7th International Scientific Conference
"Business and Management 2012"
May 10-11, 2012, Vilnius, LITHUANIA

ISSN 2029-4441 print / ISSN 2029-929X online
ISBN 978-609-457-116-9 CD
doi:10.3846/bm.2012.022
http://www.bm.vgtu.lt

INFRASTRUCTURE DEVELOPMENT: ECONOMIC GROWTH EFFECTS

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Abstract. The development of infrastructure, while demanding considerable financial resources, is expected to give positive returns and facilitate economic growth in many countries and regions. The aim of this article is to investigate the effects on growth through various channels. The study consists of two parts: an empirical analysis of macroeconomic growth associated with improvements in infrastructure on the example of the European Union (EU) and CIS during past decades, and an econometric model formalizing the observations. The results show that infrastructure development, along with private and public investments, has a positive correlation to growth and output. However, the risks issues related with investments in infrastructure should be cogitated as one of the key elements.

Keywords: Infrastructure accessibility, risk assessments, impact on growth, Russia, EU.

Jel classification: E61, F43

1. Introduction

Regional integration and globalization of production processes increases the need for quick, efficient and reliable communications and transport infrastructure. The infrastructure development couldn't have been perceived separately from a number of factors such as macroeconomic policy, political influence on foreign direct investments and competitiveness. The disparities in global and regional integration should also be taken into consideration. Both the developed and emerging economies face more intense international competition, so they need to create and maintain a stable political environment, access to imports, efficient infrastructure and reliance on private sources of financial markets (World Bank 2006).

The accelerated development of globalization was possible over the past decades mainly due to a few significant factors. The first one is the technological progress, especially in the information technologies, international communications and the robust expansion of global transportation. Not only goods, but also services and knowledge can be exchanged faster because of the innovations in digital media (Clementia 2008, Inda *et al.* 2007). The second factor, as it is pointed out by many researchers, is the shift in the economic policy orientation. Globalization has reshaped economic governance in terms of the globalization of finance, trade, production and distribution networks. Once a certain threshold of economic integration is passed, economic policy inevitably converges both in terms of its policy prescriptions and its instructional infrastructure (Martin 2004).

The globalization processes might lead to the formation of regional clusters across borders, which can be regarded as a tool that could improve regional growth and prevent the underdevelopment of regions (Blien *et al.* 2008).

The purpose of this paper is to define the scopes for infrastructure development analysis among regions with economic disparities such as the European Union and Russia considering various factors and to estimate the possible effects on the growth of configuration in clusters. Nowadays, the European Union is not a homogenous structure. It is operating through a complex system of supranational independent institutions along with intergovernmental resolutions negotiated by all member states. Most of the challenges confronting Russia in the areas of social and physical infrastructure are not unique and are rooted in the past, due to the turbulent transitions in Russia. Cluster building and synergy leveraging perspectives are essentially hypotheses that deserve serious empirical investigation (Blien *et al.* 2008).

2. Clusterization: a broader scope

Countries and regions can be grouped or clustered together based on similarities, measured on the basis of several macroeconomic variables, which can be analyzed with the use of evolving clustering methods (Kasabov 2007).

Regional welfare improvements are viewed as a natural outcome of cluster building efforts (Blien *et al.* 2008). Regional-level specialization, which is clearly seen in a large number of industries, raises the related issue of clustering. The term regional cluster refers to the geographically bounded concentration of independent organizations. The regional clusterization encouraged specialization at the regional level, despite the increased range of options for firms to relocate production away from higher cost locations (OECD 2007). Countries with close interindustrial production and value chains could be interested in cluster policy (Salais 2005).

From a broader perspective, the European Union is facing profound challenges because of the eastward expansion of the Union and the need for reform, enhancing the efficiency of management and public support. One of the key subjects in this area is the European Cohesion Policy (ECP), aiming at diminishing the regional economic disparities. Infrastructure plays a central role in ECP investments. The reason is that new EU members, who joined the EU after 2000, generally have a less developed transportation sector. The pattern for spending cohesion funds followed the examples of Spain, Portugal and Ireland in the 1980s (Peterson *et al.* 2007). The regulating document of the Council Regulation (EC) is focused on covering major transportation and environmental protection infrastructures, according to the EU Council Regulation No 1164/94.

