FACTORS AFFECTING ECONOMIC GROWTH - THE CASE STUDY FOR THE CZECH REPUBLIC

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Abstract

The relation between the economic development, and the critical factor of growth is that in many cases they are elaborated in economic literature nowadays. In many papers, there is a description and quantification of the different factors for research and development. However, these views are often combined, so the use of those models are only for whole economies. The effects within individual regions may be different, due to the decreasing countryside population. The approach for the solution is to build upon the classic Solow growth model. This progress helps to identify critical variables for the next solution. All calculations are examined within individual regions of the Czech Republic. The results are then compared. The sales of paper are the definition of the factors that affect economic growth in the Czech Republic. The paper is the primary focus of these factors (technology – research and development). Date set contains a comparison between regions in the Czech Republic, the results from some areas are different from the factor for the whole Czech Republic. Expenditure for research and development has no global effect for all of the regions, but this is the most important point. Other factors are not significant. The main computing method is the multiple regression analyses.

Keywords: Regression, Economic Growth, Expenditure, Research.

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Introduction

The concept of innovation is well known. For its definition, it is possible to use the generally accepted procedure of Prof. Schumpeter (Schumpeter et al., 1991). Schumpeter describes the innovation as "a new combination of things and forces involved in the reproduction process." Examples can be:

➢The Implementing of new products or new quality products;

➢Introduction of a new, practically unknown, production method;

➢Opening markets for a new product;

➢Opening new sources of raw materials;

➢Implementing a new organization of work.

The Czechoslovak respectively Czech economic authors heavily contributed to the development of innovation theory, primarily as an elemental change in the production process. The relatively intense, and several decades-long, flows of published works was initiated by Prof. Valenta, who introduced a unique category of innovation factors and innovation rules into the Innovation

Theory. Valenta described innovation factors according to what changes occurred due to the innovation. This solution is very close to the original Schumpeter definition of an innovation process. Innovation ranking is different according to how the change considered is rooted and how vital this fundamental change is (Valenta, 2001).

However, the utility value of both scientific and technical knowledge is also greatly influenced by the passing of time, since the original and their first use. We will probably not expect economic benefits from the ship's bolt invention, which is over 160 years old. Already licensed patents typically sold for only part of the cost of the research (example: a third of the total cost of the research) which lead to the invention. Finally, the original theory of innovation by J. Schumpeter relied on the idea that the innovative product is rare.

The drop in inventory prices also follows the law of simple discounting techniques and the mathematical expression used by E. Mansfield in econometric studies (Mansfield, 1994). In this term, reminiscent of the production function of the Cobb-Douglas type. A first coefficient is applied to research costs as a development factor, taking into account the time elapsed since the end of the research. Let us assert that the value of scientific and technological knowledge has been decreasing over time, both spontaneously, as a result of scientific and technological progress in the thematic environment, and in connection with its use in innovative processes.

Innovations have been seen in further development as part of technical progress. They are factors in the growth of production efficiency, and as an essential tool for shaping the economic strategy.

1 Literature Review

In the recent years there is a growing number of empirical works on cross-country growth and convergence. Within the theoretical and empirical growth literature, the Solow model is apprehended as the foundation of basic endogenous growth models. The first paradigm of Solow growth model asserted that long-term rate of growth is exogenously determined. More explicitly, economies converge towards a steady state level of growth, which mainly depends on the rate of technological progress and workforce growth. The aggregate production function for the unique final product is written as:

$$Y(t) = F(K(t), L(t), A(t)) \qquad (1)$$

where *Y (t)* is the total amount of production of the final good at time *t*, *K(t)* is the capital stock, *L(t)*is total employment, and *A(t)* is technology at time *t*. (Acemoglu, 2009)

There are several different types of research that empirically assess the validity of Solow's paradigm. First, one line of research developed the single cross-section regression. For example, the most cited and influential paper by Mankiw – Romer – Weil (Mankiw et al., 1992). It examines the consistency of Solow's paradigm with the international variation of living standard. The idea of the augmented Solow model is that aggregate technology is usually described by a common Cobb-Douglas production function, in which human capital plays an important role. The augmented Solow model can account for the known stylized facts about growth. Mankiw, Romer and Weil (1992) estimated two specifications of the augmented Solow model. The first specification assumes that the economy is already in a steady state, and described by a Cobb-Douglas constant returns to scale production function (Canarella et al., 2011):

