PUBLIC EXPENDITURE ON CAPITAL FORMATION AND PRIVATE SECTOR PRODUCTIVITY GROWTH: EVIDENCE FROM LITHUANIA AND THE EURO AREA

Jolanta Žemgulienė[*],

Faculty of Economics, Vilnius University, Lithuania

Abstract. *This paper explores a relationship between government expenditure on fixed capital formation and private sector productivity in Lithuania and Euro area economies. The extent to which variations of productivity in private Lithuanian economy can be explained by the flow of government expenditure on gross capital formation is estimated from regression analysis based on Cobb-Douglas production function approach. Quarterly state-level data from Lithuania and pooled data from the Euro area countries (12 countries) for the period of 2000 – 2010 were used. The regression estimation indicates the insignificant result for the impact of volume of government expenditure on fixed capital formation on the private sector output growth. Empirical analysis also revealed the negative significant result for the government expenditure on fixed capital formation as a share of GDP for both Lithuania and the Euro area countries.*

Key words: government expenditure on fixed capital formation, capital productivity, labor productivity

Introduction

The impact of fiscal policy on the output and aggregate productivity has been discussed in the academic literature since the 1960's. The government size and structure of government expenditure is a question of public choice, therefore the theory developed a rationale for the efforts to support the economic growth by the instruments of public expenditure policy. The issue of economic research is the development of theoretical framework and empirical evidence for the productivity of government expenditure (Barro, 1990, Aschauer, 1989, Munnell, 1990). The authors provide the distinction between productive and unproductive government expenditure; it has been shown that public investment has a positive relationship with output growth, however, government consumption is likely to have a negative growth effect.

*   Department of Business, Faculty of Economics, Vilnius University, Sauletekio 9, Vilnius, Lithuania.
    E-mail: jolanta.zemguliene@ef.vu.lt

The effect of public sector capital accumulation on economic growth has been characterized by a number of empirical analyses, focused on various datasets. Aschauer (1989), Munnell (1990), Fernald (1999), Holtz-Eakin (1992) used annual data on the United States government investment, Bajo-Rubio and Sosvilla-Rivero (1993) have examined possible influence of public capital formation on private sector economic performance using Spanish data, Everaert, Heylen (2001) analysed the impact of public capital on multifactor productivity in Belgium. Recent research provided by Ligthart and Suarez (2011) has summarized 49 studies of public capital impact on economic performance. Most of them are studies based on the economic data of a particular country, only a few of them have used pooled data from a number of countries.

Applying the production function for studying economic performance patterns in different groups of countries could provide support in obtaining the evidence of the common factors of productivity and considering the impact of different patterns of government spending. There is lack of empirical evidence of the disparity in the link between public investment and aggregate productivity, inherent to the groups of countries. The main focus of our analysis is to examine and contrast the implications of public investment flow in emerging and developed economies of EU, the economies that differ substantially in their size and degree of industrialization and development. It has been argued that the emerging market economies are considered as heterogeneous in terms of institutional and economic realities. However, emerging market economies share a number of features that could be captured by our framework. Emerging market economies traditionally are characterized as economies with low to middle (per capita) income and high growth. Increase in overall production levels and gross domestic product is considered as a typical feature of emerging market economies, meaning they (at least most of them) are in the process of convergence with developed economies. The emerging market economies of the European Union have sufficiently developed market institutions, and that allows a meaningful comparison of their macroeconomic performance properties with the ones observed in developed countries.

Particular interest of this paper is focused on the endeavour to understand two related issues: first, is there any evidence that changes of productivity in the economy can be associated with the flow of government expenditures on fixed capital investment? And, second, is the impact of public sector capital flow different for emerging and advanced countries?

The aim of this paper is to evaluate the extent to which behavior of productivity in the EU euro area (12 countries) and emerging market Lithuanian economy can be explained by the flow of government expenditure on gross fixed capital formation. This paper provides the evidence about the dynamics in productivity during the recent ten years (2000-2010) and evaluates the impact of flow of government capital expenditure on aggregate productivity.