In order to describe Russia's case, it needs to be elaborated on larger scope. Firstly, according to the Goldman Sachs report (2003), over the coming decade, Russia could become a much greater force in the world economy. Secondly, however, according to the historical data of the World Bank (World Bank Data), the share of gross capital formation of the Russian GDP is extremely low, considering the current level of development. Russia should have invested more intensively to achieve a better and more stable growth, such as that of Estonia, where the share of investments is much higher. China's investments have been about 35-40 percent of the GDP over the last quarter of the century, which guaranteed a significant economic growth.

In Russia's case, there are large, sparsely populated territories with limited infrastructure possibilities. Such areas need active planning in order to create a basis for economic development. According to the Infrastructure and Transport Report published by Renaissance Capital, the infrastructure spending in Russia remains the top priority for government stimulus spending. The total share of $56.5bn spending on infrastructure is divided between transport ($24bn; 43 %), utilities ($13bn; 23 %), as well as oil and gas ($19bn; 34 %). The Ministry of Economic Development of the Russian Federation reported that the investment in infrastructure development will amount to over US$1 trillion by 2020. They offer a range of state financial funds for co-financing investment projects in order to lure the private investors and a better tax regime for concession agreements (Renaissance Capital, 2009).

The infrastructure clusters across European borders are divided not only geographically, but also by common interests, for example in the transshipment sectors, with five main modes of transportation, which are rail, road, pipeline, water and air (Gourdin 2000). Each of them requires a certain degree of developed infrastructure in order to render services. A good example of cluster configuration by transshipment mode might be the stimulation of shorter delivery times for goods from China to the EU via Russia, using railroads network. Such long transshipment corridors require a new approach in the railroad freight concept, involving all interested parties, who are able to manage a modal shift of cargo from road to rail, creating an effective and scalable freight corridor.

Note that the Russian and EU policy is to collaborate. The EU has launched a number of projects, which aim to facilitate the economic growth through infrastructure development among various regions. It pays to mention the First Rail Infrastructure Package (EC/13/14/16/EC) by the EU Member Countries and the ongoing work on the adoption of the Interoperability Legislation (EC/16/2001), which enabled rail operators to have access to the trans-European network on a non-discriminatory basis (EIM, 2006).

In the RETRACK Consortium, the upcoming European rail freight operators, experienced IT and training specialists and leading European research and development organizations have taken the initiative to design, develop and implement a new and innovative trans-European rail freight service concept (Retrack 2011).

3. Infrastructure from the macroeconomic perspective

According to the literature, the macroeconomic aspect of infrastructure related issues appears through different channels. Therefore, we need to discuss the possible role of infrastructure in a broader sense.

Kohsaka regards infrastructure as an aggregate term for many activities referred to as social overhead capital, which incorporates activities with such technical features as economies of scale

and such economic features as spillovers from users to non-users in respect of public utilities, public networks and other transport sectors (Kohsaka 2006). The main characteristics of infrastructure consist of low mobility, heavy initial investments organized by the public sector, external economy and ownership of public and private sectors.

The studies about infrastructure show amphibious conclusions, mainly because of the methodological approach used. Depending on what issue is exposed, there are a number of areas and parameters, with which the infrastructure development is dealing with. However, the empirical analysis in economics is often troubled by the nature of the data. These problems are probably the cause of the great variability in the results shown in literature.

The studies of infrastructure in literature can be seen from different methodological approaches and perspectives.

