Analysis of the Nature of Economic Growth of Slovenian Economy

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The aim of this article is to outline the economic growth for the Slovenian economy between 1992–2001. Our major interest is the nature of the past growth. Was it intensive or extensive? On the basis of four groups of different arguments we were expecting that there would be a predominantly extensive economic growth. In order to answer this question we developed an empirical study, which follows the conventional neo-classical growth accounting framework.
First we estimated three mathematical specifications of aggregate production functions. The analysis was than conducted through an econometric analysis of these estimates. Using these results we developed the growth accounting equation, which allowed us to compute the contributions of each particular input (physical capital, human capital and technical progress) to output growth.
On base of our received empirical results we are able to state, that the past economic growth of the Slovenian economy was significantly extensive.

Introduction

In the Slovenian economy from 1990 on there was an intensive process of accepting new concepts of economic actions in the direction from a semi command toward a market economy. This fact raises questions about the nature of economic proceses: production, distribution, export intensity and structural adjustment. The basic process from which all other forms come is production, whose characteristics are described by the aggregate production function.

The comparative empirical analyses of aggregate production functions between developed industrial economies and developing countries, which were made from 1950 till 1990, called attention to the fact that there exist completely different characteristics of the basic production processes on aggregate level between the compared groups of countries. The first group of countries feature an intensive economic growth, while the economic growth in developing countries (second group of economies) is rather extensive.

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After a period of fully ten years, since the transition process in the former centrally planned economies started, the question about the characteristics of the economic growth is also interesting for transition countries. We are especially interested in finding out how successful[1] were the transition economies in using available resources. How did they solve the basic economic problems of scarce resources? Is economic growth in these countries mainly extensive or intensive? Which production factor in this process was more important: physical capital, human capital or the sources of technical progress (Total Factor Productivity – TFP)?

We will find the answers to these questions trough an ex post analysis of the aggregate production function of the Slovenian economy.

Hypothesis

No common answer could be found to the nature of economic growth for transition economies. Therefore, we do not have any common pattern whose validity we could use for testing purposes for the selected economy (Slovenia). But in spite of all that, we can expect a predominantly extensive economic growth.

There are four groups of reasons, which justify our hypothesis:

- The growth rate of gross domestic product in transition economies was on the average higher than in the developed economies (Campos in Corricelli 2002).
- In the transition period this growth was mainly financed through foreign direct investments (Kudina 1999).
- Different national governments tried to reduce the pressure of unemployment and so made greater efforts to increase the use of labor (Blanchard et al. 1992).
- Typical for all economies in transition is the improved educational structure of the population. This has a large influence on the increase of human capital, which is also an important production factor (Jeffries 1993; Ayers et al. 1996; Sjögren 1998; Friere-Seren 2001).

The high economic growth is therefore connected with an intensive use of production factors. But was the use of these resources the main source of growth as we suppose? An empirical analysis will prove the facts.

Methodology

We will examine the characteristics of basic economic processes[2] at the aggregate level with the help of two analytical instruments, which means realizing our empirical research in two steps. First we examined the characteristics of the production process in the Slovenian economy, which can be deduced from econometric estimations of aggregate production functions. In the second step we evaluated the growth accounting equation, which presents how much of the output growth can be attributed to each particular production factor.

If we want to construct the growth accounting equation on the basis of the estimated parameters of aggregate production functions, we have to consider the restriction that the estimated parameters satisfy the conditions of efficiency and structural stability. When analysing these conditions we will use the procedure of statistical inferences. Following these results we can choose the most suitable mathematical specification of aggregate production function for developing the growth accounting equation.

Theoretical Background

AGGREGATE PRODUCTION FUNCTION

The production function defines the technical connection between used inputs (capital, labour) and output. The researcher has to be aware of the fact that using the production function as an analytical instrument bears a decisive influence upon the specification of the variables, from criteria, which have to be fulfilled by the valuation, and from the choice of an adequate mathematical specification.

In our case we shall use the aggregate production function as an instrument of an ex post analysis of the basic economic process at the aggregate level. The definition of variables and mathematical specification of equations must be subordinated to this aim.

Definition of Variables

A theoretical (non-deterministic) specification of the aggregate production function is based on two production factors and the efficiency parameter:

$$Q = f(K, L, A)$$

Symbols:

Q – output,

K – capital,
L – labour,
A – efficiency parameter.