To provide a specific example in our analysis, the Euro area (12 countries), a large developed economy, and the small economy of Lithuania, a representative of emerging

economy in Eastern Europe, have been selected. Considering the heterogeneity of emerging market economies, our results should not be generalized to the majority of emerging markets. However, our findings from an empirical analysis of the dynamic of the main economic indicators (GDP per inhabitant, total employment, labor productivity, government expenditure) of emerging economies in the Baltics provide the evidence for the homogeneity of the Lithuanian, Latvian, Estonian economies. Therefore, generalization of the results concerning the impacts of government investment on the aggregate productivity of the Baltic emerging economies could be hypothesized.

Theoretical framework

Macroeconomic literature discussed the link between public capital and private sector output. Some authors explore the interpretation of this relationship by focusing on public capital as the factor of private sector output growth. It is argued that public capital investment provides the infrastructure and public services for the private sector, and therefore, flow of public investments explains some variation in private sector output. Various authors have investigated the impact of public capital on the private sector production possibilities by estimating output elasticity of public capital. The majority of studies provide the econometric analyses of the state data, based on the production function approach. The results of these studies suggest a wide array of interpretations.

Studies that use aggregate or industry data, reporting a productive role of public capital, include Aschauer (1989), Munnell (1990), Everaert, Heylen (2001), Rubio, Rivero (1993), Fernald (1999), Ligthart, Suarez (2011). Based on the study of productivity in the United States economy, Aschauer (1989) explained the stimulative impact of public capital spending on private output by the shift of the rate of return to private capital, induced by the public investment spending. Along with the evidence, increase in the rate of return to private capital induces private investment. Aschauer (1989) considered the relationship between aggregate productivity and government spending variables. He found that estimated elasticity of public capital is 0.39. Ligthart and Suarez (2011) have explored the contribution of public capital to private output using meta-regression analysis based on meta-dataset of 49 studies. They reported that output elasticity of public capital equals 0.14. Everaert & Heylen (2001) analysed the impact of public capital on multifactor productivity in Belgium, estimating an error correction model to check the direction of causality. Their results support positive relationship with causality running from public capital to productivity.

Holtz-Eakin (1992) has explored the state specific characteristics in the state production function and summarized that results of aggregate data analysis do not provide sufficient evidence that variations in private productivity are caused by the government capital spillovers.

Empirical analysis of state data supports the thesis that public sector capital stock is a potential factor of growth in macroeconomic performance. Importantly, the estimates

of production function do not include variable of the flow of government expenditure on gross fixed capital formation.

The production function approach has been used for the empirical study of the relationship between private output and government expenditure on capital formation. Flow of expenditure on public capital formation is considered as separate input in Cobb-Douglas production function. Public capital is assumed to be an exogenous variable. Linearized specification has been obtained by taking natural logarithms on variables:

$$q = \beta_0 + \beta_1 k + \beta_2 l \ + \ \beta_3 g; \tag{1}$$

where q is the logarithm of output, measured as gross private sector value added, k is the logarithm of private expenditure on gross capital formation as a proxy of private capital stock, l is the logarithm of labor inputs, as total employment, measured in thousands of persons, g is the logarithm of government expenditure on fixed capital formation, β_0 – constant, β_1, β_2, β_3 – elasticities of production factors. As from the Cobb-Douglas production function, public expenditure on capital may impact production directly or by increasing economy-wide productivity. A constant in the production function is a proxy of economy wide productivity. While the focus of this paper is the impact of inputs on the amount of yield, a related issue is the assumption of returns to scale. Restriction of constant returns to scale in private inputs was imposed:

$$\beta_1 + \beta_2 = 1. \tag{2}$$

Subtracting l from both sides of equation (1), labor intensive form of production function was assumed:

$$q - l = \beta_0 + \beta_1 \, (k - l) \ + \ \beta_3 \, g \, ; \tag{3}$$

Subtracting k from both sides of equation (1), capital intensive form of production function was assumed:

$$q - k = \beta_0 + \beta_2 \, (l - k) \ + \ \beta_3 \, g. \tag{4}$$

Ordinary least squares regression analysis has been used to estimate output elasticity of public capital.

The data used for empirical analysis focuses on the period 2000 to 2010, quarterly data have been utilized. The data on gross value added, gross capital formation (GDP component) as a proxy of private capital stock, total employment, public capital flow (total government expenditure on gross fixed capital formation) have been obtained from database of indicators of Eurostat.