First of all, there are a number of studies performing the analysis of the economic effects of public capital by measuring the return effects of investments in public sectors. From this perspective, the role of infrastructure in the economic growth of emerging economies is undeniable. The public infrastructure has always been considered to be the prerequisite condition for social and economic developments in many regions (Chatterjee 2003). Therefore, the development of infrastructure leads to positive effects, especially in emerging economies through various channels. Firstly, a developed public infrastructure leads to specialization in the production sector by decreasing the marginal productivity costs of other existing factors of production due to economies of scale. Secondly, developed public infrastructure attracts resources from other regions, increases the inflow of skilled labor, capital and advanced technologies more so than less developed regions. It has, in general, a positive effect on the Foreign Direct Investment.

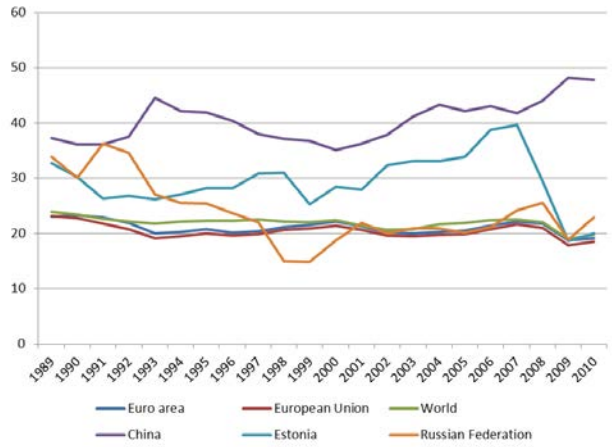

Fig. 1. Gross capital formation (% of GDP) by Worldbank

However, other studies conclude that the development of infrastructure does not influence regional growth rates (Bell 1994). In case of well-developed economies, transportation infrastructure investments can lead to negative results for economic growth, because better transportation possibilities might lead to increasing competition among regions (OECD 2006).

As Aschauer (1989) proved that the fall in the private sector productivity in the USA in 1970s and 1980s can be explained by a general fall in public investments. Aschauer argues that besides other possible causes a very large part was played here by the fall in outlays on public capital, and, first of all, on infrastructure, whose growth rate was 4.1 % on average in 1950–1970, 1.6 % between 1971–80, and 0.7 % in 1981–85.

Therefore, despite the accumulation of numerous studies on infrastructure, empirical analyses have focused on the industrial countries, largely due to the lack of data. Such analyses should carefully scrutinize the obtained results before applying them to the emerging economies because, in the industrial countries, infrastructure had already been developed to a certain degree even in the beginning of the estimated period (Yoshino *et al.* 2000).

The contribution of the infrastructure sector can be viewed through different theories described in literature, such as the neoclassical growth theory, endogenous growth theory. All of them emphasize the influence of infrastructure on economic growth and development.

The effects of infrastructural development on economic activity can be broken down into the characteristics of the econometric models involved in analysis: cross-section, time-series and panel-data production functions. In this respect, the main question is how to measure the effect of the infrastructural development among heterogeneous regions, which should be able to boost the economic growth in case of economic disparities.

The infrastructure development strategy should be communicated and cautiously scrutinized, in order to fit the overall economy output, political context and environmental challenges. The infrastructure development should follow the economic challenges by implementing appropriate macroeconomic policies (World Bank 1999). However, while some market reforms have continued to progress – notably in difficult areas such as enforcement of competition policy, commercialization of infrastructure and development of capital and private equity markets (European Bank 2011).

4. Econometric estimation framework

There are different approaches in researches, which are trying estimate the relationship between transportation infrastructure and economic development. Such studies involve a number of aspects to find the possibility to measure various points of view and analysis methods focused on interrelationship between transportation infrastructure and regional development.

A vast number of studies have utilized cost function specifications in order to measure the effects of total or specific infrastructural capital on productivity (Pesaran *et al.* 1999). In order to estimate the effects of clusterization on infrastructure development, a number of estimative parameters are needed.

The production function methodology generally utilizes the aggregated Cobb-Douglas production function, where the role of infrastructure in economic growth is separated by the public capital from the productivity parameters. Besides the productivity issues the production function should also consider spatial variations in distribution of economic effect subsequent the infrastructure investments.