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} (A(t)L(t))^{1-\alpha-\beta} \qquad (2)$$

Where *Y* is output, *A* is technology, *K* is physical capital, *H* is human capital, and *L* is labor. The parameters α and β are the output elasticities with respect to physical and human capital (shares of physical and human capital in total income), respectively. Mankiw, Romer and Weil extended the Solow dynamics of physical capital accumulation to human capital. Thus the dynamics of growth takes the form (Mankiw et al., 1990):

$$\dot{K}(t) = s_k Y(t) - \delta K(t) \qquad (3)$$

$$\dot{L}(t) = nL(t) \qquad (4)$$

$$\dot{A}(t) = gA(t) \qquad (5)$$

$$\dot{H}(t) = s_h Y(t) - \delta H(t) \qquad (6)$$

Where s_k and s_h denote the fraction of output devoted, respectively, to physical and human capital accumulation, n is the growth rate of labor, g is technological progress, and δ is the rate of depreciation. A dot over a variable indicates the derivative with respect to time.

The Romer (Romer 1990) closely describes the technology. Equation (5) contains two substantive assumptions and two functional form assumptions. The first substantive assumption is that devoting more human capital to research leads to a higher rate of production of new designs. The second is that the larger the total stock of designs and knowledge is, the higher the productivity of an engineer working within the research sector will be. According to this specification, a college-educated engineer working today and one who worked 100 years ago would have had the same human capital; which is measure concerning years of forgone participation in the labor market. The engineer working today is more productive because he or she can take advantage of all the additional knowledge that has accumulated as design problems solved during the last 100 years. Linearity in A is what makes infinite growth possible, and in this sense, unlimited growth is more like an assumption rather than a result of the model. The marginal product of human capital H in the manufacturing sector grows in proportion to A. If the marginal productivity of human capital in the research sector does not continue to grow in proportion to A, then human capital employed in research would shift out of research, and into the production factory. The changes in the manufacturing area make A larger.

In this context, many studies were trying to explain the relationship between investment in R&D, and growth. Investment in R&D is positively correlated with firms productivity and profitability, which produces a relatively high private rate of return. Other researchers provide substantial evidence that R&D investment and growth are positively related to the US economy (Bayarcelik,2012).

The case study from the European countries is very similar, like the case in the United States of America. It shows that there is a healthy positive relationship between innovation (patent stock) and per capita GDP in both OECD and non-OECD countries. While only the OECD countries with broader markets, which include the G-7 (Australia, Netherlands, Spain, and Switzerland) can increase their innovation by investing in R&D. The fact that only the large market OECD countries promote their innovation by investing in R&D provides support for the theories emphasizing the importance of market size for active R&D sectors. These results also suggest that the OECD countries that do not have useful R&D sectors seem to promote their innovation through technology spillovers from other OECD countries. (Ulku, 2007)

2 Methodology

In this section, we will evaluate the impact of R & D on economic growth within individual regions. First, we need to determine what we will measure (which variables will be entering the analysis). We will draw on the work of Turkish Professor Ebru Beyza Bayarçelik It assessed the impact of the innovation intensity on GDP using three variables, namely R & D expenditures, the number of patents, and the number of R & D employees. In this article, we add two more variables, namely the number of research and development departments, and the number of tertiary educators. For the number of employees, we will use the value of 6 The recalculated persons as used by the Czech Statistical Office. It expresses the actual value paid for only R & D work within one year. The physical number of R & D personnel includes people who have a part job in this area. There is a risk of double counting because many researchers work in multiple workplaces at the same time. For the number of patents, we will use the number of patents granted to applicants from the Czech Republic in the previous years.