Results of empirical analysis

Income distribution change over time could be seen when output positions are compared with the EU 27 in corresponding years. Dynamic in the income per inhabitant, as GDP (based on purchasing power standard) percentage of the EU 27 total, during the last fifteen years shows upward convergence – in 1995 income per inhabitant in Baltic countries constituted one third of the EU 27 average, whereas in 2010 it amounted to
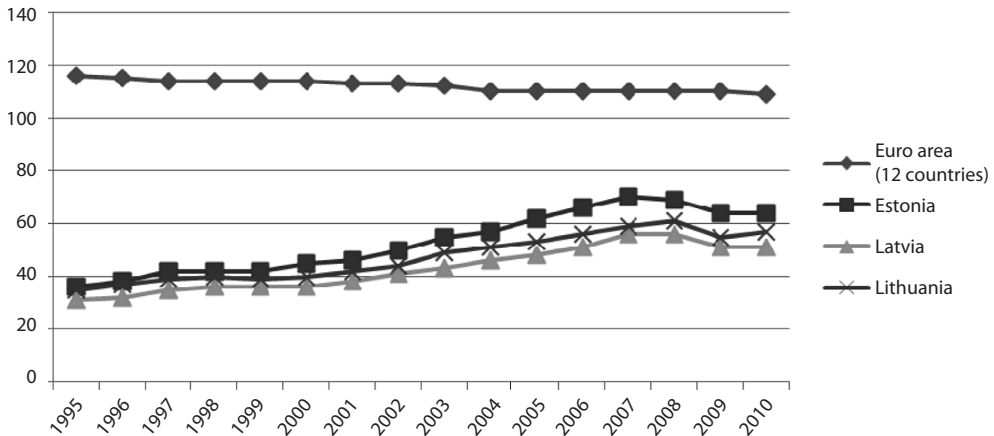
FIGURE 1. **GDP per inhabitant as percentage of the EU 27,**
based on purchasing power standard per inhabitant

half of the EU 27 average (Figure 1). Income per inhabitant in the Euro area countries exceeded the EU 27 average by 10-15 percent during the period of 1995 – 2010.

Production function provides the theoretical framework to determine the sources of economic growth – increase in amount of labor and capital factors, and higher productivity. EU statistics data over the 1995 to 2010 period show the higher volatility and homogeneity of variation of gross capital formation expenditure growth in the Baltic countries – the volume of gross capital formation expenditure increased almost three times in 2007 as compared to 2000, however, in 2009, the year of economic recession, it declined to the level slightly exceeding that in 2000 (Figure 2).
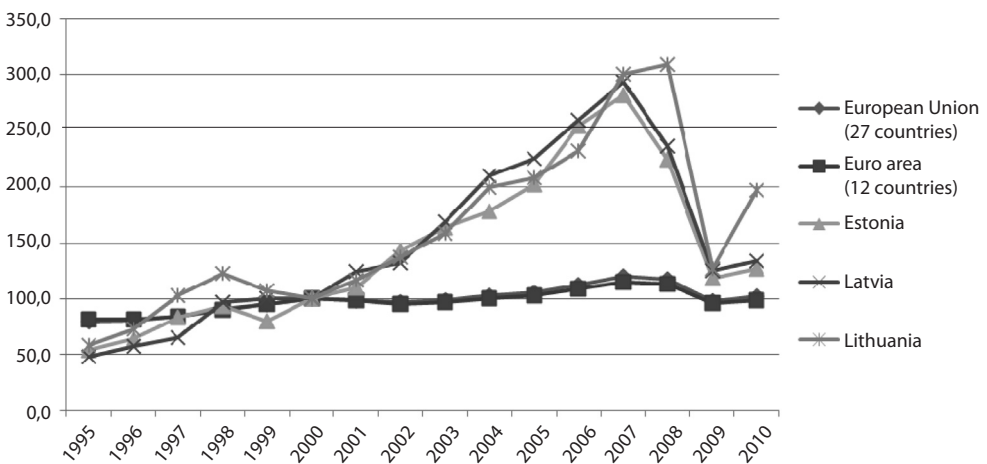
FIGURE 2**. Gross capital formation expenditure (index, in percent, 2000=100)**

