Production Function, Human Capital and selected Countries of the European Union

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Abstract: - The effect of education was already emphasized by the Classical economists. Comprehensive frameworks of human capital theories appeared in the early Sixties of 20th century. The human capital effect on economic growth and productivity was confirmed by many economic studies in the last two decades. The main aim of this paper is to find out growth effect of human capital in the selected European Union countries during 2000-2010. Augmented standard aggregate production function linking output to productive inputs – labour, physical and human capital and total factor productivity is used according to the new theories of economic growth. Due to shortcoming of observations panel data model was performed. Positive and statistically significant effect of all inputs was found.

Key-Words: economic growth, human capital, national competitiveness, panel data model, production function

1 Introduction

The production function determines the interdependence of input production factors and output. The production function specifies the maximum volume of output which could be produced for a certain time period and for a given amount of inputs and with the combination of inputs.

The aggregate production function describes the relationship of the volume of used input production factors, technological progress and output. The aggregate production function became the core of models of economic growth. The issue of economic growth accompanies economic theory for its whole existence.

In the 20th century we can distinguish two important milestones in the development of the theories of economic growth. Firstly, Forties and Fifties brought Keynesian models of growth followed by the neoclassical models of growth. Solow's model is the best known neoclassical growth model and became the subject of the further research. Assumption that labour is identical in all countries belongs to the contentious issues of Solow's model. This model assumes that education and qualifications are coincident in all countries. Equally qualified labour allows apply the best available technologies to all countries, which is not really true. The poorer countries often have worse educational systems and suffer from a lack of qualified workers, who hinder the use of advanced technologies.

This shortcoming should be removed by including the human capital in the production function, as an additional explanatory variable. The second wave of interest in the issue of growth appeared at the end of Eighties and Nineties. In particular this was reflected by developing models of endogenous growth, which contain human capital, inter alia.

The main aim of this paper is to find out growth effect of human capital in production function. The second goal is accept or reject the hypotheses: the higher the competitiveness of countries at the national level the more powerful effect of human capital in production function can be identified.

The paper is structured as follows. In section 2, we define production function, position and importance of human capital in this function and national competitiveness. In section 3, we introduce and describe the dataset and specify the used methods. In section 4, the obtained results are presented and section 5 concludes.

2 Human capital and competitiveness

Becker [8] defined human capital as skills and adequate motivation to apply these skills. The main premise, which the human capital theory is based on, postulates that education increases the productivity of the individual. Each individual tries to optimize the return on their investment in education and will continue in the study until the rate of return on her investment in education will exceed the rate of returns of alternative investments. The benefit to the society is then the increased labor productivity of better educated members of society and also technological progress. Generally, economists of the 1960's were trying to determine how various factors contribute to economic growth.

2.1 Human capital as a production factor

We distinguish single-factor and two-factor, more precisely multifactor production functions. The single-factor production function expresses the relationship between one variable input used in the production (usually labour) and a range of output. However, two-factor production function is examined and discussed in the economic theory more often. The two-factor production function can be represented graphically by using isoquant. Generally the two-factor production function can be expressed as follows:

$$Y = f(L, K) \tag{1}$$

where Y is the real product, L is the labour and K is the capital.

A Cobb-Douglas production function became a significant and widely used two-factor production function. Its authors belong to representatives of the neoclassical growth theory. Cobb-Douglas production function thus involves two input production factors – labour and capital [9]. Labour and capital are included in the production function in various proportions and combinations, with the possibility of their mutual and unlimited substitution and with a free pricing of production factors depending on the dynamics of labour and capital. In basic expression is constructed the Cobb-Douglas production function so that the production effect of one production factor could be represented by the effect of another [16]:

$$Y = f(A, L^{\alpha}, K^{\beta}) \tag{2}$$

where Y is the real product, A is transformation parameter, L is the labour, K is the physical capital, α is labour elasticity coefficient and β is capital elasticity coefficient. If $\alpha + \beta = 1$, then there are constant returns to scale. The transformation parameter A is a coefficient of the aggregate productivity of production factors, which refers to both factors (also called total factor produktivity). We discover size of the parameters α and β through the statistical methods. For the original production function applied $\alpha + \beta = 1$ and decreasing border labour productivity and decreasing efficiency of capital were assumed.

Human capital as a production factor is included in the new growth theory models. Total product in the endogenous growth models is determined by both physical capital and labor and human capital which is accumulated in through education in every individual. The new growth theory applies the extended Solow's model (3) [16] and production function presented in the following form (4) [6]:

$$Y = A \cdot L^{\alpha} \cdot K^{\beta} \cdot e^{rt} \tag{3}$$

where Y is the real product, A is transformation parameter, L is the labour, K is the physical capital, α is labour elasticity coefficient and β is capital elasticity coefficient and e^{rt} is time factor, which reflects the influence of quantitative changes in production, including technological progress,

$$Y = A_t (L_t)^{1-\alpha-\beta} K_t^{\alpha} H_t^{\beta} \tag{4}$$

where Y is the product, A shows the level of technology, L is the labour, K is the physical capital, H is the human capital, α and β determine the proportions of individual factors on the overall product.

