

# Economic Growth and Transition: 'D-i-D' Approach

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## Abstract

In this report, we examine the structure of economic growth in centrally planned economy and a market economy. In order to do this, we decompose the economic growth of the Czech Republic and Austria between 1970 and 2016 to get both time and spatial comparison. We use growth accounting techniques and augmented Solow model with human capital by Mankiw, Romer and Weil. The analysis fails to fully prove our expectations, but it indicates a strong role of human capital in development and transition.

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# 1 Introduction

This paper intends to examine the macroeconomic differences between a centrally planned economy and a capitalist economy. In particular, we turn the attention to the economic growth. The question central to this report is whether there exist significant differences in the structure of economic growth spanning over both space and time.

In order to get a reliable comparison, we estimate the growth characteristics of two countries, Czech Republic and Austria, in the period between 1970 and 2016. Therefore, we get a twofold comparison: The time dimension is the Czech Socialist Republic, which existed until 1990, when the centrally planned economy was replaced by a capitalist, market-oriented system. The question here is whether the characteristics of growth evince significantly different patterns before and after the year of so called ‘Velvet Revolution’ of 1989.

The spatial dimension lies in the comparison of the Czech Republic with a neighboring country, Austria. This country was chosen as a ‘control group’ for its geographical and historical proximity as well as for the fact that Austria’s economy is of the same size as the Czech one. What makes the difference, however, is that after the communist coup in 1948, a Soviet-style centrally planned economy was implemented in Czechoslovakia.

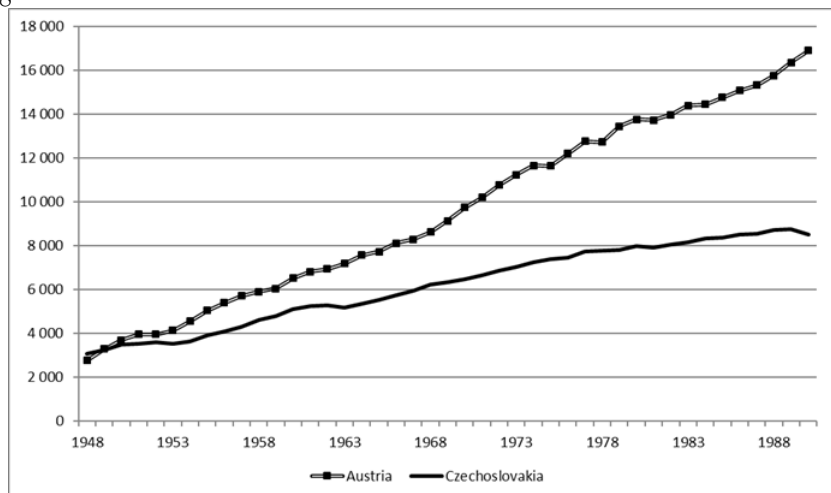
The report consists of 6 parts. In the first one, the transition and the differences between a centrally planned and market economies are described generally. The second part introduces and summarizes the data and comments on the development of the time series. In section 3, based on a literature review, we discuss the approaches that have been used for similar types of analyses and give reasons for the methodology we employ in this study. Section 4 applies this methodology on a particular model and the results are discussed in section 5. Section 6 concludes.

## 2 Development of the Czech(oslovak) economy

The communists took control of Czechoslovakia in 1948. At that time, the GDP per capita was on a level comparable to or even higher than in its close neighbor, Austria. The communists immediately introduced a centrally planned economic system and nationalized a vast majority of the economy. Economic results in the first years seemed to be positive and the economy achieved high rates of economic growth, but the results worsened with time and average growth of social product in the 1980s was just 1.8% per year. The economy permanently lagged behind the developed countries. See Figure 1 for comparison with Austria.