In an ex post analysis we are interested in finding out how many disposable production factors the economy used in the past in order to produce a calculated quantity of gross domestic product. We are therefore calculating the use of production factors and not the disposable capacities. Along with these criteria we also have to consider the restrictions, which are related to disposable empirical data from the national statistics bureau.

Considering these restrictions the discussion in Novak (2003) shows that the series of labour may express the use of human capital, the series of capital payments for investments, and that the efficiency parameter should present Hick's definition of the neutral technical progress. The non-deterministic (common) formulation of the aggregate production function used in our analysis is defined as follows:

$$Q = A \cdot f(INV, HL)$$

Symbols:
Q – gross domestic product,
A – efficiency parameter,
INV – physical capital,
HL – human capital.
Source: own specification.

Mathematical Specification of Aggregate Production Function

Next we have to construct a mathematical (deterministic) specification of the aggregate production function. In economic analysis the Cobb-Douglas production function is often used. This function exhibits constant returns to scale. The partial coefficients of this function are at the same time the elasticity coefficients.

The Cobb-Douglas function:

$$Q = A \cdot K^{\alpha} L^{(1-\alpha)}$$

Symbols:
Q – product,
A – efficiency parameter,
K – capital,
L – labour,
α – elasticity of product with respect to capital,

$(1-\alpha)$ – elasticity of product with respect to labour.
Source: Humphrey (1997, 52).

Beside the Cobb-Douglas specification, the universal form of power function is also used in economic analysis. This form does not exhibit linear homogeneity apriori.

Universal specification of power function:

$$Q = A \cdot K^{\alpha} L^{\beta}$$

Symbols:
Q – product,
A – efficiency parameter,
K – capital,
L – labour,
α – partial elasticity of product with respect to capital,
β – partial elasticity of product with respect to labour.
Source: own specification.

The dilemma occurred with the question about the unitary elasticity of substitution, which is inherent to both the Cobb-Douglas function and universal specification of power function. The group of authors mentioned in the literature as ACMS (Arrow, Chenery, Minhas, and Solow 1961, 225–250) designed the new form of the neo-classical production function – the CES[3] production function.[4]

CES function:

$$Q = A\left[\delta K^{-\psi} + (1-\delta)L^{-\psi}\right]^{\frac{\rho}{-\psi}}$$

Symbols:
Q – product,
A – efficiency parameter,
K – capital,
L – labour,
δ – distributon parameter $(0 \leq \delta \leq 1)$,
ψ – parameter of substitution $(\psi \geq 1)$,
ρ – parameter of homogeneity.
Source: Guarda (2000, 52–53).

The three mathematical specifications described are often subjects of theoretical and empirical analyses and will be therefore used in our empirical research.

Empirical Claims of Estimated Parameters

Consider the fact that the estimation of the aggregate production function is only the starting-point of developing the given study of our empirical work and that our final goal is to construct the growth accounting equation. But which of the presented mathematical specifications can be used further on in the empirical work? This depends on the selected criteria.

Antras (2000, 10–15) mentions three conditions to be fulfilled by the estimated production function when using it in the growth accounting framework.

- The first criterion is connected with the goodness of fit of the estimated regression line.
- The second condition refers to the statistical significance of the partial regression coefficients. As they are the constitutional part of the growth accounting equation, it is recommended that they be statistically significant.
- The third criterion requires that the estimated production function does not contain a statistically significant structural break. The structural stability of the estimated parameters would signify that the role of individual production factors is not different in various periods. Therefore it is acceptable to establish a growth accounting equation for the whole period, because the characteristics of the productions are unique for the whole pattern of observation. According to the content it would be correct to make conclusions about extensive or intensive growth on the basis of results received in this way.

GROWTH ACCOUNTING EQUATION

Having estimated the parameters of selected aggregate production functions we can set up the growth accounting equation. By calculating the parameters of this equation we can analyse the contribution of individual factors to the economic growth as we determine what part of the production growth can be explained by the growth of used human capital, physical capital and what part is attributed to the growth of total factor productivity (TFP). When analysing the contribution of production factors to the economic growth our attention is directed to the changes of the dependent variable in connection with the changes depending on the marginal changes of all explanatory variables. The conventional instrument for this analysis is the mathematical tool of a total differential.