24

The dynamic of annual changes in the volume of total employment shows the considerable decrease in the number of persons employed during the recent years in the Baltic countries, respective data for the developed countries are not provided. The data also suggest that some amount of the decrease in the number of persons employed could be explained by movement of labor to the developed EU countries (see the data for 1999 – 2001 years) (Figure 3). The rate of employment in the EU 27 grew slightly from 0.5 to 1.7 percent annually during the period.
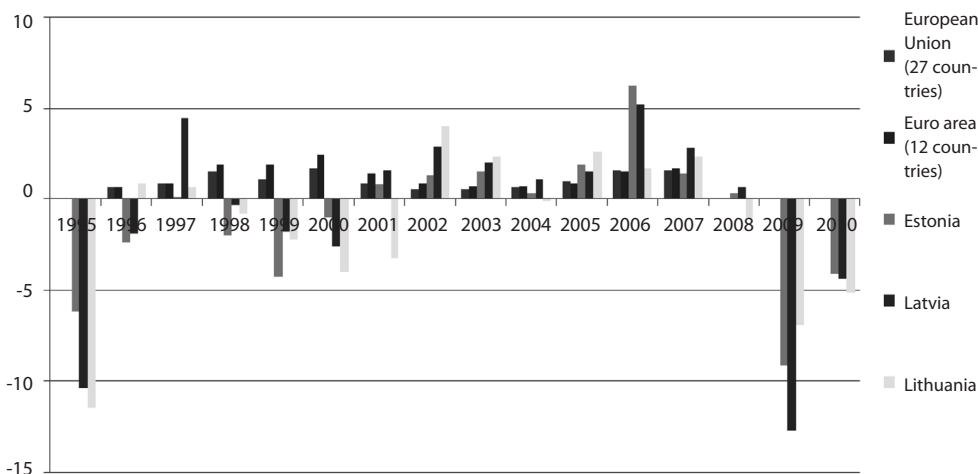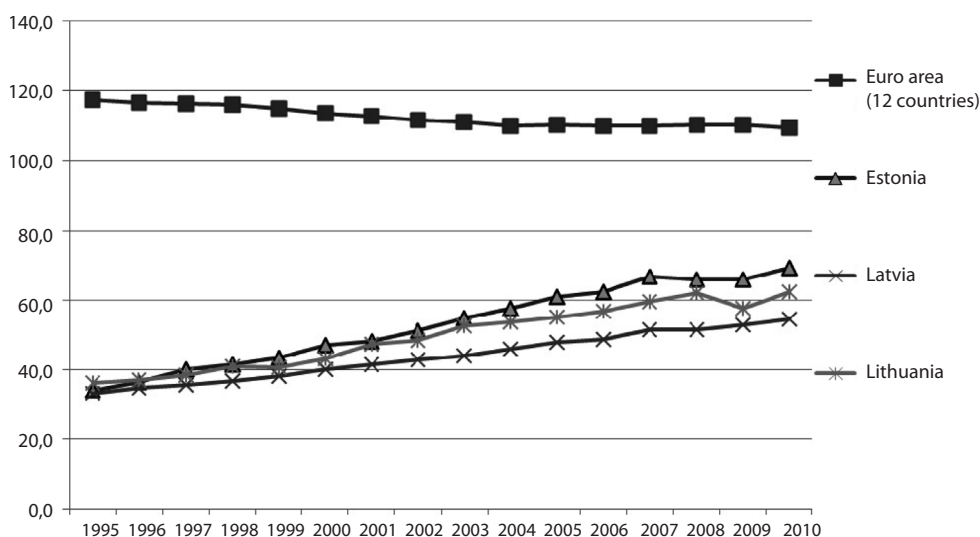

Source: Eurostat database

FIGURE 3. **Total employment (annual change, in percent)**

Labor productivity change over time could be seen and possibility to compare respective data for the emerging economies and developed economies of the EU could be ensured when output positions are compared to the EU 27 in corresponding years. The dynamic in the labor productivity, as percentage of the EU 27 total (based on purchasing power standard), during the last fifteen years shows upward convergence and resembles the income dynamic – in 1995 labor productivity in Baltic countries constituted one third of the EU 27 average, whereas in 2010 it amounted to half of the EU 27 average (Figure 4).

Labor productivity growth in Baltic countries could be explained by the stimulative impact of various factors, such as technological progress, and increase of skill of labor force. Output per worker can rise because of the increasing amount of capital per worker. Advances in technology can result in productivity of capital or productivity of labor.

The annual rate of change in aggregated growth, production factors and labor productivity gives some idea of the sources of growth – an increase in the amount of capital and the rise in labor productivity were important factors of the growth during the last decade in Baltic countries.