All centrally planned economies were inherently prone to grow extensively rather than intensively. There were relatively many free resources at the beginning of the communist era and they contributed to high economic growth. But these new resources were naturally diminishing as time progressed and so was the economic growth. There were multiple reasons for the prevalence of the extensive character of growth lay in the very basis of the functioning of the system

Figure 1: GDP pc, Czechoslovakia and Austria (dollars). Source: Maddison, 2008

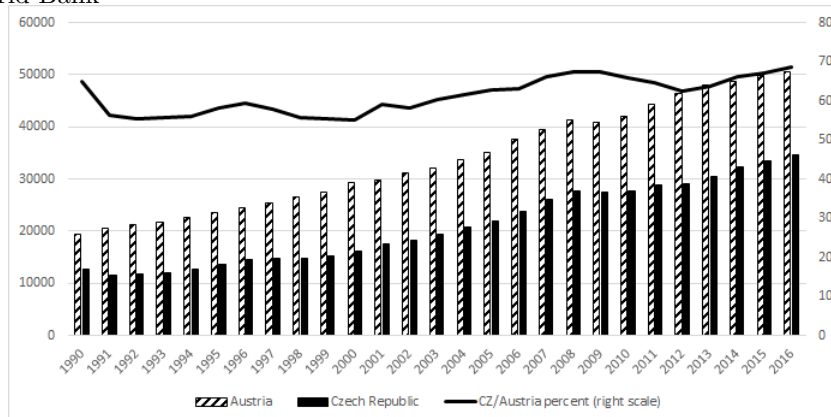


– it lacked competitive pressure (Roemer 1994) typical for the capitalist system; the structure of the economy was monopolistic (Průcha 1988). The system did not support economic initiative partly because of the state ownership, but on the contrary, in practice it encouraged companies to seek input maximization and output minimization (Mlčoch 1990). The central planners were aware of the character of economic growth and the omnipresent goal was to change the character of economic growth to an intensive one. The system was never able to achieve this goal even though there were several attempts for reforms (1950s, 1960s, beginning of the 1980s).

The communist regime fell at the end of the 1980s. It was followed by economic transformation back to the market economy. The reformers decided for quick reforms – often referred to as a shock therapy. The main steps embraced price liberalization, trade liberalization, devaluation, introduction of inner convertibility of Czechoslovak crown, elimination of subsidies and application of restrictive fiscal and monetary policies. These reforms were followed by broad privatization process. The main goal of the reforms was to improve the efficiency of the whole economic system and generally to increase the long-run growth capability. However, the short-run consequence was economic recession. The Czechoslovak economy slumped by 15% on cumulative bases. The economy started to recover in 1993 (in the same year the country split to the Czech and Slovak Republics), but strong economic growth that followed was interrupted by currency crisis in 1997 which resulted in a two-year economic decline. The consequent period of economic growth lasted until the great recession in 2008.

There are good reasons to expect that the character of economic growth has changed in the transformation period. The reasons are multiple – privatization process increased motivation of the market participants on the efficiency of the individual companies. Private companies were motivated to seek profit opportunities and profit generally became a criterion. Abolishing the policy of wage

Figure 2: GDP pc, Austria, Czech Republic and percentage share. Source: World Bank



leveling contributed to the increase of motivation of the personal level. Government ceased to provide subsidies to inefficient companies which were allowed to bankrupt. De-monopolisation increased competitive pressures in the domestic economy. And these pressures were deepened by integration to the world markets. The inflow of foreign capital helped to overcome the technological, capital and managerial gaps and increased the efficiency of individual companies. All market participants had a chance to increase the knowledge by learning by doing process or generally by replicating efficient and profitable process from developed countries.

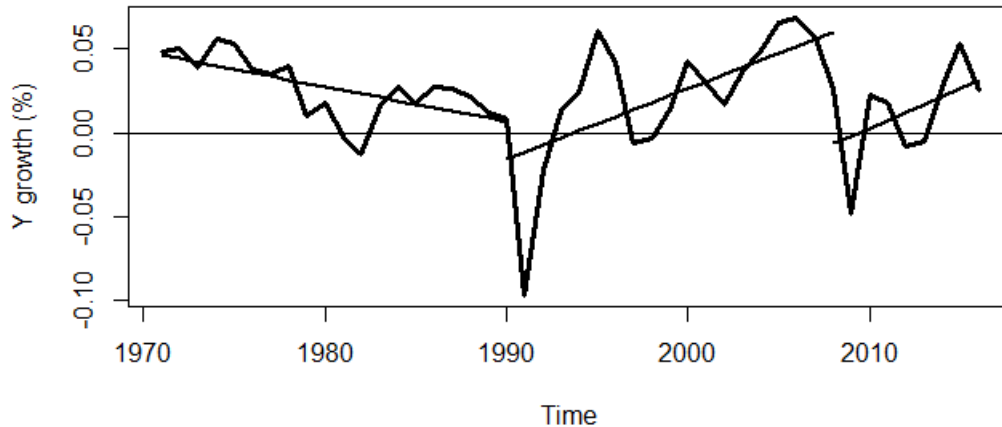
The overall trend of economic growth means that gap in the GDP per capita between Austria and Czech Republic is not deepening and after overcoming the consequences of the recession in 1998 Czech economy is slowly converging towards Austria

