GDP AND CHOSEN INDICATORS OF INNOVATION LEVEL

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Abstract

Paper proposes analysis of chosen variables that might be on the background of successful knowledge economy. We focus our analysis on USA, Canada and Sweden. These countries are, according to several ratings, top innovators. By running OLS we analyse impact of Gross Domestic Expenditures on Research and Development, Government Budget Appropriations or Outlays for Research and Development, Number of researchers within economy, Exported high tech products and Number of endorsed patents on Gross Domestic Product. According to our analysis, there are different regressors that model GDP for USA and Canada on one hand and for Sweden on the other hand. We find that GDP in USA can be explained by Government Budget Appropriations or Outlays for Research and Development and Number of endorsed patents. GDP in Canada can be modelled by Government Budget Appropriations or Outlays for Research and Development, Patents Endorsed to Universities and Number of researchers within economy. GDP in Sweden can be modelled by Domestic Expenditures on Research and Development and Exported high tech products.

Key words: Knowledge Economy, Patents, Gross Domestic Expenditures on Research and Development, Regression

JEL Code: O38, Q55,

Introduction

In 1970s structural changes in developed economies has appeared. They concerned transformation of economies from production toward services and customer relationship management. Mentioned changes in economic life caused augmentation of importance of intangible goods and information above tangible goods. Somewhere here we start to identify information based society. In 1962 Machlup (1962) defined information society as a society based on knowledge transfer. Machlup estimated that in mid 1950s sectors where the information had dominated presented one third of Gross Domestic Product in United States. In 1970s knowledge based economy contributed 46 % to Gross National Product in United States. Klinec (2010) mentions that in post-industrial stage new forms of capital, such as information capital, knowledge capital, technologic capital has upraised. This allowed capitalization of science, knowledge, adaptability, flexibility, organization, structure or technology.

In 1990s endogenous theories of growth appeared. These theories introduced technological progress as endogenous variable. Most famous theories have been presented by Lucas (1998) and Romer (1990). Aghion and Howitt (1992) understand research and development as a mainspring of economic growth and point out the significance of state support of research and development. For better understanding of theories of growth based on innovations see Jones and Wiliams (2000), Zeng (2000), Segerstrom et al. (1990).

Prodan (2005) in his study identifies positive correlation between research and development (hereafter R&D) expenditure and patent application; shows up that R&D investments induce patent applications with time lag and quantity of patent application depends on R&D expenditure in the business sector rather than on R&D gross domestic expenditure. Coccia (2007) also reveals positive relationship between Gross Domestic Expenditures on Research and Development (hereafter GERD) and Gross Domestic Product (hereafter GDP). Andersson and Ejermo (2005) study influence of external and internal knowledge sources on performance of Swedish firms in terms of number of patents. They point out existence of positive relationship between the innovativeness of a corporation and its accessibility to university researchers within region. Schertler (2007) finds out that countries with high volume of knowledge capital have high volume of venture capital. This one is dependent on the countries' knowledge capital measured by the number of patents, or the number of R&D researchers or GERD. Katz (2005) also finds tight dependence between GDP and GERD in European and Canadian innovation systems. Hulya (2004) confirmed positive relationship between GDP and innovations, thus patents. Also, only big economies are able to innovate without state investments to research and development.

In this paper we run ordinary least squares regression with aim to study relation between GDP and chosen regressors. Here, dependent variable is GDP in billion $ and regressors are GERD in billion $, GBAORD in billion $, Number of researchers within economy (NoR), Exported high tech products (EHTP) in billions of $ and Number of endorsed patents (NEP). In our study we look closer on USA, Canada and Sweden. We have chosen these countries because they are taken as worldwide prime innovators. In USA and Canada we expand our analysis by Patents endorsed to universities (PEU). GERD comprises total amount of investment of companies, research institutions, universities, state owned labs and other organizations. GERD thus embraces private sector, public sector, nonprofit sector and educational sector. GBAORD represents state subsidies and budget expenditures toward firms, state institutions and nonprofit organizations.

We are using secondary data from Eurostat, World bank´s surveys and OECD´s surveys. Time series are from 1996 to 2010. Our model has following equation:

$$GDP_i = \beta_0 + \beta_1 GERD + \beta_2 GBAORD + \beta_3 NoR + \beta_4 EHTP + \beta_5 EP + \beta_6 PEU + \varepsilon i \qquad (1)$$

Paper is organized as follows. Next part proposes quick overview on R&D policies in USA, Canada and Sweden. Regressions can be found in second part Analysis. Discussion and concluding remarks are in final part of the paper.