Source: Eurostat database

FIGURE 4. **Labor productivity as percentage of the EU 27 total
(based on purchasing power standard)**

Theoretically, public capital is considered to have direct and indirect effects on economic performance. The EU data show that average government expenditure on gross fixed capital formation constitutes 2.3 – 2.7 percent of GDP, variations in the Baltic countries are considerable and exceed the average level of the EU in 2010 (Table 1).

TABLE 1. **Total government expenditure and government expenditure on gross fixed capital formation (percentage of GDP)**

	Total government expenditure				Government expenditure on gross fixed capital formation			
	1995	2000	2005	2010	1995	2000	2005	2010
European Union (27 countries)	52.2	44.7	46.8	50.6	2.6	2.3	2.3	2.7
Estonia	41.3	36.1	33.6	40.6	5	3.7	4	3.9
Latvia	38.6	37.6	35.8	43.9	1.9	1.3	3.1	3.7
Lithuania	34.4	38.9	33.2	40.9	3.2	2.4	3.5	4.6

Source: Eurostat database

In the light of empirical literature it is anticipated that public capital has positive effect on private sector output. Estimating the effect of public capital, the sign of public capital coefficient should indicate the order of the effect.

The estimation of public capital effect is based on the regressions modeling by OLS, therefore, in pursuance to avoid spurious results, all variables were tested for autocorrelation and differenced variables were included into the model.

The estimation results of production function for the private output are reported in Tables 2, 3 and 4.

TABLE 2. **Estimates of private sector production function**

	Lithuania Coefficients of regression	Euro area (12 countries) Coefficients of regression
Dependent variable Δ q		
Δ l , (95% CI)	-0.84 (ns)	-49.15* (-95.16 – -3.14)
Δ k , (95% CI)	0.24* (0.04 – 0.44)	2.59* (0.19 – 5.00)
Δ g , (95% CI)	1.30 (ns)	2.62 (ns)
constant	-0.01 (ns)	-0.04 (ns)
D.W.	2.11	3.41
R^2	0.43	0.38
Dependent variable Δ q		
Δ l , (95% CI)	0.08 (ns)	-22.75 (ns)
Δ k , (95% CI)	0.18* (0.04 – 0.32)	1.70* (0.25 – 3.16)
Variable of total government expenditure on fixed capital formation as percentage of GDP, (95% CI)	-0.04** (-0.05 – -0.02)	-0.44** (-0.56 – -0.32)
constant	1.52	1.12
D.W.	2.05	2.79
R^2	0.66	0.75

** – significant at 1 percent level, * – significant at 5 percent level

The estimated coefficients for the pooled data of Euro area (12 countries) and Lithuania show common tendency that public expenditure on capital formation have no significant result on the private output (Table 1). Considering the method which was applied for the transformation of variables (taking the log and differencing variables), interpretation of the results should take into account that such transformation converts the meaning of variables to their respective growth rates, and parameters of regression show the output growth elasticities of capital, labor, public capital growth. In order to support the proximate interpretation of the resulting effect of public capital on private sector output growth, post hoc regression analysis has been performed, including the variable of total government expenditure on fixed capital formation as percentage of GDP (variable is stationary). Table 2 shows that coefficients for this variable are significant with negative sign for Lithuania and the Euro area countries. Therefore, increasing the share of public spending on fixed capital formation would influence the contraction of the private sector output growth rate for emerging and developed economies.

The results for the private sector labor productivity and capital productivity also should be interpreted as growth elasticities (Table 3 and Table 4). Value of Durbin-Watson statistic indicates that there is no serial correlation in the residuals of the estimated equations.

