TRANSPORTATION INFRASTRUCTURE AND ECONOMIC GROWTH: THE CASE OF ROMANIA

by

Mihail Pogrletchi

A thesis submitted in partial fulfillment of
the requirements for the degree of

MA in Economic Analysis
.

Kyiv School of Economics

2014

Thesis Supervisor: ______________________ Professor Tetyana Dubovyk

Approved by ______________________
Head of the KSE Defense Committee, Professor Irwin Collier

____

____

____

Date ______________________

Kyiv School of Economics

Abstract

TRANSPORTATION
INFRASTRUCTURE AND
ECONOMIC GROWTH: THE
CASE OF ROMANIA

by Mihail Pogorletchi

Thesis Supervisor: Professor Tetyana Dubovyk

This thesis analyze the impact of transportation infrastructure which differs in terms of quality and administrative status in Romania on economic growth, using panel data on the county level for the period from 1995 to 2010. The general model is built on the basis of Cobb-Douglass production function, adding extra infrastructure variables. Model with lagged values of infrastructure variables is used in order to get the results, which are robust to endogeneity.

The results of models with different specifications show convincing evidence that Gross Regional Product is more sensitive to roads with national administrative status. At the same time, lower quality roads are an important driver for economic growth having county status. Also stock of roads makes larger distribution to economic growth in counties with lower quality of government, while overall stock of capital has larger impact on growth in counties with better local government.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The author wishes to express sincere gratitude to his thesis advisor Professor Tetyana Dubovyk for the continuous support, motivation and supervising of my work. Additionally author address words of words of thankfulness to all Research Workshop Professors and especially to Professor Tom Coupe, Professor Dennis Nizalov and Professor Elena Besedina for their comments and advices for this research.

The author kindly thanks his family for the motivation and financial support during author's study in KSE.

Special thanks for Yulia Ghenova for the spiritual support during the last four years, when the author was a student.

Thanks to all my colleagues and especially to Artur Grygorian for motivating discussions, support and collaboration.

GLOSSARY

GRP. Gross Regional Product

Development regions of Romania. The eight regional divisions created in Romania in 1998 in order to better co-ordinate regional development as Romania progressed towards accession to the European Union.

EU. European Union.

NUTS. Nomenclature of Units for Territorial Statistics

Chapter 1

INTRODUCTION

A considerable amount of studies on infrastructure around the world show a positive influence of improvements in different kinds of transportation infrastructure and infrastructure in general on economic growth and development of regions and countries as a whole. In this paper, we analyze the impact of roads and railways transportation infrastructure on economic growth in Romania. The case of Romania is of interest since Romania is a transition country, which has recently joined EU. Thus, EU is often associated with trade liberalization, so transportation infrastructure plays a crucial role within this framework. Actually it is impossible to benefit from liberalization of trade and following economic growth without developed transportation infrastructure. The majority of transportation services are conducted by the roads and railways system in Romania. For example, 74% of goods were transported by roads and 14% by railways in 2010

The results of this thesis can generate valuable recommendation for the implementation of development policies in the field of transportation infrastructure. It is of importance because Romania is in the bottom of the transportation infrastructure in the EU, and a lot of developments in this area should be realized in Romania in the future. Moreover, Romania is in the process of implementing the "Intermodal transport strategy in Romania 2020" and probably the results of my thesis may be relevant for to actualization of this strategy.

The specification of this study is not only the fact that it is done for Romania. It also evaluates not only the impact of different types of transportation infrastructure (paved roads and railways) it also estimates the impact of paved roads with different quality of covering. Moreover, we estimate the impact of roads with different administrative and geographical status on economic development of Romanian regions (national roads and county roads).

In order to estimate the impact of transportation infrastructure on real regional GDP I follow the approach of Canning (1999), who added to the usual Cobb-Douglas production function, several variables describing different kinds of infrastructure. I use the panel data for 41 Romanian counties and the municipality of Bucharest (42 regions) during the period from 1995 till 2010 years. The data are provided by Romanian National Company of Motorways and National Roads (RNCMNR). Unfortunately larger samples with data on a more disaggregated level (on cities and communes) are not available since RNCMNR has only counties offices.

This thesis has the following structure: first two chapters are devoted to Introduction and Country profile of Romania. Literature review is oresented in the third chapter. The fourth chapter describes the model and methodologies to be used in order to conduct panel unit root test and get robust estimations. The last two chapters discuss the results and corresponding conclusions.

C h a p t e r 2

ROMANIA. ECONOMIC PROFILE

2.1 Internal sector

Romania performed an huge transition over the last 25 years: from the collapse of the communist regime in 1989 to integration in EU in 2007. Generally, this period of time can be characterized as a period of economic development and growth. However, the real GDP dynamics was not a stable up trend, it fluctuated during the last decade of the twentieth century, and decreased being affected by the world financial crisis.

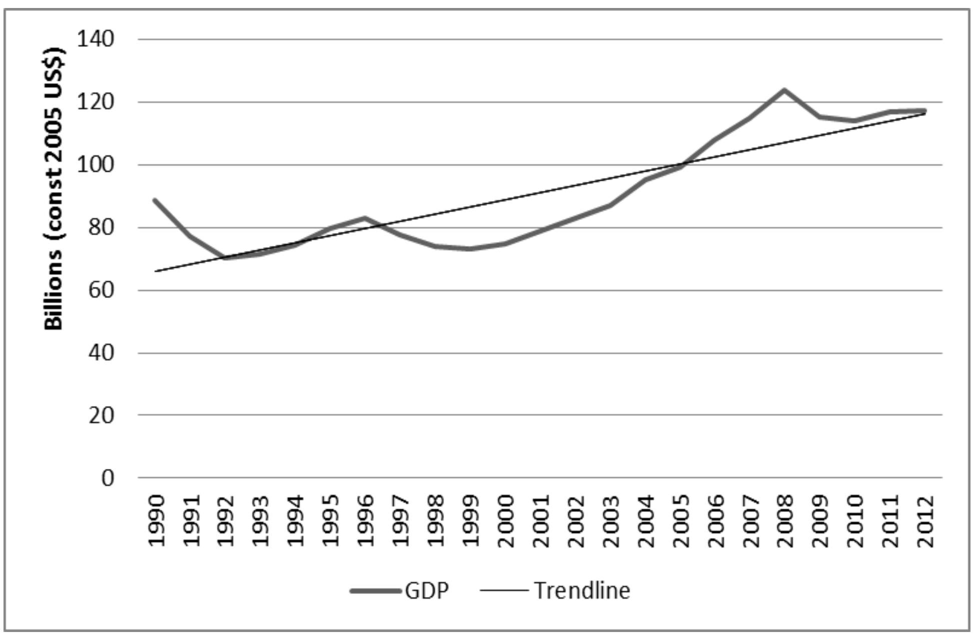

Figure1. The dynamic of real GDP (1990-2012)

The structure of GDP is divided into three sectors: industry, services and agriculture. The services area became one of the dominant share in GDP structure in the analyzed period (51.65% in 2012), one of the reasons for this increasing dynamic is the fact that Romanians enjoyed large amounts of remittances. Agricultural area also followed a down trend in GDP structure from about a quarter og GDP in 1990 to about 5% in 2012. The main agricultural products are: wheat, corn, grapes, eggs and sheep. The industry share of GDP declined from 1990 to 2000 losing the position of the largest GDP component from 49.94% in 1990 to the minimum value of 33.44% in 2000, which means that it was going on during the period of GDP fluctuations, after that it started to grow reaching the value of 43.5% in 2012.The most important industrial products are machinery and equipment, light auto assembly, construction materials and others.

