999, it was used the following formula to derive the capital stock data (the calculation for 1995 is used as an example):

Stock 95 = Stock 94 + I 95 – Depr. Rate 95 · Stock 94)[10)]

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9) As a matter of fact, Bosworth found in the sample of 88 developed and developing countries that there was no significant correlation between the rate of change in the capital stock and the investment rate.

10) Of course, the ideal situation would be to have all real I 95, 96… measured in 1994 prices. However, since the base year was changed several times during the first transition decade and there have been so many shifts in relative prices, looking for this kind of data is only illusion.

For the years before 1994, the formula had to be altered moderately. Using the equation for the year 1994 and reorganizing in order to find an expression for 1993

$$\text{Stock 93} = (\text{Stock 94} - \text{I 94}) / (1 - \text{Depr. Rate 94})$$

is obtained.

The result depicting the capital stock data series for the Czech Republic is presented in Table 3.

Table 3
Capital Stock in the Czech Republic (in %)

Year	Stock (in CZK mill.)	Change stock	Investment	Depreciation
1990	17120840.9			6.33
1991	13124836.6	-23.34	-17.50	5.84
1992	13514644.3	2.97	8.80	5.83
1993	11633405.8	-13.92	-8.10	5.82
1994	13007311.0	11.81	17.30	5.49
1995	14882965.2	14.42	19.90	5.48
1996	15286293.6	2.71	8.20	5.49
1997	13791294.1	-9.78	-4.30	5.48
1998	12511462.0	-9.28	-3.80	5.48
1999	11237795.2	-10.18	-4.70	5.48
	Average	-3.84		

Source: 1994 capital stock from the Statistical Yearbook of the Czech Republic 2000, Table 11-10, p. 340-341 Gross tangible capital stock. Investment from EBRD, Transition Report 1999. Depreciation rate – author's calculation from Chapter 4.

Notice the extreme swings in the capital stock changes. Such variation would not normally be found in developed economies. However, the economic transition is an exceptional and abnormal situation allowing this kind of huge swings. As will be seen later, these changes in capital stock are the main source for growth accounting to predict even larger economic growth collapse than actually happened.

Also in Slovakia, fluctuations in capital stock are quite rough. However, the average decline of this variable is almost three times smaller than in the Czech Republic and from 1996 registers only positive numbers.

In case of Slovakia, pursuing the same procedure, the following capital stock data are obtained:

Table 4
Capital Stock in Slovakia (in %)

Year	Stock (in SKK mil.)	Change stock	Investment	Depreciation
1989				6.34
1990	2708305			6.33
1991	1907505	-29.57	-25.20	5.84
1992	1715464	-10.07	-4.50	5.83
1993	1531788	-10.71	-5.40	5.61
1994	1379346	-9.95	-4.60	5.61
1995	1370968	-0.61	5.30	5.61
1996	1809092	31.96	39.80	5.61
1997	1955204	8.08	14.50	5.61
1998	2048524	4.77	11.00	5.61
1999	2117294	3.36	9.50	5.61
	Average	-1.37		

Source: 1997 capital stock from the Statistical Yearbook of Slovakia 1999, Table III. 4-12, Gross tangible fixed capital assets stock by groups. Investment from EBRD, Transition Report 1999. Depreciation rate – author's calculation from Chapter 4.

6. Labor

Finding data on labor quantity is a relatively easy task. In theory, there are three indices commonly used – actual employment, economically active population and total population.[11)] Usually, where availability of the data allows the measure of the quantity of labor is actual employment (mostly for the industrial countries) and estimates of the economically active population for the other countries (usually taken from the International Labor Organization).

The Table 5 shows the labor quantity data for the selected CEE countries. For the Czech Republic, both the total number and the percentage change are shown, for other countries only the annual percentage change is presented.

The average annual changes of labor statistics during the 1990s in transitive economies are negative.[12)] Why is that? Four potential explanations can be thought of:

– people spend more years studying, some study for the second time (mostly university level),

– some people have left the country and live and work abroad,

11) Bosworth found that the use of the labor force measure instead of the total population, as is also sometimes practiced in some studies, makes little difference in the aggregate. The two series taken from more than 80 countries have nearly identical growth and the correlation between the changes is 0.82.