TABLE 3. **Estimates of private sector labor productivity**

	Lithuania Coefficients of regression	Euro area (12 countries) Coefficients of regression
Dependent variable Δ (q – l)		
Δ (k – l) , (95% CI)	0.22* (0.02 – 0.41)	0.12 (ns)
Δ g, (95% CI)	0.98 (ns)	1.63 (ns)
constant	0	1.78**
D.W.	2.11	1.44
R²	0.38	0.1
Dependent variable Δ (q – l)		
Δ (k – l) , (95% CI)	0.17* (0.01 – 0.33)	0.05 (ns)
Variable of total government expenditure on fixed capital formation as percentage of GDP, (95% CI)	-0.04** (-0.06 – -0.02)	-0.14** (-0.23 – -0.06)
constant	0.15**	2.16**
D.W.	2.08	0.62
R²	0.65	0.18

** – significant at 1 percent level, * – significant at 5 percent level

TABLE 4. **Estimates of private sector capital productivity**

	Lithuania Coefficients of regression	Euro area (12 countries) Coefficients of regression
Dependent variable Δ (q – k)		
Δ (l – k) , (95% CI)	0.78** (0.59 – 0.98)	-0.54 (ns)
Δ g, (95% CI)	0.98 (ns)	-2.02 (ns)
constant	0 (ns)	0.72**
D.W.	2.11	2.43
R²	0.79	0.25
Dependent variable Δ (q – k)		
Δ (l – k) , (95% CI)	0.83** (0.70 – 0.97)	-0.40 (ns)
Variable of total government expenditure on fixed capital formation as percentage of GDP, (95% CI)	-0.04** (-0.05 – -0.02)	-0.16** (-0.21 – -0.11)
constant	0.15**	1.10**
D.W.	2.08	1.53
R²	0.86	0.71

** – significant at 1 percent level, * – significant at 5 percent level

The estimated coefficients for labor and capital productivity equations for the pooled data of the Euro area (12 countries) and Lithuania also show a common tendency that variation in public expenditure on capital formation has no significant result on the

variation of productivity of private sector performance. Post hoc regression analysis for the productivity data also has been performed, including the variable of total government expenditure on fixed capital formation as percentage of GDP (variable is stationary). Tables 3 and 4 show that coefficients for this variable are significant with negative sign for Lithuania and the Euro area countries. Therefore, increasing the share of public spending on fixed capital formation would have a negative effect on private sector productivity both for emerging and developed economies.

Discussion

The centerpiece of the analysis is whether elasticity coefficient for the public capital formation is positive, and how large its effect is. The result of our analysis did not conform to the majority of studies in this field, which report a wide range of results, varying from negative to high values for the effect of public capital stock. However, a non significant result for the public capital flow in the production equation is consistent with the standpoint of some authors. Holts-Eakin (1992) presented the opinion that public sector capital has essentially no role in affecting private sector productivity. Negative mean values for public capital output elasticity were reported by Evans, Karras (1994), Batina (1998). Perhaps the most proper explanation of our result should be based on two perspectives. Firstly, in this analysis the data of government expenditure on fixed capital formation have been used as a proxy for the public capital stock. Typically, in most studies the data for the public capital stock are employed, therefore they explore an effect of the total amount of public capital stock factor in the framework of production function, whereas in this report the data for the public capital flow have been used. In this study the output elasticities derived from production function equations are based on the first or second differences of variables. Some authors suggest that the estimations which use the differences of variables usually derive a lower output elasticities than those of studies which estimate the equations in levels of variables (Button, 1998; Ligthart, Suarez, 2011). Secondly, the government expenditure on fixed capital formation includes a wide range of areas. Some part of capital inflow is accrued to the infrastructure facilities, core infrastructure, which is considered as more productive (Aschauer, 1989, Fernald, 1999). Chatterjee, Sakoulis, Turnovsky (2003) contrasted the effects of a public transfers tied to investment in public infrastructure from a traditional pure transfer. They concluded that public transfers tied to investment have an effect on long-run growth. However, the flow of government expenditure entails other components like capital investment to military or social objects, which are considered as less productive.

The result of post hoc analysis suggests that excessive relative flow of public expenditure on fixed capital formation reduces the capacity of private sector output growth. Increased relative amount of government expenditure on fixed capital formation has a negative impact on the private sector productivity. This result is consistent with the findings of Devarajan, Swaroop, Zou (1996). Based on the production model

developed with productive and unproductive government expenditure, the authors derived that productivity of different components of public spending and share of government expenditure effect the growth rate. They found that capital expenditures are unproductive in developing countries.

Variations in the results of regressions did not support the assumption concerning the different impact of public capital expenditure on the private sector productivity for the emerging and developed economies of the European Union. The dynamic of the income and productivity for the last 15 years suggests the upward convergence of emerging Baltic economies toward the levels of the developed Euro area countries. This analysis provides the evidence that public expenditure on fixed capital formation did not make distinctive impact on this pattern of development.