Multiple regression will be used to create the model. The simple linear regression model is not adequate for modeling a lot of economic phenomena, because to explain an economic variable it is necessary to take into account more than one relevant factor. In the model of multiple linear regression, the regressand (which can be either the endogenous variable or a transformation of the endogenous variables) is a linear function of p regressors corresponding to the explanatory variables. The equation is:

$$Y = a + b_1 * X_1 + b_2 * X_2 + ... + b_p * X_p \qquad (7)$$

3 Results

This procedure will apply to all regions in the Czech Republic. Due to the limited scope of this article, it will show only the detailed procedure for the Czech Republic as a whole. The summary conclusion will contain comparison in all regions. The approach of the solution is the same for all samples. The numerical value of variables contains tab.1.

Tab. 1: Data for the Czech Republic

	GDP (mln. Kč)	R & D Investment (mln. Kč)	Number of patents	Number of researchers	Number of R & D departments	Number of tertiary educators (th. person)
2005	3257972	38146	347	43370	2017	907
2006	3507131	43268	265	47729	2142	955
2007	3831819	50009	235	49192	2204	975
2008	4015346	49872	251	50808	2233	1050
2009	3921827	50875	385	50961	2345	1147,2
2010	3953651	52974	293	52290	2587	1236,3
2011	4033755	62753	339	55697	2720	1337,1
2012	4059912	72360	422	60329	2778	1411,9
2013	4098128	77839	434	62198	2768	1495,7
2014	4313789	85104	492	64443	2840	1552,5
2015	4554615	88663	604	66433	2870	1603,1

Source: Czech Statistical Office

Before using the time series of our variables for multiple regression, we have to test their stationarity and normality (The calculations are performed in the program Gretl). First, we test the stationarity of the individual variables. To determine stationarity we use the augmented Dickey-Fuller test (ADF). If the resulting p-value is more magnificent than the critical value α (0,05), we cannot reject the zero hypothesis. The zero hypothesis, is in our case, such that the series is monitored non-stationary. The results contain next tab. 2.

Tab. 2: Stationarity ADF test

	ADF p-value
GDP (mln. Kč)	0,9689
R & D Investment (mln. Kč)	0,7941
Number of patents	0,1673
Number of researchers	0,5269
Number of R & D departments	0,8916
Number of tertiary educators (th. person)	0,9665

Source: Own processing in GRETL

It is clear from the values that the time series is not stationary. For further calculations, the trend will be removed. The second control test is checking for normality distribution. We will use the Shapiro Wilk test. The calculated value is compared to the critical value.

Tab.3: Normality Shapiro Wilk test

	Shapiro Wilk p-value	Critical p-value
GDP (mln. Kč)	0,945103	0,582203
R & D Investment (mln. Kč)	0,916057	0,287152
Number of patents	0,941327	0,536227
Number of researchers	0,946282	0,596882
Number of R & D departments	0,884953	0,120196
Number of tertiary educators (th. person)	0,926863	0,379997

Source: Own processing in GRETL

For the use of a multifactor regression, it is necessary for the regressed variables to be in a linear relation. Therefore, the correlation coefficient for the relationship between the regressor and regressand will be calculated. Spearman's correlation rank is used. The results are shown in the next table.

Tab. 4: Spearman correlation test

	Spearman p-value	Critical p-value
R & D Investment (mln. Kč)	0,945	0,536
Number of patents	0,727	0,536
Number of researchers	0,973	0,536
Number of R & D departments	0,964	0,536
Number of tertiary educators (th. person)	0,973	0,536

Source: Own processing in GRETL

The critical value for all cases is 0.536. This means that the correlation has been demonstrated for all variables. Four out of five of the variables are close to one, so there is a perfect linear relationship. Those variables will be used for calculations of the final model. The whole equation is:

$$\begin{aligned} GDP &= 3687{,}47 + 22{,}78 * R\ \&\ D\ In. - 1037{,}53 * Num.\ pat. - 22{,}8 * Num.\ researchers \\ &- 440{,}11 * Num\ of\ R\ \&\ D\ dept - 264{,}33 * Num\ ter.ed. \end{aligned} \tag{8}$$