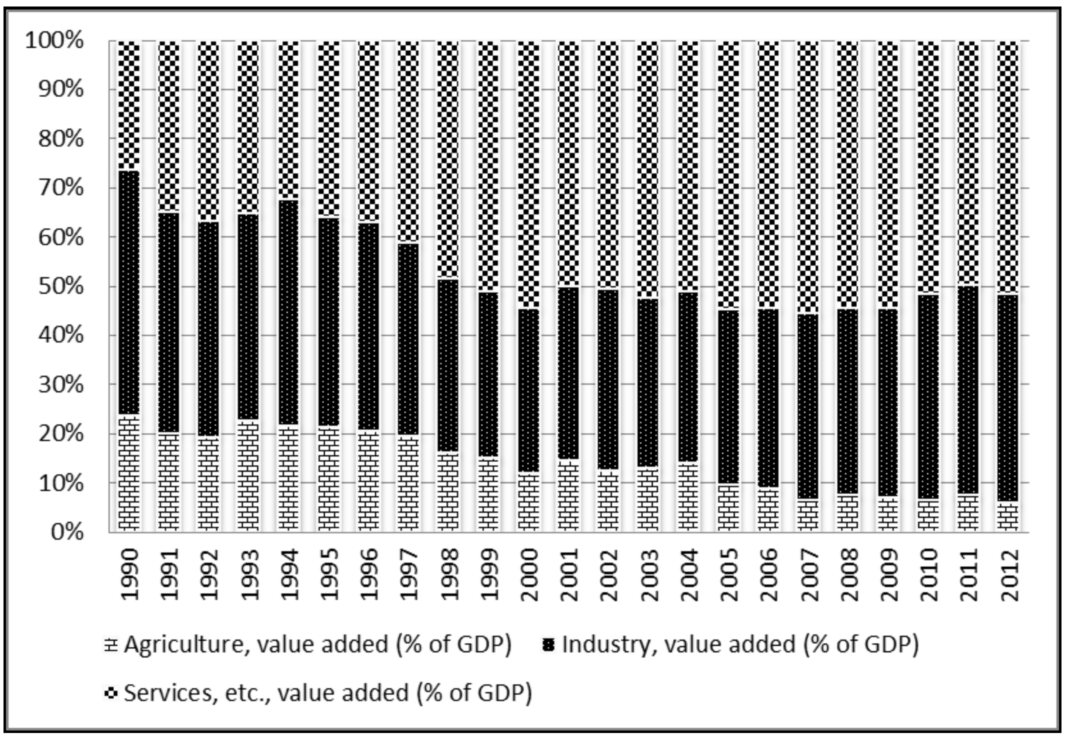

Figure2. The dynamic of GDP structure (1990-2012)

Unemployment rate showed fluctuations between 6-8% at significant decrease in population from about 23mln persons to 20mln during the analyzing period. The youngest part of working-age population suffers the most with unemployment rate of 23.7% according to UN data.

2.2 External sector

Romania experienced negative trade balance during the period of interest. Moreover the gap between Import and Export increased during the period of GDP growth (2002-2008) and sharply decreased during the crisis period. The main Export and Import partners are Germany, Italy and France. Another import partners are Russia and Kazakhstan.

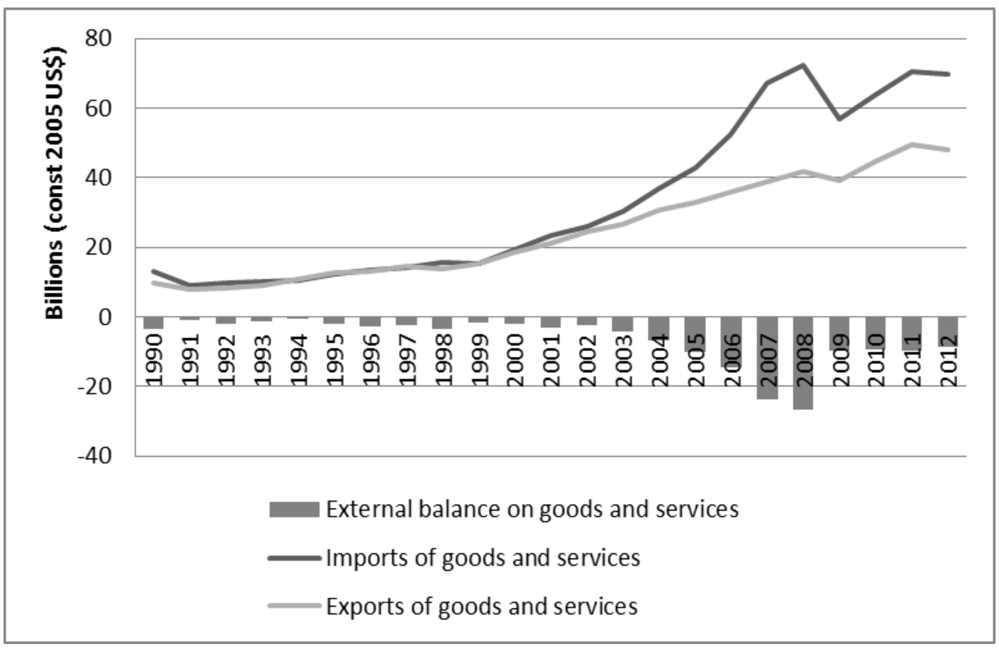

Figure3. The dynamic of the Trade balance deficit (1990-2012)

2.3 Regional development

Romania was divided into 8 development regions in order to simplify implementations of projects in EU integration framework, however these development have no administrative status or regional authorities. Simultaneously, the official administrative division includes 42 counties (including municipality of Bucharest). The average population of counties is about half a million and almost all of them experienced the decrease of population during the last 25 years in line with general tendency in country. Decrease in population can be explained by the migration and superiority of death rate over birth rate. Regional unemployment rate differs from 5%-7% in the North development regions to 8%-9% in the South regions and the highest unemployment is registered in Central counties. Gross regional product followed up trend in all counties. The distribution of GRP produced in 2010 is shown on the figure #4. So the greatest part of GDP is produced in the West and Central regions.