12) Opting for total employment or economically active population instead of labor force data was dictated by availability of data series of these variables. However, since total employment data are influenced by unemployment (which was growing in transitive countries), the actual labor force decrease seems probably exaggerated when judged only from changes of employment data. If we look at incomplete Czech labor force data for 1992 – 1999, the annual average decline is only 0.032.

– some dropped out from the official statistics but engaged in gray economy (meaning they are not looking for a job, but are not unemployed),

– some rich people simply lost a motivation to work and enjoy their luxury.

None of these activities were possible under communism, where there was a law forcing everyone to work (or at least to have some "official" job). After the collapse of central planning and opening up of various opportunities, quite many people fell out of the labor force.

Table 5
Labor Changes (in %)

	Czech Republic	Slovakia	Poland	Hungary	Estonia	Slovenia
1989	-0.114	-0.112	-1.375	-0.353	n.a.	-1.146
1990	-4.766	-1.2	-4.934	-1.419	-1.372	-3.684
1991	-3.564	-14.4	-5.981	-5.381	-2.251	-7.567
1992	-2.906	0.3	-5.054	-8.395	-5.212	-5.969
1993	3.934	-0.1	-3.674	-6.256	-7.523	-3.750
1994	1.461	-4.2	-1.585	-1.981	-2.189	0.710
1995	-0.101	2.1	0.907	-1.938	-5.270	3.643
1996	-0.223	3.3	1.203	-0.835	-1.600	-0.454
1997	-0.651	-1.1	1.390	-0.049	0.434	2.278
1998	-1.351	-1.2	1.179	1.410	-1.265	1.002
1999	-2.262	-2.7	n.a.	3.078	-3.936	-12.238
1989-99	-0.959	-1.756	-1.792[1)]	-2.011	-3.018[3)]	-2.471
1991-99	-0.6294	-2.00	-1.452[2)]	-2.260	-3.201	-2.483

1) 1989 –1998.
2) 1991 – 1998.
3) 1990 – 1999.

Explanation and sources: **Czech Republic** – Civilian employment, OECD, Labor Force Statistics, end of year estimates; **Slovakia** – Employment annual average, EBRD; **Poland** – Economically active civilian population, IMF, International Financial Statistics; **Hungary** – Total employment, International Labor Organization; **Estonia** – Total employment, International Labor Organization; **Slovenia** – Total employment, International Labor Organization.

One could remark that changes in the quality of the labor force should also be somehow included in the labor statistics depicting changes on the labor market in transitive economies.[13)] The most commonly used variable in this respect is the secondary school enrollment rate. However, particularly among European transitive economies, incorporating this variable would only confuse the changes that have occurred on the labor market. The reason is that the former centrally planned economies had extraordinarily high secondary school enrollment ratios. When, at the beginning of the democratization process around 1990, people could start to opt for other choices than studying (private business, life abroad, etc), enrollment rates decreased considerably. However, that does not mean that the quality of the labor force has gone down. Quite on the contrary – the contents of education and the

13) It would be advisable to do decomposition of labor at this point. Any decomposition relies on the notion that the quantity of labor as well as the quality characteristics of labor have the same relevance for services produced by this labor. However, it is very hard to find measurable labor characteristics. Labor is dependent on the level of knowledge, decision-making capability, physical coordination, communication skills, etc. Such characteristics are extremely difficult to measure scientifically. It is because labor services are so complex and heterogeneous that no practicable scheme of categorization will catch all of the quality characteristics.

quality of textbooks, for example, are nowadays much more in line with modern western methods.

Theoretically, one might also consider incorporating into *L* a variable reflecting hours worked. It is possible that *L* would slightly increase when hours worked were taken into account, since there was almost no overtime in socialism, while many people working especially for foreign firms nowadays devote more time to working than before. However, there is no suitable data to express hours worked for transitive economies.[14)] Therefore, I decided to stick simply to the quantity of labor force because there is not a satisfactory variable that would explain changes in the labor force quality.