### 3 Data

The methodology introduced below is being applied on a unique dataset assembled by economists from the University of Economics in Prague. This dataset comprises the yearly time series estimates of Czech GDP between the years 1970 and 1990. The uniqueness of these data lies in the fact that the macroeconomic time series of the post-communist countries usually start (at best) in 1990, that is, after the totalitarian regime was overthrown. For detailed methodology of estimating the data, see Sixta, Vltavská, Fischer (2013) and Sixta et al. (2016).

Concerning the rest of the data, that is the Czech Republic after 1990 and Austria through the whole period, these are yearly data from the World Bank (capital), OECD (labor) and UNESCO (human capital). The capital is measured as gross capital formation (like in the dataset for Czech Republic between 1970 and 1990). The labor is measured as labor force, that is, the number of people who are currently working or actively seeking job and ready to work.

Figure 3: Czech Republic: GDP growth

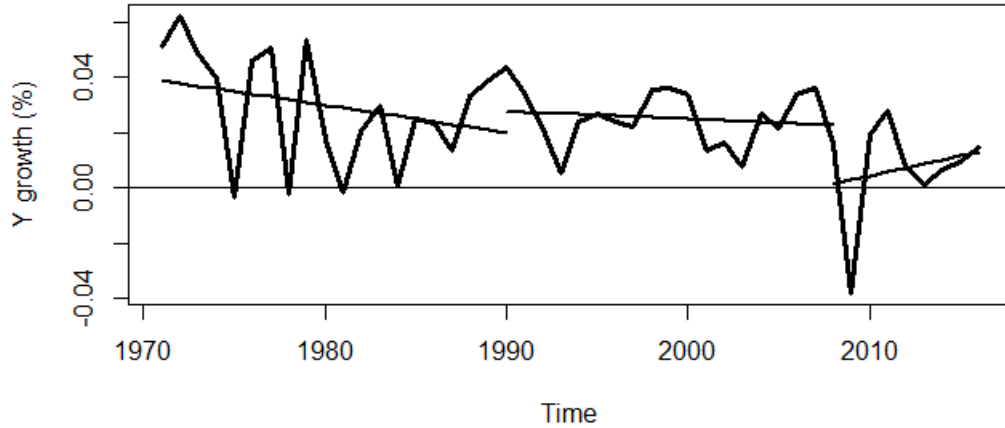


Therefore, this variable is measured in persons. As the last variable, human capital, we take the number of people enrolled in tertiary education. Unlike other studies (Mankiw, Romer, Weil, 1992; Islam, 1995; Gerry, Lee, Mickiewicz, 2010), that used the enrollment rates in secondary education, we decided for the tertiary education as it is usually more specialized, and thus is more reasonable to consider it a distinct production factor. Moreover, the tertiary education underwent the most significant boom among the stages of education after the transition to the market economy. In further research, we intend to study the effects of this boom in more detail.

In Figure 3, we see the growth rates of Czech GDP. At the beginning of the period, the economy performed quite well, however, the growth rates were constantly decreasing. It is obvious that at the end of the 90's, the economy almost converged to its steady state (in the context of neoclassical growth theory). After the Velvet Revolution, Czechia underwent a (relatively short) transformation recession and started to grow significantly. The financial crisis of 2008 caught the economy in a phase of an enviable boom. Therefore, we cannot talk about getting any closer to a new steady state after the transition to market economy.

Figure 4 tells us a different story. As expected, there is no structural break in 1990 apparent from the data. It rather seems as if the economy was slowly getting closer to its steady state. Before reaching it, however, it was hit by the same exogenous shock like the Czech economy, after which it started to recover as well.