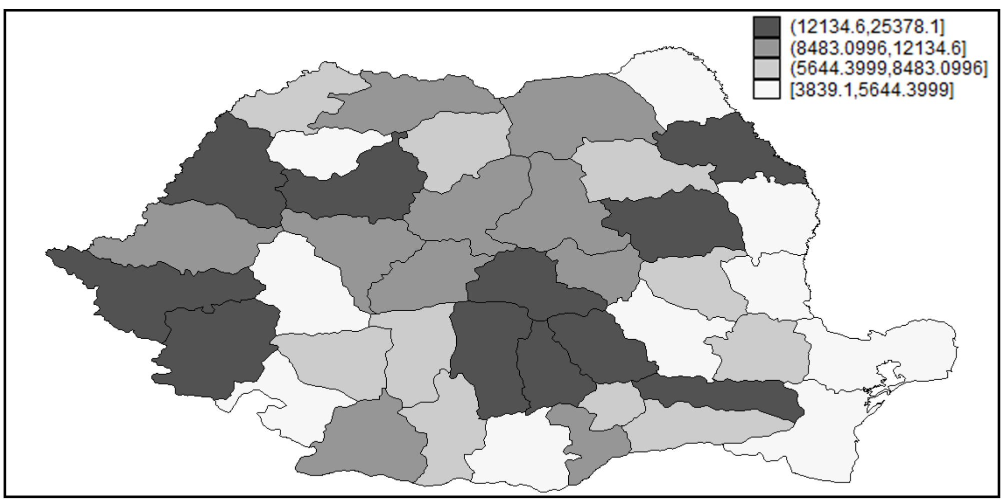

Figure 4 The Distribution of GRP in 2010

Chapter 3

LITERATURE REVIEW

The relevant literature on this topic can spited in several groups and sub groups according to the following structure: firstly, different kinds of development in transportation infrastructure may be used as independent variable to explain the dynamics of the real Gross Domestic Product, an alternative way is to use of the same explanatory variable for Total Factor Productivity (TFP), which is also a very important driver of economic growth according to the Solow Growth Model. The next issue is the data, which can be used in such models. Generally, there are two alternatives: to use investments, both public and private, in transportation infrastructure as independent variables or to use real stock of corresponding infrastructure for the same purpose. Having real stock of infrastructure there are three alternatives of normalization: it is possible to use the length of transportation channels such as different types of roads, railways or water channels in per capita or per worker terms, another opportunity is to use spatial density, dividing the stock of infrastructure by the area of corresponding region or country. A separate part of the literature includes articles, which offer solutions to problems related to endogeneity caused by reverse causality. Such issues often arises in models which explained economic growth by stock of capital, since it is not clear what exactly causes the increase: on the one hand, increase in the stock of infrastructure capital can contribute to higher productivity and increase in output or vice versa high levels of output allow to allocate more resources for accumulation of different types of infrastructure. Another separate part of literature review part is concern with estimations of the quality of government, since we try to estimate the influence of the quality of government on the impact of transportation infrastructure on economic growth.

3.1 TFP, real GDP and alternative approaches

Cantos et al (2005) used both methods in order to estimate the impact of aggregated stock of transportation infrastructure and impact of four separate types of infrastructure: roads, airports, ports and railways on the case of Spain. Firstly they introduced transportation variables in Cobb-Douglas production function and estimated the impact of variables of interesting on real GDP. Secondly having determined values of TFP they tied to explain it by infrastructure variables. They used fixed effect regressions and got the following results: about 10% increase in aggregated transportation infrastructure is associated with about 0.42% increase in the level of output and 0.38% increase in TFP. Regressions with different types of infrastructure showed that road infrastructure generally contribute more than any other analyzed type in both GDP and TFP.

One more Cantos et al (2005) interesting finding is a positive network effect of transportation infrastructure. In order to estimate it they run the same regressions, but now they summed stocks of infrastructure from several geographically closed regions into one observation instead of using usual region data. So here they tested the hypothesis that stocks of infrastructure available in one region has positive spillovers for neighbor regions. So they got higher coefficients on variables of interest using aggregated data than using regional data. For example they got that the same 10% increase in overall transportation infrastructure is associated with 0.62% increase in real GDP (instead of 0.04% in previous case) and 0.61% increase in TFP (instead of 0.38%, using regional data). Both coefficients shows that network effect on transportation infrastructure exists in Spain.

Na at all (2011) also find the network effect of motorway stocks in per workers terms. They used data for 19 OECD for the period of 17 years (1990-2006) countries in order to estimate the impact of motorways stock on TFP. They used many models, which included a set of control variables, which also can be TFP drivers.

The existence of the network effect also is found by Rodrigue et al (2013), who consider the utilization level of transportation infrastructure as an important element of the economy and driver of economic development. They split the impact of transportation into three groups: direct impacts, which include such benefits as an higher degree of accessibility to markets resources, savings in time and costs and overall increase in output as a result; indirect impacts, including the advantages related to the fact that there are a lot of linkages among transportation infrastructure and other sectors of the economy. For instance, the construction and maintenance of a highway or even simple four-lane paved road lead to the increase in local employment and purchases from local suppliers of construction materials and other goods and services; related impacts, which include benefits from dependence between agents economic performance and the quality and/or effectiveness of transportation system.

Another impact of transportation infrastructure is mentioned in World Bank (2011), which claimed that the development of transportation infrastructure also leads to economic growth. Since the developed and qualitative road and railway network contributed to lower cost distribution of goods among an huge set of regions and locations and increase in productivity through the availability of access to diversified set of resources. Another important feature of the development in transportation infrastructure is the increase reliability of traffic, which results in reducing of costs due to road accidents.

In the following articles the authors tried to explain dynamic of GDP by different types of infrastructure, including roads and overall transportation infrastructure.

Estache et. al (2005) obtained other significant results for African countries. They used the augmented Solow model in order to estimate the impact of the set of infrastructures such as roads, telecommunications, water supply, electricity supply and sanitation on the GDP. "All infrastructure sub-sectors, except sanitation, are shown to be statistically significant engines of growth. In other words, they contribute to explain Africa's GDP growth prospects" (Estache et. al, (2005)).

Following Estache et. al (2005) approach Seethepalli et al (2008) estimated the relationship between economic development and the stock of infrastructure. They figured out that higher levels of economic growth are usually related to huge infrastructure stocks. Their research is based on the data of 16 Asian countries for two decades. They used GDP in real terms as the dependent variable and the following independent variables: roads, water supply, sanitation infrastructure, electricity supply and telecommunications.

At the end of this section I want to mention several alternative approaches, which also shows the importance of infrastructure for economic development.

So, Esfahani and Ramires (2003) focused their research on costs related to building and maintenance of infrastructure, its contribution to the economic development and quality of governmental institutions. The results show that the benefits of infrastructure usually exceeds corresponding costs, however, the quality of governance is more important driver of economic development than the infrastructure itself. Their research was based on the data from 75 countries for the period of 30 years.

Shepherd and Wilson (2006) show that road quality and infrastructure clearly matter for trade in the Eastern Europe and Central Asia regions. They developed a simulation of a feasible but optimistic scenario of the development of the paved road network in this region. The results of above mentioned simulations show that in any case, the combined impact of the improved road network quality and improving trade facilitation appears likely to produce gains well in excess of those that could be expected from comparable tariff reductions.

3.2 Real stock of infrastructure and Investments

Sanchez at al (1998) used two data sets the first one with 57 countries for 15 years period and the second one with 19 countries for period of 12 years. The specification of their research is that they used two different approaches for both samples. First of all they estimated the impact of infrastructure on economic growth by using expenditures on infrastructure as independent variables. They unexpectedly obtained negative coefficients for the first sample (57 countries), however, these coefficients were statistically insignificant. Applying the same approach to the next sample they got both positive and significant coefficients, however, these coefficients were very small.

Nevertheless, using physical units of infrastructure as independent variables and the same samples, they estimated a positive and statistically significant influence on economic development. Another advantage of the second approach is that stocks of infrastructure represented in physical units are easily comparable among countries around the world.

The case of using real stock arises the issue of normalization, there are three possible ways, as mentioned before: to divide stock of infrastructure capital by the number of people or workers, the third alternative is to divide stock of infrastructure by the area of corresponding region or country.

Queiroz and Gautam used two types of the regression analysis. They used GDP per capita of 98 countries as dependent variable and length of roads per inhabitant as independent variable in the first case and spatial road density as independent variable in the second. The second approach got the most significant result with the coefficient of determination about 0.76.

Using the first one they estimated the coefficient in correlation equation between per capita GDP and length of paved roads in per capita terms. So the increase in the lengths of paved roads per inhabitant by one millimeter is associated with the increase in $1.39 of the per capita GDP with the coefficient of determination equal to 0.5.

So both approaches give statistically significant results. The main conclusion of this research is that the coefficient 1.39 is an indicator which can help to make interpretation of a country's stock of paved roads. So countries with their coefficients above 1.39 have probably scarcity of paved roads and need some quantitative improvement of their paved roads system, while countries with coefficient less than 1.39 are likely to have too much paved roads and should concentrate on keeping or improving in terms of the quality of their current road system.