The Cobb-Douglas production function is the most widely used in empirical studies. Nevertheless, the values for this equation obtained from the use of a Cobb-Douglas might ignore relevant variables and might lead to vague interpretations of causation. The high correlation between private and public capital causes multicollinearity in the estimation of regional production functions, which include both types of capital as inputs (Arias *et al.* 2005).

The basic model can be written as follows:

$$Y_{it} = f(A_t, L_{it}^{\alpha}, Kp_{it}^{\beta}, Kg_{it}^{\gamma}, U_{it}) \text{ , (1)}$$

where:

Y – Aggregate output,
A – Total factor productivity,
L – Labor,
Kp – Stock of private capital,
Kg – Stock of public infrastructure,
U – Environmental risk factor.

The basic model can be extended by introducing of elasticity α, β, γ in respect to private capital, labor and public capital, where the effects in total product and *i* and *t* indexes represent regions or clusters and time periods. Following the pioneering study of Aschauer (1989) with the constant returns to all inputs:

$$\ln\left(\frac{Y_{it}}{Kp_{it}}\right) = \ln(A_{it}) + \beta\left(\frac{L_{it}}{Kp_{it}}\right) + \gamma\left(\frac{Kg_{it}}{Kp_{it}}\right) \text{ , (2.1)}$$

Aschauer (1989) triggered numerous researches in the literature on the public infrastructure at the national and regional level. The main issue of the studies was an extensive discussion about the role of public investments in creating national income.

In the pioneering study of Aschauer (1989), a constant (a_0) and a time trend (*t*) are introduced as a proxy for multifactor productivity ln (A_t). Moreover, the capacity utilization rate (CU_t) is also included to as a regulating mechanism for the effects of the business cycle on productivity. Celebi (2007) explains that the utilization rate depends primarily not only on the state of economy but also the stage of business.

However, for a deeper analysis, it is important to differentiate two types of public capital: physical infrastructures (*Kgd*), which are directly related to the production and social infrastructure (*Kgs*), which is not expected to have a direct effect on growth, but will affect the future development level. Hence, the risk factor can also be included to control the side-effects of the business cycle on productivity and political disturbances *u* for the given time period and region.

Then the following equation is:

$$y_{it} = a_t + \alpha l_{it} + \beta kp_{it} + \gamma_1 kgd_{it} + \gamma_2 kgs_{it} + u_{it} \text{ , (2.2)}$$

The small letters denotes that our variables are in natural logarithmic terms. The second equation is considered to be part of the heterogeneous clusters. For this reason, the population density is involved in the case of social capital. This assumption is made to reflect the fact that infrastructures are important not because they are a direct part of the production process, but because they provide additional value added to firms through skilled workers and a better production organization.

The panel data analysis can be employed. With repeated observations of enough cross-sections, panel analysis permits study the dynamics of change with short time series. In this respect, non-stationary panel analytical procedure can be applied to investigate the macroeconomic effects of public capital between clusters under the aggregate Cobb-Douglas production function framework, as described. Models have to be estimated by methods that handle the problems afflicting them. Use of a pooled data set reduces the likelihood that data are non-stationary. If data are non-stationary, the positive elasticity coefficients

which emerge from estimation may reflect spurious correlation.

Polak and Heertje (2000) points out that for transportation infrastructure it is not easy to take into account its network properties in the production function approach. One possible approach is to distinguish various types of transport infrastructure according to their spatial dimensions.

With this respect Rietveld and Bruinsma (1998) emphasize a few factors in both the theoretical and empirical studies and offer to measure analyze the infrastructure issue from the various aspects. One of them is the accessibility, which changes measured by different ratios and sometimes fairly complicated formulas are one of the most important effects of the transport improvements. Another aspect is the influence of transportation costs on the production scale in the specific area.

5. Model estimation and practical aspect

The practical estimation included data set of East European countries EU members and CIS economies from the Worldbank, Russian Federal State Statistics Service of Russian Federation and Eurostat in terms of the public sector investments and consumption, output and labor, private capital, road infrastructure. The data set was combined from different sources for the period of 1990 up to 2010 and considered the main frequent problems of the cross-section analysis: correlation, heteroscedasticity and data non-stationary.