1 Countries overview

USA invests 2,9 % of GDP into research and development and has 9,5 employees per 1000 in research. USA has strong national innovative system. In 2009 expenditures to research and development reached 400 milliard dollars which was 2,9 % of its GDP and ranked 9th place worldwide. Beside state innovations, USA has strong private investment in R&D. In 2008 private investment in R&D has reached 2 % of GDP. In private sector 10 employees per 1000 are employed in R&D. USA is attractive work destination for researchers. USA provides important tax reliefs for research in healthcare, environment and weaponry. Venture capital is widely used in R&D in USA.

Canada invests 2,33 % of its GDP into research and has 8,6 employees per 1000 in research (OECD, 2011). In Canada, similarly as in USA, subsidies, own capital and venture capital is used in R&D. Venture capital is not used as much as in USA

Sweden invests 3,6 % of GDP into research and development and has 10,5 employees per 1000 in research. Sweden is innovative leader in European union and is one of few countries that respect goals of Treaty of Lisbon concerning R&D. Sweden plans to invest in R&D 4% of GDP by 2020 (OECD, 2013).

2 Analysis

In this part we present regression analysis for each country. Here we would like to state, that we did also regressions with lagged variables, but no significant changes in terms of results have been observed. Moreover, we observed problems with models specification. Table 1 presents regression for USA. As one can see, in USA the most influencing factors are

GBAORD, Number of Endorsed Patents and Number of Researchers within economy. Distribution of residuals for regression are on Figure 1.

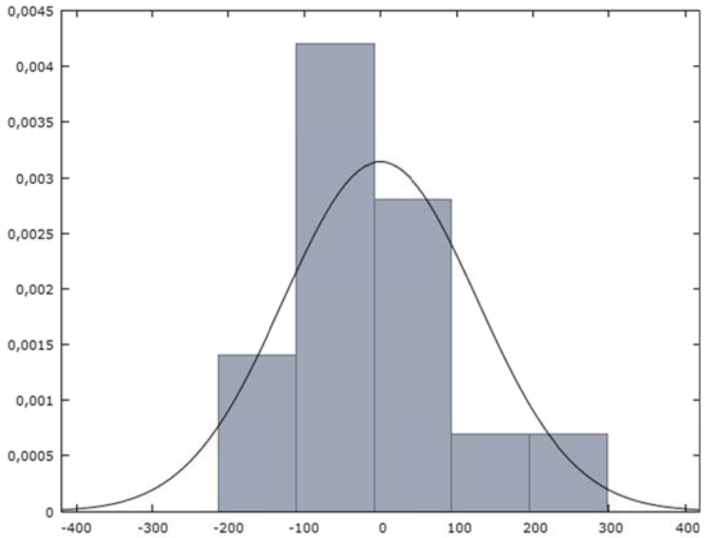
Tab. 1: Regression model for USA

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	2565,96	920,972	2,7861	0,02119	**
GBAORD	23,6857	2,59274	9,1354	<0,00001	***
NoR	0,0025264	0,00102859	2,4562	0,03639	**
EHTP	1,13043e-08	1,43429e-09	7,8815	0,00002	***
NEP	0,00704014	0,00232113	3,0331	0,01418	**

Mean dependent var	11854,14	S.D. dependent var	1113,566
Sum squared resid	145053,4	S.E. of regression	126,9529
R-squared	0,891002	Adjusted R-squared	0,987003
F(4, 9)	247,8019	P-value(F)	3,39e-09
Log-likelihood	-84,58574	Akaike criterion	179,1715
Schwarz criterion	182,3668	Hannan-Quinn	178,8757
rho	-0,456690	Durbin-Watson	1,842714

Source: Own

Fig. 1: Distribution of residuals – Regression model for USA



Source: Own

Table 2 presents regression analysis of GDP in Canada. We find two same determinants of GDP in Canada as we found in USA, GBAORD and NoR. Here, striking fact is, that GBAORD has negatve impact on GDP. Thus, more state invests to R&D, the smaller GDP is. Another interesting fact is, that number of Patents Endorsed to Universities has positive and significant influence on GDP in Canada. Distribution of residuals for regression model of Canada is on the Figure 2.