In the same paper Queiroz and Gautam (1992) also analyzed relationships between density of paved roads in km per 1000 inhabitants and per capita Gross National Product in $1000 per inhabitant based on US data. They used OLS in order to get estimations of road contribution to economic growth and intercept. Unfortunately, the negative value of the intercept has no straight forward interpretation. At the same time, coefficients on the length of roads per 1000 inhabitants remain statistically significant in case when the equation is forced to go through the origin, indicating significant impact of the length of paved roads on the GDP in the US

Moreover, these data and equation give a good possibility to estimate the time lag between the construction of the roads infrastructure and the impact on per capita

GNP. "We found the highest correlation existed when GNP for a given year was associated with the length of roads per 1000 inhabitants four years earlier. This seems to indicate that paved roads had an effect on GNP, but there was a lag of about four years between construction and ultimate effect. (Queiroz and Gautam (1992))

Canning (1999) used different types of infrastructure, including the stock of transportation infrastructure, in per worker terms. He used the panel data on cross-country level for the 30 years period (1960-1990) in order to estimate the impact of the following stocks of infrastructure: the number of telephones, electricity generated capacity and the lengths of roads and railways. He found that electricity and transportation stocks of capital have the impact on real GDP

3.3 Reverse causality

Reverse causality is quite common econometric problem for the majority of models discussed in this section, as we mentioned at the very beginning. However, there are several approaches which help to get estimations robust to reverse causality. For instance, Canning (1999) uses the cointegration method described by Kao and Chiang (2002) in order to get results, which are robust to reverse causality. An alternative issue is to use lags and/or instrumental variables. Thus, Cantas et al (2005) used lagged values of the stocks of the infrastructure to instrument the current stock of the infrastructure by lagged values of this variables.

3.4 Quality of local government

Sundström and Stockemer (2013) used data for 174 regions of 18 EU countries (including Romanian regions) provided by European Election Database in order to estimate the relationship among the quality of local government and voter turnover. Using multi-level model they showed that the voter turnover had positive relations with the quality of local government measured by European Quality of Government Index. In particular in regions with good governance there are 20 percent points more active citizens during elections.

Chapter 4

THE DATA AND MODEL

The panel data include 41 Romanian counties and municipality of Bucharest (42 regions) during the period from 1995 till 2010 years (672 observations). The data are provided by the Romanian National Company of Motorways and National Roads (RNCMNR). Unfortunately, larger samples with data on more disaggregated level (cities and communes) are not available since RNCMNR holds only counties offices and it does not provide any statistics on any deeper level.

In order to estimate the impact of infrastructure on economic growth I'm going to follow the approach described by Canning (1999). Using the Cobb-Douglass production function:

$$Y_{it} = A_{it} K^{\alpha}_{it} X^{\beta}_{it} L_{it}^{1-\alpha-\beta} U_{it} \qquad (1)$$

Where: Y is the GDP produced in the region i in year t; A is the aggregate factor of productivity; K is a real stock of assets accumulated in the region i; X is the stock of infrastructure assets; L is labor; U is the error term; i is the index of the country or municipality and t is the index of the time. Also it is important to introduce a set of assumptions for this model: the first one is constant return to scale, that is why, the second assumption is that log $A_{it} = a_i+b_t$, where a_i is regional or municipality fixed effect and b_t is the whole country's overall productivity in a given year t.

Deriving by L and then taking logs in (1) it is easy to derive:

$$y_{it} = a_i + b_t + \alpha k_{it} + \beta x_{it} + u_{it} \qquad (2)$$

After that I can split the variable x (infrastructure) into four different parts: the length of paved roads (roads) available in year t; the length of available paved roads after modernization in year t (mod_roads); the length of railways available in year t (railways). At this level it is important to introduce the assumption which says that all roads and rail ways in Romania have no differences in quality status.

So I am going to estimate the following models. I will start with a short model, which is supposed to show the evidence of road infrastructure impact on Romanian economic growth.

$$y_{it} = a_i + b_t + \alpha k_{it} + \beta_1 road_{it} + \beta_2\ railways_{it} + u_{it} \quad (3)$$

However, there is an interesting issue related to the quality of roads and its impact on economic growth. Due to data limitations I can use only two classes of the quality: the length of roads repaired or modernized during the period t in county i (mod_road) and roads with light covering (light_road), which are usually associated as roads of lower quality than average, sometimes such roads are built in regions with low traffic density.

$$y_{it} = a_i + b_t + \alpha k_{it} + \beta_1 road_{it} + \beta_2 mod\_road_{it} + \beta_3 light\_road_{it} + \\ + \beta_4 railways_{it} + u_{it} \quad (4)$$

Also I am going to test one more issue, using this model. There is probably a lag between stocks of available road infrastructure and the effect on GRP. It is possible to run GRP on independent variables from (3) by using different time lags. We will use time lags from 1 to 4 since my data with 16 periods do not allow to use longer lags. This exercise also allows to get results being robust to endogeneity caused by reverse causality.

After that I am going to split variables road, mod_road and light_road into two groups of the same variables, which will differentiate roads according to their administrative status:

- National roads – roads connecting cities or other administrative units located in different counties
- County roads – roads connecting cities or other administrative units located in the same county.

$$y_{it} = a_i + b_t + \alpha k_{it} + \gamma_1 nat\_road_{it} + \gamma_2 nat\_mod\_roads_{it} + + \gamma_3 nat\_light\_road_{it} + \gamma_4 cou\_road_{it} + \gamma_5 cou\_mod\_roads_{it} + \gamma_6 cou\_light\_road_{it} + + \gamma_7 cou\_light\_road_{it} + u_{it} \quad (5)$$

The next issue to be tested is the influence of the quality of local government on the impact of capital and the stock of different types of transportation infrastructure on economic growth. I use voter turnout as proxy of the quality of local government as Sundström and Stockemer (2013) shown that higher quality of local authorities has positive impact on voters participation rate during the elections. So we are going to split the sample into three groups according to the average voters turnout, which had place on Senate election in 2008 and 2012. The structure of these groups is provided in the Table A 3. So added the dummy variable eu, which is equal to 1 for periods from 2005 to 2010, when Romania joined EU, and zero otherwise. Logically it is expected that better government is associated with better usage of all resources and capital stocks.

The following data is used in order to fit models, described above.
The dependent variable is Gross Regional Product (GRP) in per capita in Romanian countries at constant prices 2000 in millions euro.

The independent variables are: stock of capital calculated by perpetual inventory method (k) at constant prices 2000 in millions euro; the length of all kinds of roads and railways used in (3) and (4) is in km. Descriptive statistics is provided in the Table 1.

The regional stock of capital is calculated according to the perpetual inventories method: the law of motion for capital is set up as the following:

$$K_{t+1} = (1-\sigma)*K_t + I_t \qquad (6)$$

I – formation of fixed capital \$ in real terms;K – stock of capital in period t \$ in real terms; σ – depreciation.

Depreciation σ is calculated as the following:

$$\sigma = \frac{1}{t_2-t_1+1} * \sum_{t=t_1}^{t_2} \frac{CF_t}{GDP_t} \qquad (7)$$

CF – consumption of fixed capital in \$ in real terms.

The first value of K is taken as three times GDP of the initial period (1991). The source of data for calculating of capital stocks is World Bank.

Both GRP and capital follow up-trend in almost all counties in Romania during the period of interest, with the largest growth during the first three years after entering EU. All paved road variables also follow up-trend. In general, Romania increased the stock of road capital by 15% during the period of interest. The stock of railways reduced in some counties, probably this surprising result can be explained by the fact that Romania Railways transfers from the large gauge standard to thin gauge standard, which is more typical for Western –Europe countries.