Summary

The dynamic in the income per inhabitant and labor productivity during the last fifteen years shows convergence of emerging Baltic economies and the developed Euro area countries. The rapid growth of Baltic economies reflects the increase in income level as compared to the average in the European Union – from one third of the EU average level in 1995 to half of the EU average in 2010. Patterns in productivity growth show the same development.

Empirical analysis of the data was based on the conventional production function with public expenditure on fixed capital formation as an additional input. Regression parameters were estimated for the two samples, that of Lithuania as the emerging economy and pooled data from the developed economies of the Euro area (12 countries). The results of regression coefficient estimation show insignificant impact of government expenditure on fixed capital formation on the private sector output growth. This result is common to Lithuania and the Euro area countries.

Empirical analysis also reveals that government expenditure on fixed capital formation as a share of GDP is significant with negative sign for both Lithuania and the Euro area countries. Therefore, increasing the share of public spending on fixed capital formation would influence the contraction of the private sector output growth rate.

Variations in the results of regressions did not support the assumption concerning the different impact of public capital expenditure on the private sector productivity for the emerging economy and developed economies of the European Union.

Considering that the differences of variables have been used for the estimations, and given that the quarterly data have been used for empirical issue, the quantitative importance of the regression coefficients should be interpreted with care. This study can be extended in exploring the macroeconomic impact of public capital expenditures on the performance of various industries.

References

Aschauer D.A. (1989). Is Public Expenditure Productive? *Journal of Monetary economics, Vol. 23*, 177–200.

Bajo-Rubio O., Sosvilla-Rivero S. (1993). Does public capital affect private sector performance?: An analysis of the Spanish case, 1964–1988. *Economic Modelling, Vol. 10*, Issue 3, July, 179–185.

Batina, R.G. (1998). On the Long-Run Effects of Public Capital and Disaggregated Public Capital on Aggregate Output. *International Tax and Public Finance, 94*, 263–281.

Button, K. (1998).Infrastructure Investment, Endogenous Growth, and Economic Convergence. *The Annals of Regional Science, 32*, p. 145–162.

Chatterjee A., Sakoulis G., Turnovsky S.J. (2003). Unilateral capital transfers, public investment, and economic growth. *European Economic Review, Vol. 47*, Issue 6, December, 1077–1103.

Devarajan, S., Swaroop, V., Zou, H.(1996). The composition of public expenditure and economic growth. *Journal of Monetary Economics, 37*, 313–344.

Evans, P., Karras, G. (1994). Are Government Activities Productive? Evidence from a Panel of US States. *Review of Economics and Statistics, 76*, 1–11.

Everaert G. (2003). Balanced growth and public capital: an empirical analysis with I(2) trends in capital stock data. *Economic Modelling, Vol. 20*, Issue 4, July, 741–763.

Everaert G., Heylen F. (2001). Public capital and productivity growth: evidence for Belgium, 1953–1996. *Economic Modelling, Vol. 18*, Issue 1, January, 97–116.

Fernald J.G. (1999). Roads to Prosperity? Assessing the Link Between Public Capital and Productivity. *The American Economic Review, Vol. 89*, No. 3, June, 619–638.

Holtz-Eakin D. (1992). *Public Sector Capital And The Productivity Puzzle.* Working paper No.4122. National Bureau Of Economic Research, New York.

Ligthart J.E., Suarez R.M.M. (2011). The Productivity of Public capital: A Meta – Analysis. In Jonkhoff W., Manshanden W. (Eds.), *Infrastructure Productivity Evaluation. Springer Briefs in Economics.* New-York: Springer.

Moreno R. (2002). Public infrastructure and the performance of manufacturing industries: short- and long-run effects. *Regional Science and Urban Economics, Vol.32*, Issue 1 January, 97–121.

Munnell A.H. (1990). Why Has Productivity Growth Declined? Productivity and Public Investment. *New England Economic Review. January/February*, 3–22.

Pinnoi N. (1994). Public infrastructure and private production measuring relative contributions. *Journal of Economic Behavior and Organization, Vol. 23*, Issue 2 March, 127–148.

Sturm J.E., De Haan J. (1995). Is public expenditure really productive? New evidence for the USA and the Netherlands. *Economic Modelling, Vol. 12*, Issue 1 January, 60–72.