7. Estimation of Coefficients of Capital and Labor

The final step in the construction of the indices of growth in factor inputs and total factor productivity involves the choice of weights for aggregating the factor inputs. Prior growth accounting exercises for the rich industrial countries usually used a weight of 0.3 for capital and 0.7 for labor. However, in case of transition developing economies, it is reasonable to assume that a larger weight (arguably about 0.4 for the capital stock) would be more appropriate because of a larger proportion of self-employment in these countries (the labor component of self-employment income is assigned to capital income in the national accounts).

As mentioned before, if a degree of competition sufficient to ensure that the earnings of the factors are proportionate to their marginal product is assumed, the shares of income paid to the factors can then be used to measure their relative importance in the production process. Most cross-country studies dealing with developed economies did not have any consistent annual income data at the national level and were, thus, compelled to use some alternative “best proxies” of α and β as well as to use these “proxy” estimates for all the years of the researched period (see Bosworth, 1995).

In the case of the Czech Republic, the author was fortunate enough to have access to annual data about allocation of primary income (account II.1.2., Statistical Yearbook of the Czech Republic, various issues 1992 – 1998, Chapter 5 National Accounts). The share of capital in total income α was calculated as: α = (property income + operating surplus + mixed income) / total (allocation of primary income account II.1.2.).

The share of labor in total income β was calculated as: β = (compensation of employees) / total (allocation of primary income account II.1.2.).

The individual equation items are defined as follows in the statistic yearbooks. **Property income** results from the ownership of financial and tangible non-produced assets and includes interest (from deposits, debentures and loans), imputed interest from insurance, incomes from land (rental), dividends, and some other income from distributed profits and withdrawals from profits. **Operating surplus** includes profits of businesses, interest and other income from the ownership of capital (i.e., property and business incomes). It is determined as the balancing item between gross value-added, compensation of employees and net taxes on production. **Mixed income**

14) According to ILO statistics, only data for wage earners of manufacturing (ISIC group 3) are available for the Czech Republic from 1992. Therefore, this statistics of hours worked is not complete, moreover because it includes only enterprises with more than 25 employees. Moreover, it is not compatible with data of other transitive countries.

of small entrepreneurs is the sum of their income from business (profits) and their income from work activities (wages) for own "business", as these two incomes cannot be statistically distinguished. **Compensation of employees** includes wages and salaries and social contributions paid by employers. Wages and salaries include those for work done for the employer; salaries of members of cooperatives and associates; wages and salaries of regular members of the armed forces, pocket money and boarding allowances and clothing of temporary members of the armed forces; they also include contributions to employees for commuting to and from work, their meals, cultural and sports interests, and others. They are given before income tax, statutory (mandatory) contributions to general social and health insurance schemes and other deductions, if any. **Employers' social contributions** – paid by employers for their employees to general social and health insurance (27 % of basic wages to social insurance, including the unemployment fund, and 9 % of basic wages to health insurance) and direct social assistance provided by employers (irretrievable assistance paid, e.g., from the social fund). **Total** is defined as the sum of all the above explained items.[15)]

The average value for α was 38.8 and for β 61.2. These are the values being used in the growth accounting equation. The variation of α and β estimates for 1992 – 1998 was not very big. The highest difference between estimates of α and β was 35.2 vs. 64.2 in 1994, the lowest was 40.8 vs. 59.2 in 1997. Since there are no data for the years before 1992 and after 1998, average values as if they were calculated for the whole researched period had to be used (thanks to the described small fluctuations of the estimates, this assumption is not a serious limitation).

As for Slovakia, employing the same way of calculation while using data from the Statistical Yearbook of Slovakia 1999, Table II.1-8, Sector accounts, Allocation of primary income account (in current prices), we obtain an α of 0.294 and a β of 0.706. It can be speculated that the bigger role of labor on total income allocation in Slovakia than in the Czech Republic stems from a fact that privatization did not progress that fast in Slovakia and many companies are thus government or quasi-government owned with a considerable over-employment. The estimate is taken from the newest available data so the limitation caused by using it as the 11-year period average should not be that drastic. Moreover, if it can be reasonably assumed that fluctuations of shares of labor and capital on total income did not suffer from considerably higher fluctuations than in the Czech Republic, this assumption is easy to defend.