Figure 4: Austria: GDP growth



## 4 Methods

To describe the economic growth reached in both of the countries, we use an adjusted methodology developed by Jiří Mihola and his co-authors from Prague's University of Finance and Administration in Prague (references). The core of this methodology lies in computing dynamic growth parameters that break the overall growth into its intensive and extensive parts. We further develop this approach by applying it on the Solow-Swan model in intensive form and, more importantly, on the augmented Solow-Swan model by Mankiw, Romer and Weil. These parameters decompose the growth and allow us to compute the share which each of the factors has on the overall growth.

In 1992, in their seminal article *A contribution to the empirics of economic growth*, Gregory Mankiw, David Romer and David Weil introduced a developed version of the basic Solow model by adding human capital to the production function. Estimating the model on a cross-section of dozens of countries, they concluded that the augmented model predicts the parameter values considerably better than the original model. However, as it is the case of many other studies, their dataset did not include the countries of the former Soviet Union. We decided to use this model in the present study since it harmonizes relative simplicity and satisfactory results.

The question is, however, whether this production function is relevant for our purposes. With little doubt, we can assume that Austrian economy can be described by the standard Cobb-Douglas function as we are dealing with a typical example of small Western market economy and uncountable studies have used this assumption before. Moreover, if a small open economy of Western type can be described by the Cobb-Douglas function, then the market period

of the Czech economy can be described by this function too. The reason is that unlike many other countries, where the transition lasted for many years (Bulgaria, Romania), is still under way (Ukraine) or never occurred (Belarus) (Roland, 2000), the Czech Republic adopted a shock-therapy type of reform and became one of the quickest and most successful transformers. Therefore, after 1990, we can consider Czech economy to be similar in nature to the Austrian one.

The use of the Cobb-Douglas production function for the centrally planned economy (CPE) is more problematic. The assumption of this function, that the elasticity of substitution is constant and equal to one, cannot be taken for granted. Nevertheless, and perhaps surprisingly, there are several studies asserting that this kind of function is relevant for CPE too. Erkin Bairam (1991) used the maximum likelihood methods to estimate the structural parameters of the CES function in order to find out the best functional form of the production function relevant for several branches of the Soviet industry and also the economy as a whole. He concluded that the elasticity is approximately equal to one and therefore the use of Cobb-Douglas function is well-grounded. Whitesell (1985) compared the general CES and simplified Cobb-Douglas function for multiple CPE's, including former Czechoslovakia. The conclusion is similar to Bairam's: The latter is apt for the description of the economic growth in centrally planned Eastern European countries. Brada (1989) also used the Cobb-Douglas function to compare the economic performance in several countries of the former Eastern bloc. Finally, multiple studies that applied this kind of function on a cross-section/panel of countries (Mankiw, Romer, Weil, 1992; Benhabib, Spiegel, 1994 ; Islam, 1995), assumed it to be relevant for all the countries included. Many of these countries (perhaps even majority) cannot be considered more similar to the Western type of market economy than the Eastern European countries. Based on all these arguments, we consider the use of this kind of function apt for our purposes.

Our primary methodological approach here is growth accounting. Since we are not aware of any study that would use this 'D-i-D' approach and this is an attempt for a pioneering study the results of which are intended to be extended, we do not delve into more complex econometric techniques (although they are present at the background). The results of a growth accounting exercise cannot give us the fundamental determinants of growth since it does not give causal bonds. However, it allows us to find out the structure of growth, which is the first step to take on the ladder to deeper understanding of growth in transition.

In Figure 5 and Figure 6, we can see the development of the three observable production factors in question. It is obvious that in the case of Czech Republic, the values are much more volatile than their Austrian counterparts. The sharp fall of the labor force in Czech Republic at the beginning of transition is especially notable. It is interesting in the light of the fact that in other countries, it was usually the capital stock that was falling (Russia, Ukraine). On the other hand, the factors in Austria grow in a very stable way.