Table 1 Descriptive statistics

Variables	Mean	Std. Dev.	Min	Max
GRP	22.25917	19.2183	.5755646	86.3421
Capital	16800000	4788919	8999775	3780000
Roads	10.55598	2.851466	4.891147	16.94792
Railways	1.443507	.5981651	.5078896	3.372681
Modernized roads	2.856725	1.261793	1.025836	7.601776
Roads with light covering	2.809154	1.006297	.0195185	5.657764
National roads	2.16863	.8323797	.8320669	4.945813
National modernized roads	1.962744	.752465	.7864742	4.882192
National roads with light covering	.1770177	.1784841	.0052994	1.028623
County roads	8.387347	2.354392	3.454282	14.88448
County modernized roads	.8980365	.9378268	.0069156	5.942115
County roads with light covering	2.711734	.9158822	.07358	5.63152

Note: All variables are in per worker terms.

Chapter 5

EMPIRICAL RESULTS

We begin with estimation of coefficients of the model (3) using two types of regressions: Fixed effect and Random effect. The results are presented in the Table 2.

Table 2 Estimations of the basic model

	Fixed effect	Random effect
Log capital	1.324***	1.488***
	(0.03)	(0.02)
Log roads	2.215***	0.380***
	(0.25)	(0.07)
Log railways	-0.546***	-0.130**
	(0.13)	(0.05)
Constant	-25.145***	-23.800***
	(0.42)	(0.41)
R2	0.881	
Hausman test (pro>chi2)	0,0000	

*Note: The numbers in parentheses are standard errors, *,**,***indicates significance at the 10%, 5% and 1% levels respectively.*

Here fixed effect regression is preferable to random effect regression according to the Hausman test. The coefficient on the overall stock of roads is positive and statistically significant, however, the magnitude seems to be very large in comparison to estimations from others papers which deal with infrastructure variables in other countries. For instance Cantos at al (2005) showed that 10% increase in road infrastructure lead to 0.42% increase in GRP, using sata for

Spanish counties. Moreover impact of road infrastructure stock even exceeds the impact of overall capital, probably due to omitted variable bias. Negative signs of the stock of railways and intercept is unexpected and has no straight forward interpretation. The coefficient on the overall stock of capital is positive and statistically significant.

Table 3 presents the results of the extended model, which includes variables describing the stocks of road infrastructure with different quality: roads after modernization or reparation (high quality roads) and roads with light covering (low quality roads)

Table 3 Model with different quality of roads.

	Fixed effect	Random effect
Log capital	1.207***	1.468***
	(0.03)	*(0.02)*
Log roads	0,015	0,061
	(0.27)	*(0.10)*
Log modernized roads	2.218***	0.349***
	(0.16)	*(0.07)*
Log light covering roads	0.680***	0.094*
	(0.06)	*(0.04)*
Log railways	-0.545***	-0.192***
	(0.12)	*(0.05)*
Constant	-20.824***	-23.125***
	(0.48)	*(0.42)*
R2	0,91	

*Note: The numbers in parentheses are standard errors, *,**,***indicates significance at the 10%, 5% and 1% levels respectively.*

According to the results of the Hausman test, which shows chi^2 equals to 259.64 and p-value equals to zero, the results obtained using the fixed effect regression are preferable. Here the overall stock of roads has an insignificant effect, while both modernized and light covering roads have a significant positive coefficients. Moreover, the effect of modernized roads is almost four time larger than roads with light covering, however the magnitude of both effects seems to be unrealistically large, thus 10% increase in roads with light covering is associated with 6.8% increase in GRP, which seems to be doubtful.

Another interesting issue is to run the model (4) by using different subsamples. Romania was divided into 7 regions of development. These regions have no official or administrative status, they were established to simplify of the process of reforms implementation before entering the EU. Each of such regions includes from 5 to 7 counties. Fixed effect is also preferred to Random effect here according to the Hausman test performed for each region of development separately. The results are presented in the Table A1

Here the overall stock of capital has positive and statistically significant effect in each region. Modernized roads and roads with light covering also show positive and significant impacts across all seven regions of development. Nord-est and Sud-est regions shows a positive significant effect of the railways stocks. The overall stock of roads has insignificant impact in all regions. The larger impact of both modernized and light covering roads is estimated in the South region of development.

The next table shows the results obtained by checking for influence of the quality of the local government. This model also differentiates not only between roads with different quality of covering but also between roads with different administrative status. We consider separately national and county roads. Their impact on economic growth should differ since national roads system is responsible not only for transportation in Romania, but also for international transportation as well, while the impact of county roads is expected to be lower, but positive and significant, since transportation within the county directly depends on county roads network.

Table 4 Model for regions with different quality of local government

Variables	county	high	medium	low
log capital	1.172***	1.141***	1.150***	1.076***
	(0.02)	(0.05)	(0.03)	(0.05)
log railways	-0.211*	-0.327*	0,049	-0.935***
	(0.09)	(0.16)	(0.12)	(0.26)
log national roads	0.666*	3.409**	0.900**	-1.634*
	(0.27)	(1.05)	(0.34)	(0.74)
log national modernized roads	0.805**	-1,37	0,517	3.115***
	(0.27)	(1.17)	(0.31)	(0.76)
log national roads with light covering	-0,025	-0,013	-0,052	0,038
	(0.02)	(0.03)	(0.04)	(0.06)
log county roads	0.656***	-0,092	0.874***	0,222
	(0.16)	(0.35)	(0.21)	(0.43)
log county modernized roads	0,037	0,092	0,01	0.372***
	(0.03)	(0.07)	(0.03)	(0.11)
log county roads with light covering	0,05	0.325*	-0,018	1.050***
	(0.05)	(0.15)	(0.05)	(0.24)
eu	0.756***	0.705***	0.781***	0.542***
	(0.03)	(0.07)	(0.04)	(0.08)
constant	-20.097***	-18.859***	-20.416***	-17.264***
	(0.33)	(0.76)	(0.43)	(0.83)
R2	0,952	0,965	0,952	0,958

*Note: The numbers in parentheses are standard errors, *,**,***indicates significance at the 10%, 5% and 1% levels respectively.*

Expectedly the coefficient on capital and eu variable is larger in counties with high quality of government, however, many types of roads show inverse relationships, so county modernized roads and county roads with light covering have larger impact on GRP in counties with lower quality of local government. Being unexpected, these results are in line with corresponding literature. Thus

Steethepali et al (2008) showed that such types of infrastructure as water supply and stock of roads have lower impact in regions with high quality of government. A possible explanation can be the omitted variable bias: meaning that regions with better governance has many other drivers of the economic growth and roads are not such important as in regions with limited growth drivers due to poor performance of local authorities.

The next issue is to get the results, which are robust to reverse causality. Hence, we run per capita GRP on the lagged variables of infrastructure stocks. This exercise can show the lag between the construction or modernization of road stocks and its impact on economic development, also it can help to get the results, which are robust to reverse causality. I run one regression with lags from 1 to 4. The results are presented in Table A2.

The majority of significant coefficients are on variables with 3 and 4 lags. This result corresponds to those obtained by Queiroz and Gautam (1992), who show that roads are an important driver of economic growth, but there is 4 year delay between the period of building of the road and eventual impact on economic development. Another important result is the fact that significant coefficient on one year lag of the per worker stock of modernized national roads (0.881) in the model with lags is very close to the coefficient on this variable in the model which checking for the quality of government (0.805).

