A STUDY ON THE RELATIONSHIP BETWEEN REGIONAL ECONOMIC DEVELOPMENT AND ROAD NETWORK DENSITY IN BULGARIA

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Abstract: The subject of this study is the correlation between road network and regional economic development in Bulgaria. The research hypothesis is based on the presumption that there is a positive correlation between the density of the road network and the regional economic development in Bulgaria. This article aims to analyse the relationship between regional GDP per capita (in BGN) and the density of same-class roads by province (in km.) by means of graphical correlograms.

Keyword: regional economic development, road network density.

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Introduction

Transportation infrastructure includes facilities and structures such as roads, railways, airways, rivers, canals, and pipelines, along with terminal facilities such as airports, train stations, bus terminals, warehouses, and freight depots. Terminal infrastructure and roadway facilities aim to enhance the efficiency of logistics and transportation as well as to promote and facilitate national and regional economic growth and commercial operations. Road transportation is of paramount importance for the economic development of modern economies and is inherently dependent on the degree of development of the national or regional road network.

The relationship between the development of the road network and the economic growth across various economies and regions has been extensively studied in the economic literature. generally, the researchers are unanimous regarding the pivotal role road infrastructure plays in fostering and promoting economic development. A review of the available literature provides evidence for a multitude of aspects in which this relationship has been studied.

1. Background of the problem of economic growth and road construction

Banerjee et al. studied the effect of access to transportation networks on regional economic outcomes in China over a twenty-year period of rapid income growth. Exploiting the fact that road networks tend to connect historical cities, their study addresses the issue of the endogenous placement of networks. Their findings reveal that while proximity to transportation networks has a moderately sized positive causal effect on per capita GDP levels across various sectors, it does not significantly influence on per capita GDP growth. The study is based on a simple theoretical framework with empirically testable predictions to interpret the results, suggesting that factor mobility profoundly affects the economic benefits of infrastructure development. (Banerjee, Duflo, & Qian, 2020).

Donaldson and Hornbeck examine the historical influence of railroads on the economy of the United States, specifically focusing on its aggregate impact on the agricultural sector in 1890. The expansion of the railroad network may potentially have affected all regions both directly and indirectly. The overall effect is captured by changes in the region's "market access" - a simplified measure derived from general equilibrium trade theory. To quantitatively estimate this impact, the authors construct a network database of railroads and waterways and calculating the lowest-cost freight routes between counties. Their findings reveal that regional values of agricultural land significantly increased with improved market access as the railway network's expanded from 1870 to 1890. Removing all railroads from the transport networks in 1890 would lead to an approximate 60% decrease in the total value of agricultural land in the U.S., with limited potential for mitigating these losses through feasible expansions of the canal network or improvements to rural roads. (Donaldson & Hornbeck, 2016).

In the late 1960s and early 1970s, investments in infrastructure and productivity in the United States began to decline. This issue is examined by Aschauer, who analyses data from 1945 to 1988 to examine the relationship between infrastructure and economic growth. His findings indicate that transportation infrastructure significantly impacts economic growth.

Fajgelbaum and Redding present a novel theory and evidence regarding the impact of both external and internal integration on structural transformation and economic development, using Argentina's integration into the global economy in the late nineteenth century as a case study. Their theoretical model provides microfoundations for a spatial Balassa-Samuelson effect, in which locations nearer to global markets have higher population densities, urban population shares, relative prices of non-tradable goods, and land prices relative to wages, as well as specialization in tradable goods sensitive to transportation costs. By estimating the model's parameters, the authors provide evidence supporting this spatial Balassa-Samuelson mechanism and identify significant effects of both external and internal integration on economic development. (Fajgelbaum & Redding, 2022).