Figure 5: Czech Republic: GDP and production factors (standardized)

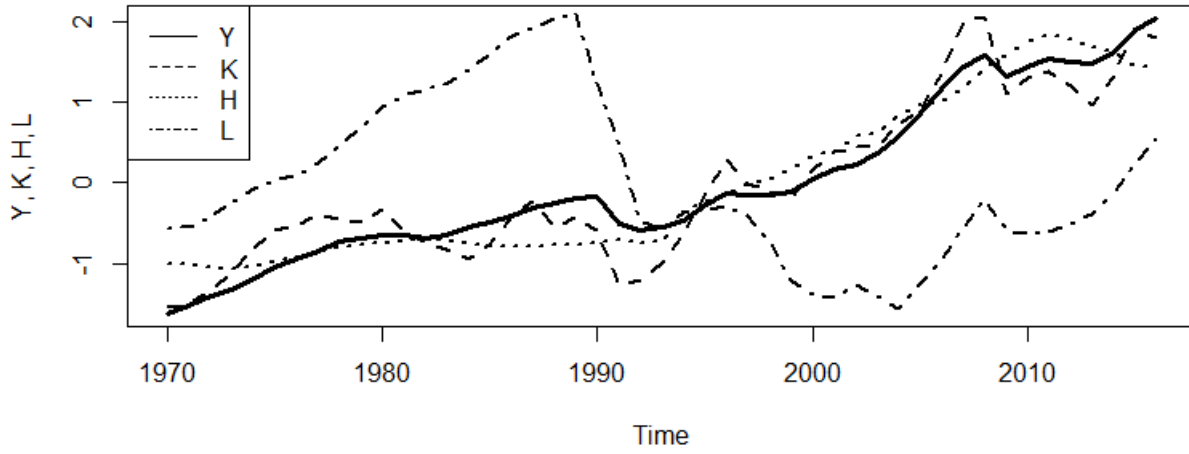
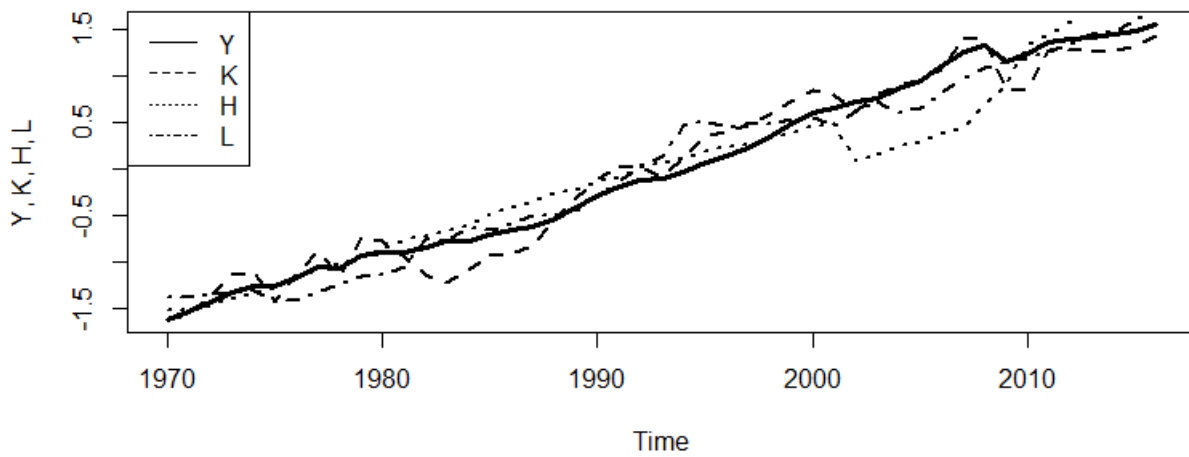


Figure 6: Austria: GDP and production factors (standardized)





## 5 Model

Unlike many other studies that assumed that the economy can be described with the Cobb-Douglas production function with capital and labor as production factors, we employ the production function with human capital in labor-augmenting form. From this function, we are able to derive the standard dynamic parameters for capital, labor and residual/TFP plus the new parameter measuring the share of human capital on overall growth.

The basic production function is

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta} \quad (\text{the basic model}) \quad (1)$$

where K is capital, H is human capital, A is TFP and L is labor. This relationship is valid for every time period. Therefore, we can divide the variables by their lagged values:

$$\frac{Y_t}{Y_{t-1}} = \left(\frac{K_t}{K_{t-1}}\right)^\alpha \left(\frac{H_t}{H_{t-1}}\right)^\beta \left(\frac{A_t L_t}{A_{t-1} L_{t-1}}\right)^{1-\alpha-\beta} \quad (2)$$