Negative coefficients of the TFP and railways is unexpected and surprising result in all models which are described above. Nevertheless, having panel data with 16 periods we perform Im-Pesaran-Shin unit root test for the panel data, with Ho: that all panels contain unit root and Ha: that at least some panels are stationary. According to results are reported in Table 5 and Table 6, we conclude that panels with data on national roads include unit roots. So it is a good strategy to use the first differences.

Table 5 Unit root test for levells

Variables	W-t-bar	P-value
log national roads	0,68	0,75
log national modernized roads	-0,81	0,21
log national light covering roads	Insufficient number of time periods to compute W-t-bar	
log county roads	-9.76	0
log county modernized roads	-2,71	0
log county light covering roads	-8,86	0

Table 6 Unit root test for first-differences.

Variables	W-t-bar	P-value
log national roads	-8,29	0
log national modernized roads	-8,63	0
log national light covering roads	Insufficient number of time periods to compute W-t-bar	
log county roads	-8.62	0
log county modernized roads	-5.53	0
log county light covering roads	-21,67	0

Table 6 shows the estimation of the model with first-differences. According to the Hausman test I use random effect regression in order to estimate coefficients in model (5). There is a positive and statistically significant impact of the overall capital, moreover the intercept is also positive and significant. The impact of railways stock is positive, but small and insignificant even on a 1% level. The only significant coefficient on road-infrastructure variables is the coefficient on overall stock of roads with national status. So 1% increase in length of the national roads per 1000 workers is associated with 0.36% increase of GRP. These results are economically significant as well.

Table 6 Model with first differences and administrative status of roads

Road status	Variable	Fixed effect	Random effect
	ΔLog capital	0.629***	0.630***
		(0.02)	(0.02)
National	ΔLog roads	0.384**	0.360**
		(0.14)	(0.13)
	ΔLog modernized roads	-0,057	-0,051
		(0.13)	(0.12)
	ΔLog light covering roads	-0,005	-0,005
		(0.01)	(0.01)
County	ΔLog modernized roads	-0.031*	-0,027
		(0.02)	(0.01)
	ΔLog light covering roads	-0,016	-0,013
		(0.03)	(0.03)
	ΔLog railways	0,005	0,002
		(0.07)	(0.07)
	Constant	0.162***	0.162***
		(0.01)	(0.01)
	R2	0,644	

*Note: The numbers in parentheses are standard errors, *,**,***indicates significance at the 10%, 5% and 1% levels respectively.*

C h a p t e r 5

CONCLUSIONS

This research estimates the influence of transportation infrastructure, which differs in terms of quality and administrative status across different Romanian counties, on economic growth. We used Gross Regional Products in per worker terms as a measure of economic growth and regional stocks of different types of transportation infrastructure for the period from 1995 to 2010. So, we started with a short model which includes overall stock of capital, roads and railways. After that, we added two variables, which allow to distinguish between roads with different quality of covering. The next step was distinguishing among roads with different administrative status. However, our initial results suspected were difficult to interpret due to reverse causality problem and possible endogeneity. Hence we modified our model to include four lags of transportation infrastructure variables in order to get results, which are robust to reverse causality. For the last step, we performed the unit root test and used the model with first differences to get stationary time series in panel data. In all models and specifications, the GRP per worker is more sensitive for overall stock of roads with national status, since such roads usually get larger load of traffic. However, we may identify that roads with county status with light covering have higher influence on regional economic growth as compared to the national roads of the same quality.

We also control for the influence of the quality of local government on economic development. We used voters turnout as a proxy for the quality of local government. We find that the GRP per worker is less sensitive to the stocks of transportation infrastructure in regions with better government.

Overall, this research shows that different types of transportation infrastructure are important drivers for economic growth in Romania. Its impact is sensitive to the quality of the road covering and administrative status of roads and the quality of local government.

The following policy recommendation can be given. First of all, roads with national administrative status should be developed in order to achieve better economic performance. Secondly, quality of counties government should be also increased. Nevertheless impact of transportation infrastructure is larger in counties with low quality of government, impact of overall stock of capital and EU integration is larger in counties with better government.

Further research may be concentrated on estimation of the impact of others infrastructure variables such as water supply, electricity lines and others for longer periods of time. Moreover, the network effect of Romanian transportation infrastructure can be investigated.

WORKS CITED

Cantos, Pedro., Gumbau Mercedes.and Mercedes Joaquín. 2005. Transport infrastructures and regional growth: evidence of the Spanish case, Universitat de Valencia, Instituto Valenciano de Investigaciones Economicas.

Canning, David. 1999. The Contribution of Infrastructure to Aggregate Output, The World Bank Policy Research Working Paper 2246. World Bank.

Canning, David. And Edler Bennathan,. The Social Rate of Return on Infrastructure Investments, World Bank research project "Infrastructure and Growth: A Multicountry Panel Study" (RPO 680-89)

Chiang, Min-Hsien, and Chihwa Kao. 2002 "Nonstationary panel time series using NPT 1.3–A user guide." Center for Policy Research, Syracuse University.

Estache, Antonio, Biagio Speciale, and David Veredas. 2002 How much does infrastructure matter to growth in Sub-Saharan Africa?. World Bank.

Esfahani, Hadi Salehi, and María Teresa Ramírez. Institutions, infrastructure, and economic growth. *Journal of Development Economics* 70.2 (2003): 443-477.

Kao, Chihwa, Min-Hsien Chiang, and Bangtian Chen. International R&D spillovers: an application of estimation and inference in panel cointegration. *Oxford Bulletin of economics and Statistics* 61.S1 (1999): 691-709.

Na, Kyoung-Youn, Chirok Han, and Chang-Ho Yoon, 2013. Network effect of transportation infrastructure: a dynamic panel evidence. The Annals of Regional Science 50.1: 265-274.

Pradhan, Rudra P., and Tapan P. Bagchi. 2013. Effect of transportation infrastructure on economic growth in India: The VECM approach. *Research in Transportation Economics* 38.1: 139-148.

Lavina, S and Razvan Zaharia,. 2011. Romania. *European Journal of Political Research* 50 pp 1108–1117

Im, Kyung So, M. Hashem Pesaran, and Yongcheol Shin.2003 Testing for unit roots in heterogeneous panels. *Journal of econometrics* 115.1: 53-74.

Jean-Paul Rodrigue 2013. *The Geography of Transport Systems. 3rd ed.* New York: Routledge.

Queiroz, Cesar AV, and Surhid Gautam. 1992. Road infrastructure and economic development: some diagnostic indicators. World Bank Publications.

Raballand, Gael. 2003. Determinants of the negative impact of being landlocked on trade: an empirical investigation through the Central Asian case. *Comparative Economic Studies* 45.4: 520-536.

Sanchez-Robles, Blanca.1998. Infrastructure investment and growth: some empirical evidence. *Contemporary Economic Policy* 16.1: 98-108.

Seethepalli, Kalpana, Maria Caterina Bramati, and David Veredas. 2008. How relevant is infrastructure to growth in East Asia?. *World Bank Policy Research Working Paper Series.*

Sundström A. and Stockemer, D. 2013. Voter Turnout in the European Regions: The Impact of Quality of Government.

APPENDIX

Figure A1. The administrative division of Romania.