Paul M. Romer, Robert E. Lucas (see [17]) and also Nicholas G. Mankiw, David Romer and David N. Weil [18] contributed significantly to the development of endogenous growth models. Overall, the research in this area confirms the existence of a relationship between the development of education and economic growth. One of the conclusions of endogenous growth models is that economic growth depends partly on the level of human capital. It assumes that human capital is the source of production of new ideas. It is true that the more developed economy, the stronger the relationship of education to the economic growth. While in less developed countries the primary task of starting economic growth nationwide is to ensure primary education, in the developed countries on the other hand is to drive further economic growth primarily on ensuring tertiary education. Romer [20] in his work addresses the issue of differences between the education and experience on the one hand, and technological progress on the other. The main source of economic growth is technological progress, in his opinion. Mankiw, Romer and Weil [18] in their work tried to eliminate shortcomings of the Solow's model by including the human capital expressed as an investment in education. Simplified representation of the value of human capital, respectively identification of human capital investment in education, with the achieved level of education or the number of students in various stages of study, is often a prerequisite in empirical studies examining the human capital at the macroeconomic level.

Barro [4] and others find a strong positive correlation between schooling enrollment and the subsequent growth rate gross domestic product (GDP) per capita. Barro [5] states that the growth of human capital expressed as an average length of education by one year corresponds to an increase of GDP growth by four percentage points a year. Bassanini and Scarpetta [7] states, that their results point to a positive and significant impact of human capital accumulation to output per capita growth. If the average length of study period is ten years, one additional year of study will increase production by six per cent. The existence of correlations between human capital, in this case the number of university graduates, and economic growth in their work was also confirmed by De la Fuente and Donénech [12]. Through that research the need for investment in human capital can be justified.

Nevertheless, there are views that refute or do not confirm the influence of human capital on economic growth. Bils and Klenow [10] in their study do not disprove any correlation between economic growth and human capital. However, they concluded that it is the level of gross domestic product, respectively its growth, leading to a higher level of human capital in the economy. Unlike previous studies on the causality of these variables this one is seen in the reverse order. Söderbom and Teal [23] came to the conclusion that human capital has a small, and not statistically significant effect, on the level of output.

2.2 National competitiveness

Competitiveness is a concept that has become one of the most used and vogue word in today's globalized world. There are lots of experts and institutions which focus on national competitiveness (i.e. competitiveness at macroeconomic level) and attempt to specify determinants and processes that affect national competitiveness. Applying the microeconomic approach, competitiveness can be defined as capability of a country to sell more abroad than it purchases from abroad, i.e. export performance. Ulengin [24] confirms trade balance and market share are insufficient indicators. Scott & Lodge [22] national competitiveness means country's ability to create, produce, distribute, and service products in international trade while earnings rising returns on its resources. However, Porter [19] argues that the only meaningful concept of national competitiveness is national productivity. Boltho [11] explains it as the long-run aim of rising standard of living and Fagerberg [13] extends this approach, it is an ability of an economy to secure a higher standard of living than comparable economies for the present and the future. Aiginger [1] summarizes that defining the competitiveness of nations is a controversial issue.

The well-known international organization dealing with national competitiveness is The World Economic Forum (WEF). WEF (Global Competitiveness Report 2012-2013, GCR) [21] defines competitiveness as the set of institutions, policies, and factors that determine the level of productivity of a country. WEF has published its annual GCR since 1979 which analyzes and evaluates competitiveness.

3 Data and econometric methodology

We employ annual data for selected countries. European Union (EU) countries were selected; more precisely Visegrad Group countries and the most competitive countries of the EU were chosen between 2000 and 2010. The most competitive EU countries according to GCR 2012-2013 are: Finland, Sweden, Netherlands and Germany.

Gross domestic product (GDP) at constant prices (2005) in EUR was used as a proxy variable of real output (Y), total fixed non-financial assets at constant prices (2005) in EUR for physical capital (K), while for human capital (H) the number of tertiary graduates (i.e. ISCED'97 levels 5 and 6) were used. The number of hours worked was employed for labour (L). All of the variables were collected from Eurostat database.

To examine the above mentioned relationship we perform panel data analysis. Panel data (or longitudinal data) cover both a time series and a cross-sectional dimension compared to pure time series or cross-sectional data [25]. Panel data models have become more and more popular among researchers because of their capacity for capturing the complexity of human behavior as contrasted to cross-sectional or time series data models [14]. There is a lot of panel data's benefits, form more information see Klevmarken [15], Hsiao [14] and Baltagi [3].