8. Calculations and Results

As can be seen in Chapter 2, the standard way to estimate the contribution of technological change to economic growth (Solow residual, total factor productivity – TFP) follows from the equation

$$\Delta\%A = \Delta\%Y - \alpha\Delta\%K - \beta\Delta\%L$$

where α and β are the respective shares of each factor payment in total product.[16)] TFP estimates calculated this way do not involve any econometric method. The estimated TFP (Solow residual) is computed by using time-series data on Y, L, K

15) The above specified items constitute around 95 % of total primary income. The remainder is a taxation on production and imports. Including of this entry would not considerably change the results presented here.

16) The condition $\alpha + \beta = 1$ must hold if all of the income associated with the gross domestic product Y is attributed to one of the factors, restricted here to capital and labor. In an international context, some net factor income may accrue to foreign owned factors, so $\alpha + \beta$ would include this net factor income.

and α and β. In practice, researchers report an average value of the computed time-series for a designated period and calculate the growth accounting equation.

However, there is one drawback to this exercise. For example, if the population's average educational attainment is rising over time, then it attributes a portion of economic growth to the rise of L. The failure to allow for these improvements in the labor quality tends to overestimate the Solow residual.

The treatment of capital is analogous. One important element here concerns the distinction between short-term and long-term capital. A shift from long-term capital (say buildings) to short-term capital (say machinery) would account for some part of economic growth. Failure to allow for this rise in the capital quality tends to overstate the Solow residual in the equation above. However, one can intuitively feel that measuring and incorporating of improvements of both L and K is extremely difficult in practice, so the studies typically omit to do it.[17)]

An alternative approach to the growth accounting equation arithmetic, recommended by Bosworth, would be to regress the growth rate of output $\Delta\%Y$ on the growth rates of inputs $\Delta\%K$ and $\Delta\%L$. The intercept would then measure $\Delta\%A$ and the coefficients on the factor growth rates measure α and β, respectively. However, the regression approach also has several disadvantages. First, the variables $\Delta\%K$ and $\Delta\%L$ cannot be regarded as exogenous with respect to variations in $\Delta\%A$. This criticism holds specifically in the transitive economies where forces that affect K and L also influence TFP. Second, if $\Delta\%K$ and $\Delta\%L$ are measured with error, then standard estimates of the coefficients of these variables would deliver inconsistent estimates of α and β, respectively (see Barro, 1998). This problem is likely to be especially serious for the growth rate of capital input, where the measured capital stock is unlikely to correspond well to the stock currently utilized in the production process. It often leads to low estimates of the contribution of capital accumulation and high estimates of the contribution of labor accumulation to the economic growth. In growth accounting, this drawback is partially avoided because it works with average values for the whole period.

Thus, given the drawbacks of the regression method, the usually preferred approach to TFP estimation is the non-econometric growth accounting exemplified in the previous chapter.

Now, finally the growth accounting equation for transitive economies of Central and Eastern Europe for 1989 – 1999 on, the example, of the Czech Republic (and Slovakia, where possible) can be presented. The following are the empirical numbers based on previous chapters.

For the period of 1989 – 1999 in the Czech Republic (α and β calculated for 1992 – 1997, capital stock 1991 – 1999):

$\Delta\%Y$ = -0.24 % per year (from EBRD Transition Report, 1999),

$\Delta\%K$ = -3.84 % per year,

$\Delta\%L$ = -0.959 % per year,

$\alpha = 0.388$, $\beta = 0.612$.

Then, the Czech growth accounting equation is $\Delta\%Y = \Delta\%A + 0.388 \cdot \Delta\%K + 0.612 \cdot \Delta\%L$. Applying the growth equation to the above data gives

$$-0.24\% = \Delta\%A + 0.388 \cdot (-3.84\ \%) + 0.612 \cdot (-0.959\ \%)$$

$$\Delta\%A = -0.24\ \% + 2.08\ \% = 1.84\ \%$$

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17) Another already mentioned fact is that a key assumption in growth accounting exercise is that factor prices coincide with marginal products. If this assumption is violated, then the estimated value of TFP deviates from the true contribution of technical change to economic growth.