The *Output* can be represented by GDP using purchasing power parity GDP data. The major problem in the data set is about *capital* variable, both private, public capital and infrastructure capital. The principles of capital accounting are highly distorted in transition economies. It the public capital can be approximated by the Gross fixed capital formation figure given by the World Bank, which includes construction of roads and railways.

For extended analysis the panel dataset includes of the qualified labor force. The model needs to include variables reflecting changes in the private stock by the infrastructure policy. The variable is derived from the European Bank for Reconstruction and Development's (European Bank 2011) to see the degree of market reform openness in the major infrastructure sectors. Including the indicator of infrastructure reform makes possible to proxy the participation of private capital stock in the infrastructure development.

Depending on estimation of different econometric models it might result economic significance of the infrastructure factor in the economic growth different way.

It was found a strong positive and significant correlation between infrastructure and the manufacturing sector's output. Within the Cobb-Douglas production function framework, the idea that infrastructure considered in the production function as a public input. The influence of the infrastructure factor such as density of the network is positive and statistically important.

It is hard to analyze the infrastructure datasets due to unexpected shift in a time series. This can lead to considerable forecasting errors and unreliability of the model in general. The result of the Chow test for structural break in the estimated function for the two clusters gave an F-statistic of 4.907, which was significant at 1 % alpha level.

The Breusch-Pagan test gave significant indications of heteroscedasticity. Another issue is that the multicollinearity factor between the role of private and public capital in the framework. If the degree of multicollinearity increases, the regression model estimates of the coefficients become unstable and the standard errors for the coefficients can be seriously affected.

Nevertheless, for the regression of the total factors of productivity growth in respect of growth of the infrastructure accessibility it is obvious that the variation among regions is important to explain the contribution of infrastructure to output. The infrastructure can explain about 4 percent of the observed variance in total productivity growth across the clusters. However, the estimation of translog function called for controversial results. The joint estimation offered is rather significant results, but the single variables appear to be insignificant. Therefore, the estimates seem to be rather incomplete, because it is not possible to draw the conclusion whether or not infrastructure alone is able to improve factor productivity.

6. Conclusions

Estimating the growth effect is not an ordinary task. Depending on a number of factors, it is crucial to elaborate a theoretical framework, which can embrace as many factors as possible.

First of all, any research on infrastructure should have a broader scope and should not be limited on country-specific parameters but include configurations in clusters over the borders.

The second findings provided the result that public infrastructure may influence output during a longer time period with a time lag. Therefore, the effectiveness of any infrastructure development policy should be evaluated over a longer time period. Further the issue of positive impact on economic productivity in the emerging economies should be scrutinized. As it proved in many

studies that infrastructure is a development factor with a positive but very modest effect on productivity.

Another conclusion is that differences in infrastructure have an impact on regional and sectorial development. The presence of interdependencies among regions has been shown to be some of the issues that make the link between infrastructure and growth complex.

References

Aschauer, D. 1989. *Economic Impact Analysis of Transit Investments: Guidebook for Practitioners* [online] [accessed 9 December 2011] Available from Internet: <http://gulliver.trb.org/publications/tcrp/tcrp_rpt_35.pdf>.

Arias, C.; Rodriguez-Valez, J.; Alvarez, A.; Fernandez, E., 2005. *Estimating the Productivity of Public Infrastructure Using Maximum Entropy Econometrics* [online] [accessed 3 December 2011] Available from Internet: <http://www.eco.uc3m.es/temp/arias.pdf>

Bell, M. et al. 1994. *Intelligent transportation systems: evaluation, driver behavior, and artificial intelligence*. Washington, D.C.: National Academy Press. 104 p.

Blien, U.; Maier, G. 2008. *The Economics Of Regional Clusters*. Edward Elgar Publishing. 311 p.