The models of endogenous economic growth can generate long-term growth without relying on external changes in technology or population. These models are typically characterized by constant or increasing returns in the factors that can accumulate. In his research, Barro employs similar models to analyse the determination of per capita growth, investments in physical (Prodanov, 2012) and human capital (Zahariev, 2012), and population growth. The primary determinants involve aspects of government policy, such as public infrastructure services, maintenance of property rights, government consumption, and taxation, as well as the initial level of per capita income. Barro examines these relationships using a large cross-country sample based on the Summers-Heston set of data, which includes approximately 120 countries. The results verify several predictions regarding the determinants of growth, as well as investment and savings rates. For instance, government consumption and investment spending, along with indicators of economic freedom, manifest as anticipated by the models (Barro, 1989).

Ramcharan examines the spatial distribution of economic activity and why it is unevenly distributed in a "core-periphery" pattern in various countries. The article employs new data on the spatial distribution of economic activity for a substantial number of nations, as well as information regarding road networks, railway lines, and surface topography, to enhance the understanding of the role of local transport costs in shaping economic geography. The evidence suggests a significant influence of physical geography and transport costs in determining the location of economic activities. Countries characterized by rougher terrains have less developed road and railway infrastructure and a greater spatial concentration of economic activity (Ramcharan, 2009).

Liu and Zhao discuss the relationship between investments in transport infrastructure, infrastructure density, and economic growth, and identify a unidirectional Granger causality relationship between economic growth and transport infrastructure (Liu & Zhao, 2005). Huang uses Dix and Panchenko nonlinear causality test to examine the relationship between GDP and transport infrastructure, to find that there is a two-way causal relationship wherein transport infrastructure significantly promotes economic growth (Huang, 2012).

Pradhan and Bagchi use the vector error correction model to find a bidirectional causality between road transport and economic growth over the period from 1970 to 2010 in India. They posit that an enhancement of transportation facilities, coupled with gross capital formation, will result in comprehensive economic growth due to a range of direct and indirect benefits (Pradhan & Tapan, 2013).

A study conducted by Iacono and Levinson examines the reciprocal causal relationship between the expansion of road networks and economic development, emphasizing that road infrastructures progress concurrently with population growth and economic activities, thereby creating a bidirectional causality that benefits both sectors (Iacono & Levinson, 2016).

Agbelie employs panel data to study the impact of transportation infrastructure on economic growth, utilizing traditional Ordinary least squares models, random effects, and random parameter models, drawing on data from 40 countries in 2010. He finds out that there is a varying elasticity of transportation infrastructure at the international level (Agbelie, 2014).

A study by Ng et al. corroborates that the increase in road length per thousand inhabitants along with factors such as per capita exports and physical capital per worker significantly contribute to economic growth. This indicates a direct positive correlation between the development of road infrastructure and economic growth (Ng, Law, Jakarni, & Kulanthayan, 2018).

Tong finds that road transportation infrastructure exerts a strengthening effect on economic growth in Inner Mongolia, with a maximum impact occurring with a two-year lag, which suggests that investments in infrastructure may require some time to achieve its full effect on the economy. (Tong, 2019).

Some studies on the causality between GDP per capita and road network density lead to diverse conclusions. For instance, a study conducted by Zhi Liu and Ingram reveals that income elasticity of the vehicle-to-road ratio diminishes with rising income levels both at national and urban levels, which suggests a negative correlation between GDP per capita and road network density (Ingram & Liu, 1999). Another study finds that the length of roads per capita is positively correlated with national income and varies over time, emphasizing the significance of historical and urban planning factors in ensuring road infrastructure (Ingram & Liu, 1999). Kommissarova emphasizes that efficient road networks can profoundly impact a nation's economic, social, and environmental well-being by reducing transportation costs and enhancing overall economic efficiency (Komissarova, 2017).

A study conducted in Romania suggests a potential correlation between GDP per capita and road network density, highlighting the importance of formulating road infrastructure policies in line with other socio-economic and urban planning strategies for sustainable economic growth (Sandu, Răcănel, Manea, & & Mihai, 2019).

All these studies indicate that the relationship between GDP per capita and road network density is complex as it is influenced by numerous factors of historical, urban, and socio-economic nature. Studies in this field consistently support the assumption that road infrastructure development is a key driver of economic growth and its benefits extend beyond mere transportation enhancement to encompass market expansion, regional development, and industrial efficiency. However, the effectiveness of such investments may vary depending on the historical context, regional specifics, and project implementation.