From the specification of the production function $Q = A \cdot f(K, L)$ we can (by mathematical manipulation) set up the growth accounting equation:

$$q = \epsilon_{Q,A} \cdot a + \epsilon_{Q,K} \cdot k + \epsilon_{Q,L} \cdot l$$

Symbols:
q – growth rate of aggregate product,
$\epsilon_{Q,A}, \epsilon_{Q,K}, \epsilon_{Q,L}$ – partial elasticity coefficients,
a – growth rate of total factor productivity,
k – growth rate of capital,
l – growth rate of human capital.
Source: Valdés (1999, 88–90).

Following the neo-classical theory we assume, that the production factors are paid marginal products. Thus we can set up from the growth accounted equation the quantification of the contributions of the individual factor to output growth:

$$\frac{q}{q} \frac{\epsilon_{Q,A} \cdot a}{q} + \frac{\epsilon_{Q,K} \cdot k}{q} + \frac{\epsilon_{Q,L} \cdot l}{q} \Rightarrow$$

$$1 = \frac{\epsilon_{Q,A} \cdot a}{q} + \frac{\epsilon_{Q,K} \cdot k}{q} + \frac{\epsilon_{Q,L} \cdot l}{q}$$

Symbols:
$\epsilon_{Q,A} \cdot a/q$ – contribution of technical progress to output growth,
$\epsilon_{Q,K} \cdot k/q$ – contribution of capital input to output growth,
$\epsilon_{Q,L} \cdot l/q$ – contribution of human capital input to output growth,
Source: Valdés (1999, 88–90).

Results from Econometric Estimation and Analysis

Econometric estimation was made with the help of the Eviews software. With the ordinary least squares estimator we estimated the parameters of Power, Cobb-Douglas and CES specification of the aggregate production functions.

DATA USED

To measure the dependent variable (output) we have chosen the gross domestic product (1995 tolars). Capital is measured by payments for investments (1995 tolars). We have received all data from Statistični urad Republike Slovenije (SURS) and from Agencija Republike Slovenije za plačilni promet (ARSPP). Variable labour was measured in units of effective labour – we calculated the series.[5] The database included 37 observations for the period 1992Q1–2001Q1.

REGRESSION EQUATIONS

The linearized regression equations of the chosen production functions were defined as:

- Power function:
$$\ln(BDP_t) = \ln(b_1) + b_2 \cdot \ln(INV_t) + b_3 \cdot \ln(EFD_t) + \epsilon_t$$
- Cobb-Douglas specification:
$$\ln(BDPefd_t) = \ln(b_1) + b_2 \cdot \ln(INVefd_t) + \epsilon_t$$
- CES function:
$$\ln(BDP_t) = \ln(b_1) + b_2 \cdot \ln(INV_t) + b_3 \cdot \ln(EFD_t) + b_4 \cdot \ln(INVefd2_t) + \epsilon_t$$

Note: The *INVefd* variable is expressed as a quotient between the variables *INV* and *EFD*, the *INVefd2* variable is expressed as the square of the quotient between the variables *INV* and *EFD*.

ECONOMETRIC ANALYSIS

On the basis of results, which are derived from econometric analysis, we can choose the best specification of aggregate production function. We started this analysis with a test of normality assumption. The purpose of the test was to find out if we could continue using the classical statistics (t, F, χ^2) in our econometric analyses. In order to test the hypothesis about distribution of residuals the Jarque-Bera test was used.

Next we checked three assumptions of the classical linear regression model: the lack of autocorrelation, homoscedasticity and the lack of multicollinearity between the explanatory variables included in the regression equation. The test of the autocorrelation was made with the Breusch-Godfrey test. The required homoscedasticity of variance was researched with the White-test and the multicollinearity was analysed by the calculated value of the variance-inflation factor (VIF). The econometric analysis was concluded by testing the fulfilment of two empirical criteria: goodness of fit of the estimated functions (F-test) and test of structural stability of the estimated functions. For analysing structural stability we used the Chow breakpoint test. We focused on the analysis of the *p*-value. The high *p*-value in individual types of the test suggests that we cannot reject zero hypotheses at an acceptable level of significance.