We see that according to the changes in labor and capital stock, the average economic annual growth should have fallen down by 2.12 % annually, i.e. even more than it actually decreased during the first 11 transitive years. Therefore, L and K more than explain the transformation growth decline in the Czech Republic. Thanks to the Solow residual ($\Delta\%A$), it went down only by 0.24 %. Hence, there must have been some structural forces (liberalization both in industry and politics, inflation reduction, infrastructure improvements, lowering of the government role on total outlays, etc.) that have helped the Czech economy to register – comparatively to drastic negative changes in labor and capital stock – only a relatively small decrease in GDP growth. Thus, studying the role of these variables in effecting the economic performance during transition makes a very good sense and is very desirable (see Jaroš, 2001).

As mentioned in Chapter 3, it is advisable to try to use a few different values of α and β because their measurement is always somewhat uncertain. Therefore, I ran the same procedure with α being 0.2 and β being 0.8 and ended up with the following TFP result:

$$\Delta\%A = -0.24\ \% + 1.54\ \% = 1.\ 295\ \%$$

Hence, decreasing the role of capital stock will decrease the total factor productivity, but it still stays very substantial and plays the most prominent role in helping understand why the annual average transition economic growth fell only so marginally.[18)]

However, we are unable to come up with a conclusion that certain percentage of the average growth rate cannot be accounted for by growth in inputs and must be attributed to other causes (TFP). It highlights one weakness in the analytical framework of growth accounting – that it is designed for a long-term analysis and may become a little unclear in assigning a specific explanation power of the Solow residual when there are large short run negative adjustments.

But, as we explained earlier, a failure to incorporate improvements in labor and capital quality as well as a probable increase in hours worked in transition results in an overestimation of the Solow residual. Therefore, the extremely high role of the residual calculated above will in reality be a little lowered by these quality improvements as, for example, the compatibility of study plans at the Czech schools have changed drastically from outmoded and inapplicable communist teaching materials to those resembling more a modern Western European style. The same would hold true for the capital stock as well, as the fossil equipment of old state monopolies is gradually being replaced by newer machines.

As for Slovakia, we get the following growth accounting formula:

$$0.7\ \% = \Delta\%A + 0.294 \cdot (-1.37\ \%) + 0.706 \cdot (-2.0\ \%)$$

$$\Delta\%A = -0.7\ \% + 1.823\ \% = 2.515\ \%$$

Thus, it can be seen that if the judgment would only rely on the considerable declines in labor and capital stocks, drastic decreases in economic growth rate would be expected. However, thanks to the technological change (residual), Slovakia registered average GDP transition growth of 0.7 % (see EBRD Transition Report,

18) Just for completeness, if we ran the procedure with usually used values 0.3 and 0.7, TFP would equal 1.58 %, still a very high figure. If we used employment average for 1991 – 1999, to be consistent with capital stock data period, and multiplied it by actual α and β, TFP would reach 1.64 %. If we apply the average of labor force changes instead of employment changes with actual α and β, we will get a TFP of 1.27.

1999). Therefore, structural forces had to play extremely important role in Slovakia as well. After summarizing growth accounting results, an alternative method of calculation of coefficients proposed above, namely regression analysis, will be explained.

Equation 2 (1991 – 1999, Czech Republic)

	Coefficient	Stand. Dev.	*t*-value	*P*-value		
Intercept	**1.45**	1.018	1.43	0.2036	# of obser	9
Labor	**0.99**	0.45	2.22	0.0684	R^2	78 %
Capital	**0.29**	0.087	3.34	0.0157		

The model is statistically significant (labor on 90% level of significance), which is even more striking taking into account the extremely low number of observations. The intercept is almost identical with TFP calculated by ordinary growth accounting method (1.88 vs. 1.45) and the coefficients of labor and capital can also be more-or-less called very similar (0.612 vs. 0.99 and 0.388 vs. 0.29).[19] These results reconfirm that the growth accounting equation's empirical results seem to be correct.[20]