National road network is an essential system for a country’s economy, connectivity, and security. It includes roads that cover routes of public importance and state interest and at the same time is a segment of the trans-European road network. The roads within the national road network are classified according to the functional classification of roads, which represents a national standard maintained by the Road Infrastructure Agency. They are categorised according to their physical condition, travel efficiency, access control capabilities, speed restrictions, actual usage, and hierarchical position. The functional classification designates the administrative and economic significance and the roles of each road within the transportation system. This classification includes motorways, expressways, and roads of category I, II, and III. Additionally, there are local roads, such as municipal roads, which cater to lighter traffic flows within local communities.

As of December 31, 2023, the total length of roads comprising Bulgaria's national road network was 19,968 km, which is an increase of 26 km compared to 2022. The total length of bituminized roads has increased by 19 km, while unpaved roads have increased by 14 km. However, crushedstone and coarse aggregate roads have decreased by 7 km compared to the previous year (НСИ, 2024).

This structure ensures an efficient and safe motor vehicle traffic while simultaneously connecting the primary transportation flows in the country. The highways and expressways are the fastest and best-maintained routes of the national road network.

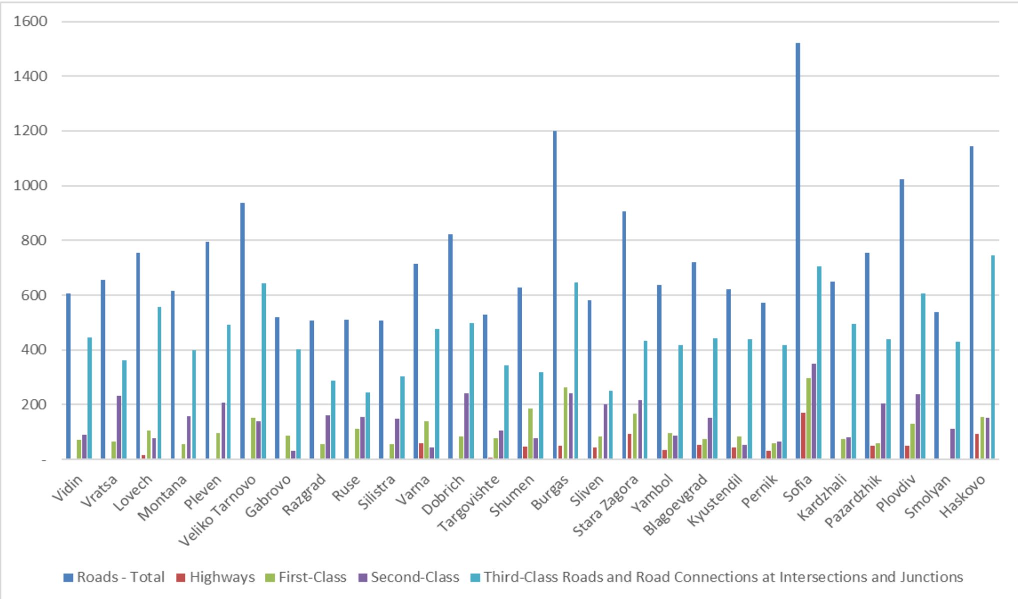
2. Correlations between regional GDP per capita and road network density by region in Bulgaria

The motorways in Bulgaria are specifically designed for high-speed motor vehicle traffic. They have dedicated lanes for traffic in either direction and emergency lanes. Intersections with other roads and railway lines are at via various over/underpasses, which ensure the continuous flow of traffic. The maximum permitted speed is set at 140 km/h. There are nine motorways planned in the country with a cumulative length of 1,661 km, of which 840 km are currently operational (НСИ, 2024). Expressways are similar to motorways;

however, they lack emergency lanes. Instead, they are equipped with designated areas for emergency stopping and local connection lanes to adjacent territories. The maximum speed limit on these roads is 120 km/h.