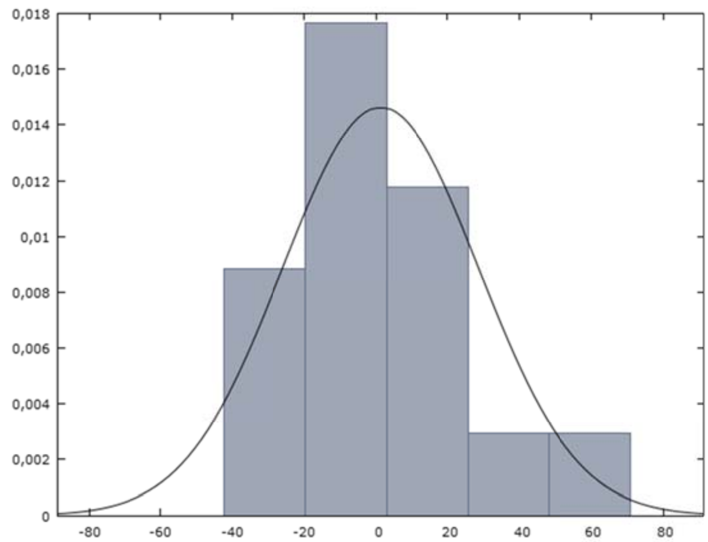
Tab. 2: Regression model for Canada

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
GBAORD	-107,979	12,1604	-8,8795	<0,00001	***
NoR	0,0130255	0,000655935	19,8580	<0,00001	***
PEU	1,01658	0,35257	2,8833	0,01375	**

Mean dependent var	1054,771	S.D. dependent var	124,5561
Sum squared resid	8940,076	S.E. of regression	27,29480
R-squared	0,899471	Adjusted R-squared	0,999383
F(3, 12)	7559,836	P-value(F)	6,41e-20
Log-likelihood	-69,21095	Akaike criterion	144,4219
Schwarz criterion	146,5460	Hannan-Quinn	144,3993
rho	-0,012464	Durbin-Watson	1,944839

Source: Own

Fig. 2: Distribution of residuals – Regression model for Canada



Source: Own

Table 3 presents regression for Sweden. Swedish GDP can be modeled by GERD and Exported high tech products. Interesting thing about Swedish regression is that GDP here can be explained by GERD, thus investments of private sector, public sector, nonprofit sector and educational sector. In USA and Canada this was explained by GBAORD, thus state subsidies and budget expenditures toward firms, state institutions and nonprofit organizations. Also, in Sweden, Number of patents does not explain GDP. Here number of Exported high tech products model GDP. Distribution of residuals for Swedish regression is on the Figure 3.

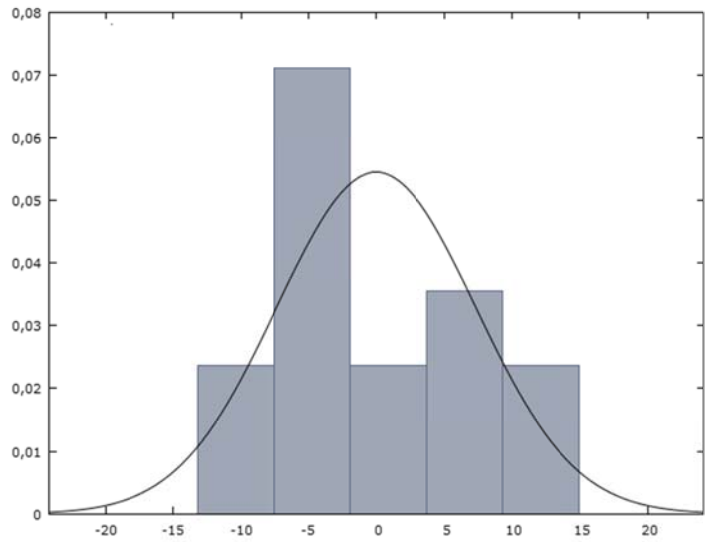
Tab. 3: Regression model for Sweden

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	60,0683	14,4321	4,1621	0,00132	***
GERD	16,3643	1,21166	13,5057	<0,00001	***
EHTP	3,33875	0,957737	3,4861	0,00450	***

Mean dependent var	275,9073	S.D. dependent var	33,46737
Sum squared resid	641,9002	S.E. of regression	7,313801
R-squared	0,959065	Adjusted R-squared	0,952242
F(2, 12)	140,5734	P-value(F)	4,71e-09
Log-likelihood	-49,45695	Akaike criterion	104,9139
Schwarz criterion	107,0380	Hannan-Quinn	104,8913
rho	-0,314661	Durbin-Watson	1,600233

Source: Own

Fig. 3: Distribution of residuals – Regression model for Sweden



Source: Own

Conclusion

Study proposes OLS modeling of GDP using GERD, GBAORD, Number of researchers within economy, Exported high tech products and Number of endorsed patents as regressors. For USA and Canada we found as major GDP´s determinants GBAORD, Number of researchers and Number of endorsed patents. Interesting finding for Canada is that the more state invests to R&D, the smaller the GDP is. In Sweden, the most innovative country within the European Union GERD and number of Exported high tech products model GDP. Our findings are in accordance with Hulya (2004) who confirmed positive relationship between

GDP and innovations, thus patents; Katz (2005) who shows tight dependence between GDP and GERD in European and Canadian innovation systems.

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