Taking logs, we get

$$\begin{aligned} \ln \frac{Y_t}{Y_{t-1}} &= \alpha \ln \left(\frac{K_t}{K_{t-1}}\right) + \beta \ln \left(\frac{H_t}{H_{t-1}}\right) + (1-\alpha-\beta) \ln \left(\frac{L_t}{L_{t-1}}\right) \\ &\quad + (1-\alpha-\beta) \ln \left(\frac{A_t}{A_{t-1}}\right) \end{aligned} \quad (3)$$

The overall change has been divided into components. To get the share of each component on the overall change, we take a ratio of each of them and the overall difference. The denominator is put into absolute values.

$$k = \frac{\alpha \ln I(K_t)}{Y_{abs}} \quad (\text{share of capital}) \quad (4)$$

$$l = \frac{(1-\alpha-\beta) \ln I(L_t)}{Y_{abs}} \quad (\text{share of labor}) \quad (5)$$

$$h = \frac{\beta \ln I(H_t)}{Y_{abs}} \quad (\text{share of human capital}) \quad (6)$$

$$i = \frac{(1-\alpha-\beta) \ln I(A_t)}{Y_{abs}} \quad (\text{residual}) \quad (7)$$

where

$$\begin{aligned} I(K_t) &= \frac{K_t}{K_{t-1}}; I(L_t) = \frac{L_t}{L_{t-1}}; I(H_t) = \frac{H_t}{H_{t-1}}; I(A_t) = \frac{A_t}{A_{t-1}} \\ Y_{abs} &= \alpha |\ln I(K_t)| + \beta |\ln I(H_t)| + (1-\alpha-\beta)(|\ln I(A_t)| + |\ln I(L_t)|) \\ 1 &= |k| + |l| + |h| + |i| \end{aligned}$$

By definition, the sum of absolute values of the dynamic parameters must be equal to unity. We pose the following expectation on the parameters - first, the share of the 'extensive' factors, that is, capital and labor, to be higher in Czech Republic on average than in Austria. The reason is that the less developed economies usually produce more thanks to employing higher amounts of 'crude' inputs - they grow extensively, possibly at the expense of 'intensive' growth. For example, as reported in Elias (1990), the fractions of capital, labor and TFP in Venezuela, a socialist economy, between 1940 and 1990 were 57/40/2. On the other hand, for Germany between 1947 and 1995, the same rates were 48/3/49 (Christenson, Cummings, Jorgenson, 1980; Jorgenson, Yip, 2001). Second, we expect the share of human capital to be higher in Austria than in the Czech Republic. And third, we expect the ratios of both countries to converge after 1990.

The final step we have to make before proceeding to the results is the calibration of the parameters  $\alpha$  and  $\beta$ . The usual practice is to set alpha as the share of capital on the total production. However, this derivation is based on the assumption, that the production factors are paid their marginal products, which is an situation occuring at competitive markets. Apparently, this is an assumption that cannot hold for centrally planned economy. Nevertheless, at first, we will use the result of Mankiw, Romer and Weil for both countries and time periods ( $\alpha = \beta = 1/3$ ). Later on, we will conduct a 'sensitivity analysis' of the results with different values of the parameters.

## 6 Results

Table 1 contains the averages of dynamic parameters (their absolute values) over the two time periods in question (which were divided into 4 decades and the values after 2011 were omitted). Figures 7 and 8 capture the development of growth shares over the whole period. The results partly live up to the expectations: In every decade, the share of capital was higher in Czech Republic than in Austria. The opposite is true for human capital, which is also in line with our expectations. On the other hand, the other extensive factor, labor, was higher in Austria in 3 out of 4 decades (the 4th is roughly equal) and has been steadily rising. The shares of the residual/TFP are roughly the same.

The third expectation, a significant structural break in czech economy and continuous development in Austria, is partly confirmed by the data, but partly is not. Taking the values for the first and second two deacades (Table 2), the difference in capital's share is practically the same: 10 percentage points. Therefore, the fall of the share of capital cannot be ascribed to a sole transition from CPE to a market one. The difference in labor shares is more spurious since its rise in Austria was significant after 1990. This fact can have roots is various, but again, our hypothesis that the difference in values will be higher in the Czech Republic has not been confirmed. (mrknout na výsledky jiných zemí ohledně růstu práce) Regarding human capital, the results live up to the expectations. The difference for the Czech Republic is 10 percentage points while the shares in Austria stay the same. The last parameter, TFP stays approximately the same in both countries.