Category I roads are designed for long-distance transit traffic and typically connect border regions. These roads serve extensive areas and align with the directions of the primary transportation flows in the country. Category II roads facilitate medium-distance transit traffic and perform distribution functions thus complementing the network of primary roads while providing options for optimal transit routes to various regions of the country. Category III roads include all other national roads that are neither motorways nor Category I or II roads. These roads distribute traffic within the territories, provide access to higher-class roads or inter-municipal connections, thereby enhancing the state national network and connecting local roads.

The figure below presents the length of roads within Bulgaria's national road network by region and functional classification according to the Road Infrastructure Agency (RIA).



Source: *NSI.*

Figure 1. ***Length of roads by category and region in the Republic of Bulgaria.***

The table below presents the road density by region (equivalent to EU’s NUTS 3 level.) The road density in each region is calculated by dividing the total length of roads in the region by its area. The formula for the overall road density as well as for road density by individual regions is calculated as:

$$Road\ density = \frac{\text{Total length of roads (km)}}{Area\ (sq.km)}$$

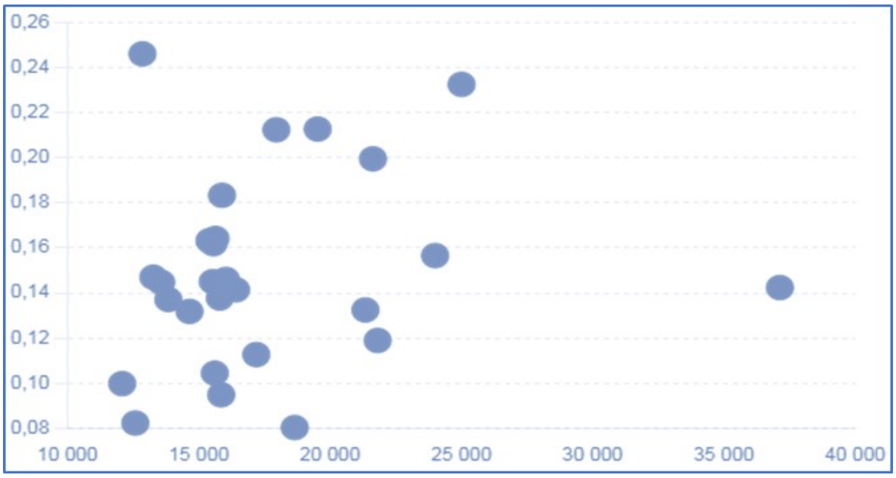
The following statistical data was used to analyse the correlation between regional GDP per capita in BGN and the density of various categories of roads in the country's regions measured in kilometers. The analysis covers all NUTS 3 regions if the Republic of Bulgaria except Sofia City, as this region is a fully urbanized territory where its road network actually comprises the streets of Sofia municipality.

Table 1

Road density by category and region in the Republic of Bulgaria

Region, NUTS 3	**Total road density**	**Motorway density**	**Category 1 road density**	**Category 2 road density**	**Category 3 road density**
Vidin	6.67032967	0	0.023079	0.030003	0.147049
Vratsa	2.844155844	0	0.021431	0.076162	0.119024
Lovech	9.679487179	0.005275	0.034619	0.025717	0.183317
Montana	3.86163522	0	0.018134	0.052423	0.131883
Pleven	3.854368932	0	0.031982	0.06792	0.161886
Veliko Tarnovo	6.692857143	0	0.050445	0.046159	0.212331
Gabrovo	17.26666667	0	0.028355	0.009891	0.132542
Razgrad	3.12345679	0	0.018464	0.053412	0.094955
Ruse	3.283870968	0	0.036268	0.051105	0.080448
Silistra	3.442176871	0	0.018464	0.048467	0.099901
Varna	17.02380952	0.019123	0.046159	0.013848	0.156611
Dobrich	3.400826446	0	0.027366	0.079789	0.164194
Targovishte	5.047619048	0.001978	0.025387	0.034619	0.11276
Shumen	8.064102564	0.015496	0.061655	0.025717	0.104517
Burgas	4.962809917	0.016815	0.086713	0.079789	0.212661
Sliven	2.876237624	0.014507	0.028025	0.066601	0.082427
Stara Zagora	4.218604651	0.030663	0.055061	0.070887	0.142433
Yambol	7.238636364	0.01154	0.031652	0.029014	0.137817
Blagoevgrad	4.736842105	0.017145	0.024069	0.050115	0.14606
Kyustendil	11.5	0.014507	0.027695	0.017804	0.144741
Pernik	8.681818182	0.010551	0.019453	0.021761	0.137158
Sofia	4.342857143	0.05572	0.097593	0.115397	0.232443
Kardzhali	8.012345679	0	0.024069	0.026706	0.163205
Pazardzhik	3.709359606	0.016815	0.019453	0.06693	0.145071
Plovdiv	4.280334728	0.016485	0.042532	0.0788	0.199472
Smolyan	4.9	0	0	0.036268	0.141444
Haskovo	7.57615894	0.030333	0.051105	0.049786	0.245961