Table 1: Results of econometric estimations and tests

	Power Function	Cobb-Douglas Function	CES Function
Parameter estimates			
$\ln(b_1)$	2.661	0.047	4.146
	(1.999)	(2.244)	(1.734)
	[0.054]	[0.031]	[0.092]
b_2	0.149	0.134	0.345
	(13.677)	(17.181)	(1.622)
	[0.000]	[0.000]	[0.114]
b_3	0.662	...	0.448
	(6.325)		(1.387)
	[0.000]		[0.175]
b_4	...	...	0.011
			(0.750)
			[0.459]
Jarque-Bera test			
LB	1.469	0.616	1.254
	[0.450]	[0.735]	[0.534]
Breusch-Godfrey test			
LM(1)	0.447	0.939	0.114
	(3.841)*	(3.841)*	(3.841)*
LM(2)	0.804	1.150	0.514
	(5.997)*	(5.997)*	(5.997)*
LM(4)	1.199	1.585	1.212
	(9.488)*	(9.488)*	(9.448)*
LM(6)	1.867	2.516	2.098
	(12.592)*	(12.592)*	(12.592)*

RESULTS

On the basis of the results represented in table 1 we can make the following conclusions:

1. For the universal specification of power function and the Cobb-Douglas aggregate production function the estimated parameters are statistically significant. In the case of the CES function the fourth parameter is not statistically significant.
2. On the basis of the Jarque-Bera test statistics we can conclude that the residuals of the estimated equations are normally distributed.
3. In the regression equation the serial correlation is not present.

Table 1 (continued): Results of econometric estimations and tests

	Power Function	Cobb-Douglas Function	CES Function
White test of homoscedasticity			
$n \cdot R^2$	5.545 (11.071)*	3.417 (5.991)*	7,148 (15.507)*
Multicollinearity			
$VIF_{\ln(EFD):\ln(EFD)}$	2.512	...	2.512
$VIF_{\ln(EFD):\ln(INVefd2)}$	...	...	50.253
$EFD_{\ln(EFD):\ln(INVefd2)}$	...	...	1.881
F-*test of adjusted* R²			
R^2_{adj}	0.962 [0.000]	0.879 [0.000]	0.964 [0.000]
Chow test of structural stability			
$p \leq 0.01$	0	0	0
$0.01 < p \leq 0.05$	0	0	0
$0.05 < p \leq 0.10$	0	0	1
$0.10 < p$	29	29	28

Note: the calculated test statistics are mentioned in round brackets. In squared brackets the exact level of significance (p value) is mentioned. Symbol * denotes the critical value of test statistic at the 0.05 level of significance. Source: own calculations.

Therefore, the error term of the regression models does not contain any systematic component. We may expect that the established definitions of the explanatory variables and the choice of statistical data for their measurements are correct.

4. On the basis of the White test we can conclude that there is no heteroscedasticity.
5. Between the variables *INV* and *INVefd2* included in the CES specification of production function there exists a high rate of multicollinearity. Therefore we can explain why the fourth regression coefficient in this function is not statistically significant at an acceptable level of significance. The statement suggests that the CES function does not differ from the Cobb-Douglas function.
6. The values of the determination coefficients show the good analytical power of the specified functions.
7. On the basis of the results obtained from the structural stability test

Table 2: Results of econometric analysis

	Power Function	Cobb-Douglas Function	CES Function
Overall significance of estimated equations	+	+	+
Significance of partial regression coefficients	+	+	–
Structural stability	+	+	+
Linear homogenity restrictions	...	–	...

Note: the symbol + signifies, that the restrictions are fulfilled, and the symbol – that they are not. Source: own calculations.

we may conclude that all estimated aggregate productions functions are structurally stable. The behaviour pattern of the economic subjects did not change. Irrespective of whatever period we might have chosen in our empirical test we would have found that differences might not be statistically significant.

With regard to these criteria we could not carry out a grounded selection between the potentional and Cobb-Douglas specification (for this reason the elimination of the CES function is justified), therefore, we decided to make another test on the characteristics of returns to scale.[6] The results show that inclusions of a priori expectations of constant returns scale, which are inherent to the Cobb-Douglas specification, are not justifiable.