Figure 7: Growth structure: Czech Republic

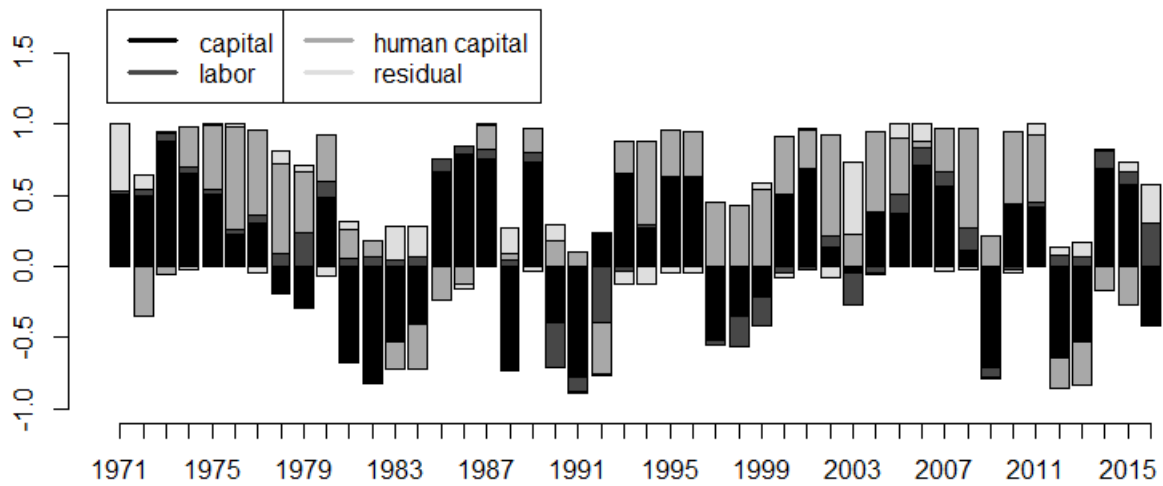


Figure 8: Growth decomposition: Austria

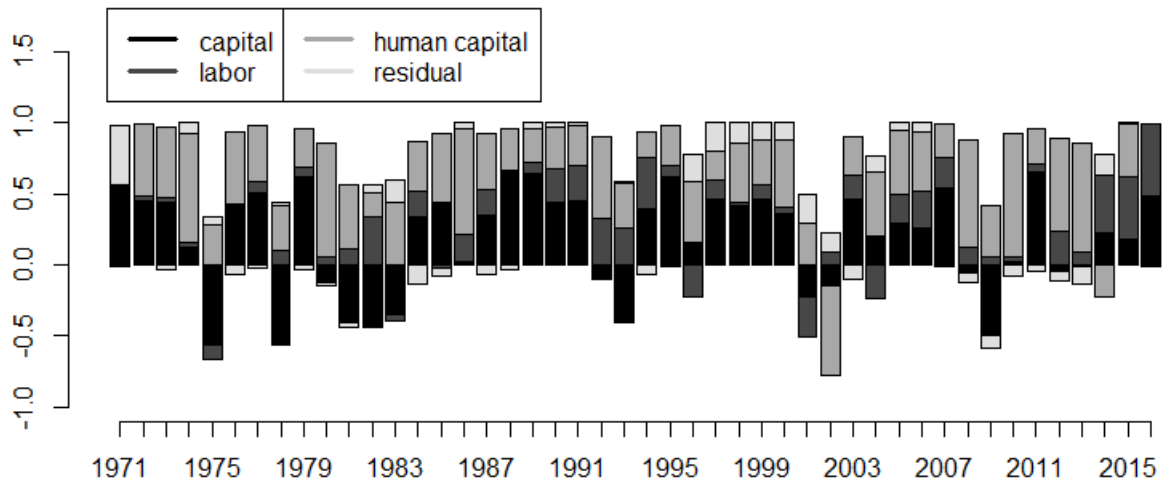


Table 1: Comparison (for  $\alpha = \beta = 1/3$ )