A panel data set is formulated by a sample that contains N cross-sectional units (individuals, firms, households, countries etc.) that are observed at different time periods T [2], i.e. N = 4 (V4 countries and EU top competitiveness countries) and T = 11 in our case. Simple linear panel data model can be written as (5):

$$y_{it} = \alpha + \beta X'_{it} + u_{it} \quad (5)$$

where y represents the dependent variable, X vector of explanatory variables and subscript i denotes cross-section dimension (countries) whereas t time series dimension (2000-2010), α, β are coefficients and u is a random disturbance term.

In general, three different methods can be used to estimate linear panel data models by means of ordinary least squares: (i) common constant as in equation (5), (ii) fixed effects and (iii) random effects. The common constant method implies that there are no differences among variables of the cross-sectional dimension, so-called homogenous panel. Fixed or random effects allow us to capture the differences among units; hence the random disturbance term u is given by (6):

$$u_{it} = \mu_i + \nu_{it} \quad (6)$$

where μ_i denotes unobservable individual-specific effect which is time-invariant and is responsible for any individual-specific effect that is not contained in the regression. The term ν_{it} denotes remainder disturbance which varies over individuals and time [3], [14]. But the question, which model is more appropriate still remains. For common constant and fixed effect model we can apply standard F-test under the null hypothesis (H_0 thereinafter) that all the constants are the same [2].

In random effect model we assume zero correlation between explanatory variables and the unobserved effect. Hausman test can be employed to find out if this assumption is fulfilled under H_0: random effects are consistent and efficient.

Moreover, it should fulfill the assumptions for standard ordinary least squares error terms, i.e. the remained disturbance is homoskedastic, serially and spatial uncorrelated. In particular, the Cobb-Douglas production function is nonlinear in the parameters; hence we take the natural logarithm of (4) and obtain (7):

$$\begin{aligned} \ln Y &= \ln A_t + (1-\alpha-\beta) \\ &\ln(L_t) + \alpha\ln(K_t) + \beta\ln(H_t) + \mu_i + \nu_{it} \end{aligned} \quad (7)$$

4 Empirical results

In this section we present and discuss the results from Cobb-Douglas production function with human capital in the case of Visegrad countries and the EU top competitiveness countries. At first we estimate step by step all three models by means of least squares method. According to above mentioned tests the fixed effect model seems to be the most appropriate model to identify the effect of labour, physical and human capital on real product.

The coefficient of determination (R^2) = 0.99 in both cases. The regression model and coefficients are statistically significant at 5 % level. The remained disturbance ν_{it} fulfills the mentioned assumptions.

After estimation equation (7), anti-log, then we get common equation (8) for Visegrad group countries (V4) and common equation (9) for the EU top competitiveness countries (EUTC).

$$Y_{V4} = 1174924821(L_t)^{0..48}(K_t)^{1.26}(H_t)^{0.14}\nu_{it} \quad (8)$$

$$Y_{EUTC} = 18463752(L_t)^{1.03}(K_t)^{0.66}(H_t)^{0.11}\nu_{it} \quad (9)$$

The unobservable country-specific effect μ_{it} is represented by changes in the intercept in Table 1.

Table 1 – Deviation from intercept

Equation 8		Equation 9	
Country	Deviation	Country	Deviation
Czech Republic	228907913	Germany	-47670411
Hungary	18048943	Finland	10327672
Poland	-33243180	Netherlands	-883714
Slovakia	-593169237	Sweden	7299884

Source: own calculations

The estimated coefficients and signs are in accordance with expectations. The intercepts (including deviations) represent total factor productivity. They differ across countries (as you can see in table 1), because they include, e.g. technology, resources, climate and institutions. If we increase worked hours in V4 countries by 1 %, output (gross domestic product) goes up by about 0.48 %, holding the other inputs constant, whereas in the EU top competitiveness countries it will increase more than 1 per cent. Capital stock and human capital influence the output more in V4 countries than in the EU top competitiveness countries. On the contrary, labour input affect the output more in EUTC rather than V4 countries. According to equations (8) and (9) we should reject the main hypotheses of more powerful effect of human capital in more competitiveness countries. Nevertheless, the variable hours worked (L) incorporates hours worked of all of the education groups including tertiary graduates. However, the indicator of tertiary graduates implies only the number of labour at the current level of education but nothing about its efficiency during the production process.

5 Conclusion

The main aim of this paper was to find out the growth effect of human capital in the selected Eureopean Union countries and then accept or reject the hypotheses: the higher the competitiveness of countries at the national level the more powerful effect of human capital in production function can be identified.

The augmented Cobb-Douglas production function was used. It expresses relations among inputs and output. Annual data of Visegrad group countries and the EU top competitiveness during 2000-2010 were employed. Gross domestic product for output, total fixed non-financial assets for physical capital, the number of tertiary graduates for human capital and hours worked for labour input.

The panel data analysis was conducted to examine that relationship. Fixed effect method was chosen as the most appropriate where total factor productivity differs across countries. The positive ling among inputs and outputs was confirmed for both groups of countries. We should reject the hypotheses because the growth effect of human capital seems to be more powerful in less competitive countries.

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