1 – Satu-Mare
2 - Maramures
3 – Suceava
4 – Botosani
5 – Bihor
6 – Salaj
7 – Bistrita-Nasaud
8 – Neamt
9 - Iasi
10 - Cluj
11 – Mures
12 – Harghita
13 – Arad
14 – Alba
15 – Sibiu
16 – Brasov
17 – Covasna
18 – Bacau
19 - Vaslui
20 – Vrancea
21 – Galat
22 - Timis
23 – Hunedora
24 – Vilcea
25 – Arges
26 – Dimbovita
27 – Prahova
28 - Buzau
29 – Braila
30 – Tulcea
31 - Caras-Severin
32 - Gorj
33 - Mehedinti
34 – Dolj
35 – Olt
36 - Teleorman
37 - Giurgiu
38 – Ilfov
39 – Ialomita
40 – Calaras
41 - Constanta

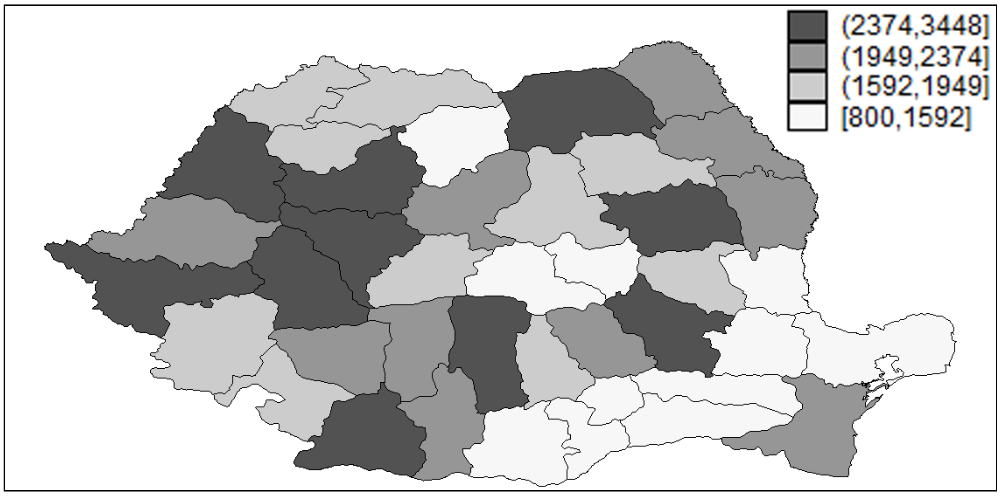

Figure A2. The road density (km).

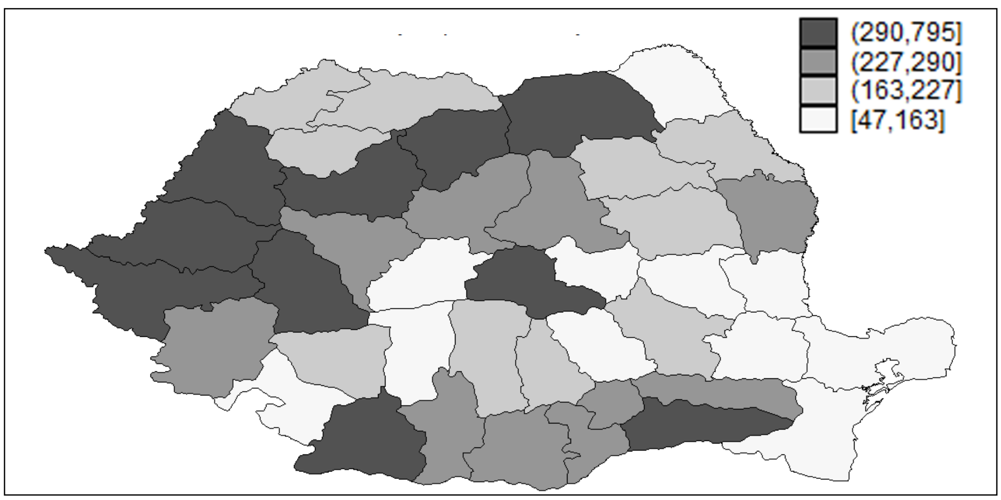

Figure A3. The railways density (km).

Table A1 The model with different quality of roads for regions of development

Variables	Country	North-Est	South-Est	South	South-West	West	Noth-West	Center
log capital	1.207***	0.903***	1.073***	0.887***	0.951***	1.396***	1.160***	1.111***
	(0.03)	(0.06)	(0.09)	(0.05)	(0.09)	(0.06)	(0.13)	(0.06)
log roads	0.015	0.527	0.110	-1.440	2.352	0.146	0.351	-0.169
	(0.27)	(0.91)	(0.68)	(0.89)	(1.41)	(0.38)	(1.42)	(0.47)
log modernized roads	2.218***	1.969***	1.809***	3.498***	2.213***	1.961**	3.408***	3.049***
	(0.16)	(0.30)	(0.34)	(0.46)	(0.49)	(0.66)	(0.85)	(0.38)
log light cover roads	0.680***	1.550***	0.448***	2.518***	0.667***	0.290	1.430***	0.651***
	(0.06)	(0.18)	(0.10)	(0.32)	(0.19)	(0.39)	(0.32)	(0.12)
log railways	-0.545***	1.476***	1.573***	-0.406**	-1.296	-5.415***	-0.584	-2.065***
	(0.12)	(0.40)	(0.28)	(0.12)	(1.57)	(0.58)	(1.14)	(0.26)
constant	-20.824***	-17.123***	-18.299***	-15.600***	-22.703***	-19.903***	-22.423***	-18.782***
	(0.48)	(1.47)	(1.24)	(1.18)	(3.25)	(0.88)	(1.93)	(0.91)
r2	0.910	0.974	0.924	0.972	0.941	0.963	0.899	0.937

*Note: The numbers in parentheses are standard errors, *,**,***indicates significance at the 10%, 5% and 1% levels respectively.*

Table A2 The model with lags. (Continuation)

Variables	Country	North-Est	South-Est	South	South-West	West	Noth-West	Center
log capital	1.529***	1.631***	0.745***	1.469***	0.662***	1.430***	1.555***	1.304***
	(0.02)	(0.09)	(0.19)	(0.06)	(0.17)	(0.29)	(0.12)	(0.07)
L. log railways	-0.313*	0.201	0.762**	-0.856***	0.069	-2.759**	-0.242	-0.154
	(0.13)	(0.38)	(0.26)	(0.21)	(0.66)	(0.94)	(0.55)	(0.26)
L2. log railways	-0.012	0.458	0.157	-0.075	0.797	0.085	-0.180	-0.068
	(0.15)	(0.37)	(0.27)	(0.27)	(0.70)	(0.88)	(0.59)	(0.31)
L3. log railways	0.001	0.109	0.325	-0.352	0.308	1.291	0.563	0.226
	(0.15)	(0.37)	(0.27)	(0.27)	(0.63)	(0.89)	(0.66)	(0.31)
L4. log railways	0.181	0.081	0.290	0.785**	0.336	1.338	0.142	0.433
	(0.11)	(0.32)	(0.21)	(0.23)	(0.45)	(0.81)	(0.57)	(0.27)
L. log national roads	0.881*	1.153	-1.158	0.638	1.507	0.180	-0.132	-2.188
	(0.39)	(3.62)	(2.43)	(0.59)	(1.68)	(4.67)	(1.08)	(2.11)
L2. log national roads	-0.372	3.432	-0.539	-1.114	-0.423	-4.639	-1.088	-2.954
	(0.41)	(3.42)	(2.10)	(0.60)	(1.90)	(7.34)	(1.08)	(2.38)
L3. log national roads	-0.183	1.110	3.424*	-0.329	1.595	0.241	-2.174	2.754
	(0.40)	(3.35)	(1.65)	(0.58)	(2.11)	(7.65)	(1.13)	(1.99)
L4. log national roads	-1.284***	0.624	-2.202	-1.505**	-0.396	1.387	-1.726	-2.090
	(0.36)	(3.12)	(1.35)	(0.50)	(1.67)	(5.07)	(1.02)	(1.56)