Czech Republic				Austria				
1970-80	81-90	91-00	01-10	1970-80	81-90	91-00	01-10	
<b>k</b>	45.325	64.921	47.683	<b>k</b>	43.751	40.884	38.336	27.006
<b>l</b>	7.305	8.642	10.660	<b>l</b>	5.418	13.853	18.086	16.619
<b>h</b>	38.414	17.634	37.639	<b>h</b>	43.416	38.616	34.572	47.390
<b>i</b>	8.957	8.804	4.018	<b>i</b>	7.416	6.647	9.006	8.986

Table 2: Comparison (for  $\alpha = \beta = 1/3$ )

Czech Republic		Austria			
1970-90	91-10	1971-90	90-10		
<b>k</b>	55.123	44.639	<b>k</b> 42.318	32.671	
<b>l</b>	7.973	10.337	<b>l</b>	9.635	17.353
<b>h</b>	28.024	38.441	<b>h</b>	41.016	40.981
<b>i</b>	8.880	6.584	<b>i</b>	7.031	8.996
	100%	100%		100%	100%

To sum it up, the results obtained from the basic model confirmed the hypothesis that the shares of physical and human capital will be higher in Czech Republic than in Austria and, in case of human capital, there values will converge after 1990. However, there is no convergence regarding the share of physical capital and the proportion of labor.

More importantly, the question is the sensitivity of the results to the values of  $\alpha$  and  $\beta$ . For example, setting the values to  $2/5$  and  $1/5$  respectively yields results summarized in Tables 3 and 4.

Table 3: Comparison (for  $\alpha = 2/5, \beta = 1/5$ )

Czech Republic				Austria				
1970-80	81-90	91-00	01-10	1970-80	81-90	91-00	01-10	
<b>k</b>	56.603	72.006	58.593	<b>k</b>	55.530	52.090	48.976	36.279
<b>l</b>	7.262	7.463	10.538	<b>l</b>	5.305	13.863	18.005	17.470
<b>h</b>	26.881	10.120	24.818	<b>h</b>	30.945	26.578	23.259	37.493
<b>i</b>	9.254	10.411	6.050	<b>i</b>	8.219	7.469	9.760	8.758

Apparently, the results stay the same. Again, the physical capital is higher in Czech Republic and is has declined by roughly 10 percentage points in both countries. We can observe a convergence in human capital and labor share is higher in Austria.

This conclusion holds for other values of other parameters as well. Nev-

Table 4: Comparison (for  $\alpha = 2/5$ ,  $\beta = 1/5$ )

	Czech Republic		Austria	
	1970-90	91-10	1971-90	90-10
<b>k</b>	64.304	55.363	<b>k</b> 53.810	42.627
<b>l</b>	7.363	10.473	<b>l</b> 9.584	17.737
<b>h</b>	18.500	26.713	<b>h</b> 28.762	30.376
<b>i</b>	9.832	7.451	<b>i</b> 7.844	9.259
	100%	100%	100%	100%

ertheless, they hold upon the assumption of identical production function for both countries and both periods of time. This assumption is very common in literature, yet very unrealistic. It can be the case that the Austrian production function has not changed significantly in time, but it most likely has in Czech Republic. It follows that there will be differences between Czech and Austrian production functions. Nevertheless, to relax these assumptions and estimate the production functions more specifically requires the use of non-trivial econometric analysis, which is not the goal of this report and will be conducted in further research.

## 7 Conclusion

In this report, we have used the growth accounting techniques and the augmented Solow model to elaborate on the difference between a centrally planned economy and a market economy. In particular, we decomposed the economic growth observed in these countries. We employed a 'difference-in-differences' approach on a macroeconomic scale - the 'treatment group' (Czech Republic) received a 'treatment' (change of the economic system) in 1990. As a 'control group', we used Austria, that did not receive this 'treatment' (more precisely, received this treatment long time ago). We expected a significant change in the observed indices in Czech Republic and convergence of both countries.

The results partly live up to the expectations - the share of physical capital is higher in Austria, but we observe no convergence. The labor share is unexpectedly higher in Austria. Human capital is the only factor that resulted from the analysis as expected since its values are higher in Austria and we observe convergence. The residual stays low and almost constant.

The analysis did not prove a significant impact of the transition from centrally planned economy to a market one. On the other hand, it indicates the importance of human capital for development. However, the analysis rested upon very strong assumptions, especially that the production function does not change through time and is similar for both countries. We will try to relax these assumptions in further research with the use of econometrics.

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