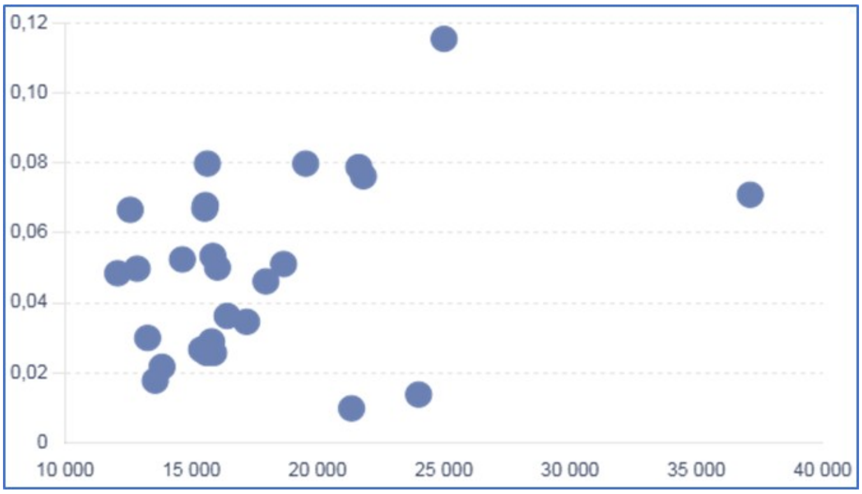
Source: *NSI statistics for 2023., author's calculations.*



Source: *NSI statistics for 2023., author's calculations.*

Figure 2. ***Correlation between GDP per capita (in BGN) and Category 3 road density (in km) by region***

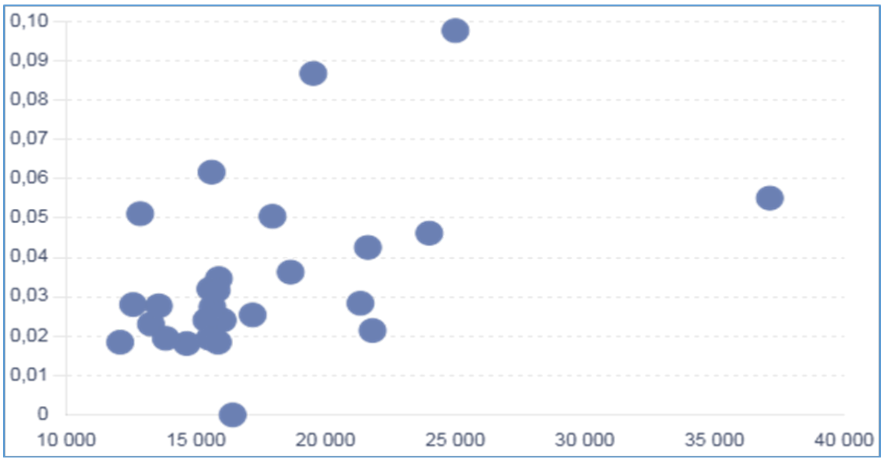
The correlation between regional GDP per capita and the density of Category 3 roads across various regions is notably weak, with a correlation coefficient of 0.169. This indicates that the relationship is weak and there is almost no linear dependence between these two variables.