Inferences About the Nature of Economic Growth

The described parameters represent objective criteria for the choice of the most suitable production function, from which we can derive the explanation and the characteristics of the production process in the observed period. The statistically insignificant parameters in the CES function and also the insignificant constant returns to scale in the Cobb-Douglas specification suggest the power function as a suitable production function.

If we were doing further research, on the ground of the hypothesis that we may describe the characteristics of production process with the selected production function, we would have to quantify the growth rates of individual series, which were included in the production function. Here we use the trend growth rates received as a result of econometric estimation of the exponent trend.

The selected results are mentioned in table 3.

Table 3: Data used for developing the growth accounting equation

Trend Growth Rate	$r_{BDP} = 0.010486$	$r_{INV} = 0.039399$	$r_{EFD} = 0.004576$
Partial Elasticity		$\epsilon_{BDP,INV} = 0.149133$	$\epsilon_{BDP,EFD} = 0.661527$

Note: r_{BDP} – trend growth rate of quarterly real gross domestic product (constant prices 1995), r_{INV} – trend growth rate payments for investments (constant prices 1995), r_{EFD} – trend growth rate of effective labour, $\epsilon_{BDP,INV}$ and $\epsilon_{BDP,EFD}$ – coefficient of partial elasticity. Source: own calculations.

Table 4: Contributions of production factors to economic growth

Contribution of physical capital	≈ 56.04%
Contribution of human capital	≈ 28.87%
Contribution of total factor productivity	≈ 15.09%

Source: own calculations.

From the data in the table we can estimate the growth rate of total factor productivity:

$$r_{BDP} = r_A + \epsilon_{BDP,INV} \cdot r_{INV} + \epsilon_{BDP,EFD} \cdot r_{EFD}$$
$$r_A = r_{BDP} - \epsilon_{BDP,INV} \cdot r_{INV} - \epsilon_{BDP,EFD} \cdot r_{EFD}$$
$$r_A = 0.010486 - 0.005876 - 0.003027$$
$$r_A = 0.001583$$

From this we receive all known parameters for writing down the final growth accounting equation:

$$r_{BDP} = r_A + \epsilon_{BDP,INV} \cdot r_{INV} + \epsilon_{BDP,EFD} \cdot r_{EFD}$$
$$0.010486 = 0.001583 + 0.005876 + 0.003027$$

If we want to find out the share part of growth of individual production factors in the explanation of 1,048 percentage of the trend growth rate of gross domestic product, we have to divide the last equation with this growth rate:

$$\frac{0.010486}{0.010486} = \frac{0.001583}{0.010486} + \frac{0.005876}{0.010486} + \frac{0.003027}{0.010486}$$
$$1 = 0.150963 + 0.560366 + 0.288671$$

Conclusion

In this article we presented the results abote empirical analysis of the nature of economic growth of Slovenian economy during the transition period 1992–2001. We were especially interested in finding out how succesful was this economy in using available resources. On the basis of four groups of different arguments we were expecting that there would be a predominantly extensive economic growth. We tested this hypothesis using empirical analysis. In the first step we estimated three mathematical specifications of aggregate production functions. In the second step we made an econometric analysis of these estimates. Using these results we selected the power function and developed the growth accounting equation, which allowed us to compute the contributions of each particular input (physical capital, human capital and technical progress) to output growth.

From the received results it follows that the sixty-five percent of trend growth rate of the real gross domestic product can be explained by the growth of physical capital, by the growth of human capital twenty-nine percent and by the growth of total factor productivity of fifteen percent of growth of the Slovenian gross domestic product.

We can conclude that the past economic growth of the Slovenian economy during the period 1992–2001 was predominantly extensive.

Notes

1. Some aspects of transition in Slovenia are well documented in Bekő (2002) and Žižmond (1994, 1996).
2. We developed our analytical framework on the basis of the following references: Brown 1957, Uzawa 1962, Fisher 1971, Senjur 1993, Thomas 1993, Humphrey 1997, Stiroh 1998, Valdés 1999, Guarda 2000, and Mrkaić 2001.
3. CES = Constant Elasticity of Substitution.
4. CES production function means according to the preliminary one of Cobb-Douglas, which is actually her generalization (Thomas 1993, 304).
5. Analytically the calculation of series effective labour is shown in Novak 2003.
6. This test is not separately mentioned in this paper. The testing procedure and received results are presented in Novak 2003.

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