Equation 3 (1992 – 1999, Czech Republic, K_{t-1})

	Coefficient	Stand. Dev.	*t*-value	*P*-value		
Intercept	**1.69**	0.95	1.79	0.134	# of obser	8
Labor	**0.22**	0.49	0.44	0.675	R^2	54 %
Capital $_{t-1}$	**0.17**	0.086	2.00	0.101		

Since it is theoretically assumed that what influences current economic growth is more K_{t-1} than K, the author also ran the same regression analysis with K_{t-1}. However, the results are not good and definitely not better than with current K. R^2 is smaller, coefficients are not significant and the absolute value of coefficients also seems to be out of reasonable range. In case of Slovakia, there are not satisfactory results in this respect with K_{t-1} either. Thus, it seems that during the first years of transition, there is a more direct and faster relationship between capital stock and economic growth.

Growth accounting formula gives better results than regression analysis in Slovakian case as well. The results of regression do not show statistically significant estimates of α and β and R^2 is low (not shown).[21] However, if labor, capital stock and GDP growth rate data are combined for both countries, quite meaningful results are obtained. Coefficients are significant at 90% level, and more-or-less resemble empirical estimates of α and β from growth accounting equations, even though la-

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19) We see that in case of the regression analysis, the sum of α and β does not equal 1, but shows signs of slightly increasing returns to scale.

20) As noted in the previous part of the paper, one of the drawbacks of regression analysis is an underestimation of the contribution of capital accumulation and overestimation of the contribution of labor to economic growth. It is exactly what happened in our calculation as well – α calculated from regression (0.29) is lower than the usually assumed 0.4 for developing economies and β (0.99) is higher than assumed 0.6.

21) It can be possibly explained by worse availability of data for Slovakia than for the Czech Republic (for example, the author could only obtain one depreciation estimate for 1993 – 1999 period and one estimate of α and β.

bor coefficient is somewhat lower than estimates of α for both the Czech Republic and Slovakia and the sum of α and β shows decreasing returns to scale.

Equation 4 (1991-1999, Czech Republic and Slovakia combined)

	Coefficient	Stand. Dev.	*t*-value	*P*-value
Intercept	**1.51**	0.97	1.55	0.141
Labor	**0.47**	0.29	1.58	0.098
Capital	**0.27**	0.08	3.24	0.006

# of obser	18
R^2	66 %

*

Growth accounting concentrates on dividing the sources of growth between the contribution of increases in the quantity of the factor inputs and the efficiency with which they are used. The main focus is on obtaining quantity series for each input, which when multiplied by the inputs' weights yield their contributions to changes in output. However, since there are no capital stock data series for transitive economies, the primary task of this paper was to estimate the macroeconomic depreciation rate and then to produce unique capital stock series, which could be used in growth accounting exercise.

The residual term (Solow residual, TFP or technological progress factor) is extremely high in case of both the Czech Republic and Slovakia. Actually, it is the main force that prevented economic growth from falling much stronger in the Czech Republic and even turned negative growth rates of the capital stock and labor into positive economic growth in Slovakia. The regression analysis only confirmed that the estimation of shares of income going to capital and labor yielded meaningful results.

Therefore, it is of the utmost interest of transitive economies of Central and Eastern Europe to keep TFP as high as possible also in the future. Since the residual term can be explained in terms of R&D outlays and technological change promoting public policies, governments should pay attention to supporting this kind of policies. At the moment, it seems quite the opposite is occurring, represented by phenomena like brain drain and the escape of high quality academic workers to the business sphere.

In general, growth accounting is viewed as a preliminary step for the analysis of fundamental and more ultimate determinants of economic growth. It is so because growth accounting is only an accounting framework in which the efficiency component is obtained as a residual.

As Bosworth (1995) notes it was high rates of factor accumulation that largely accounted for the rapid growth of the East Asian countries, while gains in TFP represented only for 20 % of the growth in output per worker. On the contrary, former centrally planned economies of Central and Eastern Europe seem to profit much more from total factor productivity gains.

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