In the calculations, we can also find the b^* coefficients. Thus, the advantage of b^* coefficients (as compared to standard B coefficients) is that the magnitude of these beta coefficients allows you to compare the relative contribution of each independent variable in the prediction of the dependent variable. For R & D Investment is b^*= 0.74, for the number of patents b^* = -1.02, for number of researchers is b^*=0,27, for Number of R & D departments b^* = -0.27 and for the Number of tertiary educators is b^* = -0.06. In comparison, that b * implied, that the greatest impact on GDP is the number of patents. The next ranking has R & D Investment. The smallest influence appears to be the number of people with higher education. For the Number of R & D departments, Number patents and the number of people with higher education is negative, with their growth being GDP decreasing. For all the remaining variables, the coefficient is positive, which means that with their growth, GDP will increase.

Conclusion

The values of the b * coefficient for each region are contained in the tab 5:

Tab.5: Value of b^* for Regions of Czech Republic

	R & D Investment (mln. Kč)	Number of patents	Number of researchers	Number of R & D departments	Number of tertiary educators (th. person)	Adjustment R^2
Czech Republic	0,74	-1,02	0,27	-0,27	-0,06	0,747
City of Prague	0,63	/	0,01	/	0,61	0,351
Central Bohemia Region	-0,52	/	-0,12	-0,32	-0,09	0,311
Southern Moravia Region	-0,18	-0,54	0,14	-0,81	-0,49	0,266
Karlovy Vary Region	/	/	/	0,55	/	0,307
Hradec Králové Region	0,43	0,72	0,08	0,29	-0,02	0,216
Liberec Region	-0,99	/	0,42	-0,36	-1,29	0,482
Moravian-Silesian Region	0,15	-1,12	0,77	-0,14	-1,17	0,949
The Olomouc Region	0,27	/	0,29	-0,24	0,62	0,467
The Pardubice Region	-1,25	/	1,06	0,44	-0,08	0,129
The Ústí Region	0,89	0,47	/	-1,09	/	0,349
Zlín Region	0,95	-0,61	0,67	-0,07	0,77	0,907
South Bohemian Region	0,29	/	-0,63	0,17	0,31	0,503

Vysočina Region	-0,38	/	0,48	-0,98	0,58	0,735
The Pilsen Region	-0,5	/	-0,03	0,32	-0,91	0,653

Source: Own processing in STATISTICA 12

A slash in a cell means that the correlation of that variable with GDP has not been shown for this region.

It is necessary to determine the impact of the variables on GDP in each region. The approach is similar to in the case of the Czech Republic. We use the value of b * coefficients. From correlation analyses we know, that there is a correlation between the independent variables and dependent variables GDP for the whole Czech Republic. The Number of researchers is significant because the higher value of b * is, there will be a positive trend. The positive trend for increasing GDP is also R & D Investment, and the number of R & D departments. Comparison with the previous valve shows that in this case, that where there is a broader region, these variables are positive and negative too. At the same time, it is necessary to say that the number of patents and people with higher education has a negative factor, so GDP will grow by declining these variables. From another point of view, growth in R & D Investment and the number of researchers should increase GDP. For attention, the number of patents has the most significant impact on GDP, and it affects it negatively. This may be due to the delayed effect of patents when they are spent on their development in one period, but the effects themselves will only manifest in the next upcoming periods of time. The adverse effect may also result from patent protection because patent protection is an example of imperfect competition and it causes damage to the economy. With the patent protection, the rest of the firm in the economy do not have access to these innovations, so the potential positive effect decreases. However, our analysis shows that R & D Investment has a definite positive effect on GDP.

The regions of the Czech Republic have naturally very diverse results. Each region is specific, and it is not possible to expect the same influence of variables as in the rest of the Czech Republic. For example, the number of patents in most regions is not affected by GDP. However, if we look at the positive or negative value for the coefficients within each region, the results are very similar and confirm the results from the Czech Republic. The significance of individual coefficients is different in each region, and the rational explanation for this fact should be in the specific conditions of each region. The smallest region, Karlovy Vary, has the lowest innovation activities than the other regions. This region has no relationship between examined variables and its GDP. The only weak relation is the Number of R & D departments; only this variable can influence GDP in this region.

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