Table A2 The model with lags. (Continuation)

Variables	Country	North-Est	South-Est	South	South-West	West	Noth-West	Center
L. log national modernized roads	0.054	-0.828	1.778	0.704	-1.235	-0.958	0.787	2.819
	(0.38)	(3.52)	(2.37)	(0.65)	(1.66)	(3.81)	(0.94)	(2.27)
L2. log national modernized roads	0.613	-3.607	0.771	0.596	0.844	4.342	0.732	3.756
	(0.38)	(3.37)	(2.09)	(0.60)	(1.69)	(5.96)	(0.83)	(2.61)
L3. log national modernized roads	0.415	-1.405	-3.170	1.379*	-1.087	-1.871	0.986	-2.932
	(0.37)	(3.32)	(1.68)	(0.58)	(1.84)	(6.27)	(0.88)	(2.19)
L4. log national modernized roads	0.992**	-1.217	3.063*	0.685	0.880	0.291	0.379	2.430
	(0.33)	(2.99)	(1.46)	(0.47)	(1.48)	(4.17)	(0.58)	(1.65)
L. log national roads with light covering	-0.030	-0.227	0.110	0.156*	0.195	0.119	0.010	-0.099
	(0.04)	(0.28)	(0.15)	(0.06)	(0.16)	(0.34)	(0.23)	(0.06)
L2. log national roads with light covering	-0.001	-0.322	0.025	0.100	0.176	0.039	-0.046	-0.057
	(0.04)	(0.28)	(0.14)	(0.08)	(0.19)	(0.40)	(0.25)	(0.06)
L3. log national roads with light covering	0.027	0.107	-0.204	0.011	0.095	-0.844	-0.063	-0.175**
	(0.04)	(0.27)	(0.10)	(0.08)	(0.19)	(0.52)	(0.32)	(0.06)
L4. log national roads with light covering	0.014	0.031	-0.086	-0.058	0.211	-0.216	-0.377	-0.202***
	(0.04)	(0.25)	(0.11)	(0.07)	(0.13)	(0.43)	(0.27)	(0.06)
L. log county roads	-0.323	0.755	-0.648	0.674	-1.412	-0.233	0.126	0.167
	(0.22)	(0.89)	(0.61)	(0.45)	(1.21)	(0.86)	(1.05)	(0.43)
L2. log county roads	0.389	0.268	-0.159	0.043	0.901	0.524	0.518	0.423
	(0.26)	(0.92)	(0.71)	(0.50)	(1.51)	(1.12)	(1.26)	(0.49)
L3. log county roads	0.028	0.325	0.011	-0.321	0.049	-0.191	2.138	0.503
	(0.26)	(0.93)	(0.84)	(0.51)	(1.45)	(1.20)	(1.24)	(0.50)

Table A2 The model with lags. (Continuation)

Variables	Country	North-Est	South-Est	South	South-West	West	Noth-West	Center
L4. log county roads	0.859***	2.102**	-0.540	0.286	0.052	1.191	1.756	1.721***
	(0.20)	(0.72)	(0.73)	(0.41)	(1.08)	(0.87)	(1.05)	(0.36)
L. log county modernized roads	0.017	-0.056	-0.094	-0.070	0.163	0.631*	-0.203	-0.030
	(0.04)	(0.11)	(0.08)	(0.17)	(0.15)	(0.31)	(0.44)	(0.07)
L2. log county modernized roads	0.020	0.078	-0.049	0.176	0.220	-0.114	0.452	-0.110
	(0.05)	(0.12)	(0.09)	(0.19)	(0.20)	(0.33)	(0.46)	(0.09)
L3. log county modernized roads	-0.029	0.021	-0.033	-0.083	0.046	0.709*	-0.157	-0.139
	(0.05)	(0.12)	(0.09)	(0.19)	(0.19)	(0.30)	(0.45)	(0.09)
L4. log county modernized roads	0.039	0.172	0.149	0.062	0.115	-0.641*	0.679	-0.092
	(0.04)	(0.09)	(0.09)	(0.15)	(0.14)	(0.29)	(0.35)	(0.09)
L. log county roads with light covering	0.145	0.153	0.651	0.229	1.399	0.864	-0.141	-0.785**
	(0.09)	(0.33)	(0.57)	(0.30)	(0.84)	(0.74)	(0.27)	(0.27)
L2. log county roads with light covering	-0.006	0.321	0.292	0.538	-0.711	0.323	0.286	0.108
	(0.12)	(0.39)	(0.62)	(0.38)	(1.11)	(1.05)	(0.30)	(0.33)
L3. log county roads with light covering	-0.110	0.106	0.378	0.800	-0.347	0.384	-0.052	0.029
	(0.12)	(0.38)	(0.58)	(0.43)	(0.99)	(1.00)	(0.29)	(0.31)
L4. log county roads with light covering	-0.099	0.004	1.261*	-0.051	-0.453	-2.207*	0.240	-0.493***
	(0.09)	(0.31)	(0.48)	(0.36)	(0.64)	(0.83)	(0.22)	(0.11)
Constant	-26.093***	-33.897***	-12.241***	-25.544***	-8.147*	-25.112***	-33.089***	-26.824***
	(0.48)	(2.07)	(3.15)	(1.32)	(3.26)	(5.21)	(2.55)	(1.66)
R2	0.907	0.966	0.961	0.969	0.975	0.976	0.959	0.976

*Note: The numbers in parentheses are standard errors, *,**,***indicates significance at the 10%, 5% and 1% levels respectively*

Table A3 Voter turnout.

County	Participation in voting, %			Quality of government
	2008	2012	Average	
Giurgiu	59,46	70,32	64,89	High
Ilfov	62,05	66,69	64,37	
Teleorman	59,55	64,83	62,19	
Olt	59,11	64,41	61,76	
Dambovita	56,46	65,47	60,965	
Valcea	56,81	62,04	59,425	
Gorj	56,34	60,31	58,325	
Buzau	53,78	62,81	58,295	
Mures	55,97	59,54	57,755	Medium
Bihor	54,09	61,4	57,745	
Salaj	55,08	60,07	57,575	
Calarasi	53,1	61,42	57,26	
Mehedinti	51,65	61,44	56,545	
Alba	52,67	59,57	56,12	
Constanta	52,95	58,53	55,74	
Ialomita	51,73	59,36	55,545	
Bistrita-Nasaud	51,55	59,53	55,54	
Hunedoara	52,16	58,05	55,105	
Dolj	51,49	58,56	55,025	
Prahova	46,41	62,65	54,53	
Suceava	52,5	56,53	54,515	
Arges	49,91	57,76	53,835	
Arad	50,94	56,33	53,635	
Caras-Severin	52,12	55,06	53,59	
Vrancea	51,92	54,56	53,24	
Neamt	51,06	53,73	52,395	
Botosani	47,88	56,88	52,38	
Braila	45,97	57,07	51,52	
Vaslui	49,6	53,16	51,38	
Satu Mare	47,32	54,85	51,085	
Tulcea	47,33	54,82	51,075	
Covasna	47,26	54,71	50,985	Low

Table A3 Voter turnout. (Continuation)

County	Participation in voting, %	Quality of government	County	Participation in voting, %
Bacau	48,64	53,28	50,96	Low
Harghita	47,69	54,01	50,85	
Sibiu	47,84	53,36	50,6	
Brasov	45,42	54,81	50,115	
Cluj	46,59	53,2	49,895	
Maramures	46,83	52,59	49,71	
Galati	44,53	52,87	48,7	
Iasi	45,54	50,71	48,125	
Timis	40,9	48,75	44,825	