Source: *NSI statistics for 2023., author's calculations.*

Figure 3. ***Correlation between GDP per capita (in BGN) and Category 2 road density (in km) by region***

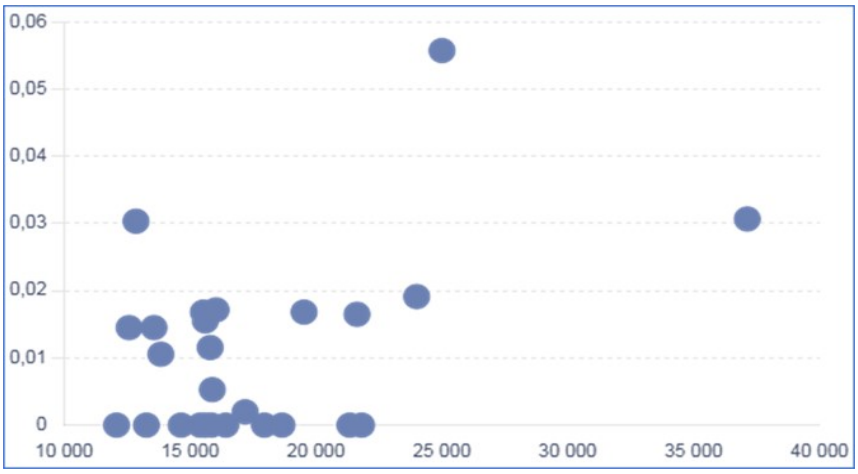
The correlation between regional GDP per capita and the density of Category 2 roads across various regions is weak, with a correlation coefficient of 0.322. This indicates that there is a positive, although not very prominent, relationship between these two variables – any increase of the density of Category 2 roads tends to increase the GDP per capita in the region, but this relationship is not strong.



Source: *NSI statistics for 2023., author's calculations.*

Figure 4. ***Correlation between GDP per capita (in BGN) and Category 1 road density (in km) by region***

The correlation between regional GDP per capita and the density of Category 1 roads across various regions is moderate, with a correlation coefficient of 0.467. This indicates that there is a positive dependence between these two variables – any increase of the density of Category 1 roads tends to increase the GDP per capita in the region.



Source: *NSI statistics for 2023., author's calculations.*

Figure 5. ***Correlation between GDP per capita (in BGN) and motorway density (in km) by region***

The correlation between regional GDP per capita and the density of motorways across various regions is moderate, with a correlation coefficient of 0.447. This indicates that there is a positive dependence between these two variables – any increase of the density of motorways tends to increase GDP per capita.

Conclusion

The overall conclusion is that the strongest correlations between GDP per capita and rod density are observed for highways and Category 1 roads. This correlation significantly weaker for the lower classes of roads, such as Category 2 and Category 3. Motorways serve as crucial transportation arteries that connect major cities and economic centres. A well-developed highway network fosters economic activity by reducing transportation costs, enhancing access to markets, and attracting investments. Regions with a well-developed highway infrastructure often have higher GDP as they are more attractive for businesses and investors.

Category 1 roads also play a vital role for regional connectivity, linking smaller towns and industrial areas. These routes contribute to economic growth by facilitating trade and mobility, providing access to natural and industrial resources, which in turn can enhance the economic output of regions.

Category 2 roads typically connect smaller settlements and rural areas. Their impact on the economy is more limited in comparison to highways and Category 1 roads. Nevertheless, these roads are crucial for agricultural regions, where economic activity may be lower; they still provide essential infrastructure for access to markets and services.

Investments in the infrastructure of regions characterized by lower economic activity tend to be more limited, resulting in a lower density of Category 3 roads. Such roads are typically local routes that connect the smallest communities and rural areas. These local roads are less significant in the overall economic landscape, as they primarily cater to local needs and do not make a substantial contribution to commerce and industry.

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