Chatterjee, S.; Roy, K. 2003. *Growth, development and poverty alleviation in the Asia-Pacific.* Nova Publishers.

Celebi, M., 2007. *The relationship between private economic growth and public nonmilitary infrastructure capital stock*. Kansas State University. 162 p.

Clementina, I. 2008. *Impact Of Globalization On Macroeconomic Policy* [online] [accessed 19 November 2011] Available from Internet: <http://www.revecon.ro/articles/2008-2/2008-2-4.pdf>

EIM. 2006. *The First EU Railway Package* [online] [accessed 1 October 2011] Available from Internet: <http://www.eimrail.org/pdf/bro/EIM_ERFA_ERFCP-Revision_of_1st_RP-17.01.06_1.pdf>.

European Bank. 2011. *Crisis in Transition: The People's Perspective* [online] [accessed 9 December 2011] Available from Internet: <http://www.ebrd.com/pages/research/publications/flagships/transition.shtml>.

Goldman Sachs. 2003. *Global Economics Paper No: 99* [online] [accessed 12 December 2011] Available from Internet: <http://www2.goldmansachs.com/our-thinking/brics/brics-reports-pdfs/brics-dream.pdf>

Gourdin, K. 2000. *Global Logistics Management.* Wiley. 344 p.

Inda, J., Rosaldo, R. 2007. *Anthropology of Globalization*. Blackwell Pub. 481 p.

Kasabov, N. 2007. *Evolving Connectionist Systems: The Knowledge Engineering Approach*. Springer. 473 p.

Kohsaka., A. 2006. *Infrastructure Development in the Pacific Region.* Routledge. 471 p.

Martin, M. 2004. *Globalization, Macroeconomic Stabilization, and the Construction of Social Reality*. Lit Verlag. 471 p.

OECD. 2006. *Decoupling the Environmental Impacts of Transport from Economic Growth* [online] [accessed 11 October 2010] Available from Internet: <http://www.oecd.org/document/7/0,2340,en_2649_34363_37676487_1_1_1_1,00.html>.

OECD. 2007. *Globalisation and Regional Economie*. [online] [accessed 9 December 2011] Available from Internet:<http://www.oecd.org/document/34/0,3746,en_2649_33735_39362594_1_1_1_1,00.html>.

Pesaran, M.; Schmidt P. 1999. *Microeconomics. Handbook Of Applied Econometrics (2).* Wiley-Blackwell.

Peterson, G.; Annez, P. 2007. *Financing Cities: Fiscal Responsibility and Urban Infrastructure in Brazil, China, India, Poland and South Africa*. Sage Publications India Pvt Ltd.

Polak, J.; Heertje, A. 2000. *Analytical Transport Economics.* Edward Elgar Publishing.

Renaisance Capital. 2009. *Russian Infrastructure*. [online] [accessed 11 October 2011] Available from Internet:<www.ppppf.ru/docs/1276006958.pdf>.

Retrack. 2011. [online] [accessed 11 October 2011] Available from Internet: <http://www.retrack.eu>

Rietveld P.; F. Bruinsma. 1998. *Is transport infrastructure effective?* Springer-Verlag. 383 p. ISBN 978-3-540-64542-9. http://dx.doi.org/10.1007/978-3-642-72232-5

Salais, R. 2005. *Europe and the Politics of Capabilities.* Cambridge University Press. 332 p.

World Bank Data. [online] [accessed 11 October 2011] Available from Internet: <http://data.worldbank.org/>.

World Bank, *Asian Development Bank, Japan Bank for International Cooperation. 2005. Connecting East Asia: A New Framework for Infrastructure. World Bank.*

World Bank. 2006. *World Development Report.* [online] [accessed 18 October 2011] Available from Internet: <www.worldbank.org/wdr>.

World Bank. 1999. *Czech Republic: Toward EU Accession.* World Bank. 33 p.

Yoshino, N., Nakahigashi, M. 2000. *The Role of Infrastructure in Economic Development* [online] [accessed 15 October 2011] Available from Internet: <http://web.econ.keio.ac.jp>.