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# STUDY OF THE RELATIONSHIP BETWEEN THE PROGRESSIVE DEVELOPMENT OF LOGISTICS AND TRANSPORT INFRASTRUCTURES OF REGIONS AND THE ECONOMIC PERFORMANCE OF REGIONS (NUTS 2 EU).

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The aim of this article is to confirm the hypothesis that „the developed logistic and transport infrastructure of the region has contributed to the improvement of the economic performance of the region". The article presents research showing the relationship between the developed elements of logistic and transport infrastructures of regions (density of roads, density of railway networks, size of warehouse space, number of intermodal trans-shipment terminals, tonnage transported in tonnes) and economic performance of regions (regional GDP, private capital productivity). The study is based on the regions of Poland with special attention to Silesia region. The results indicate that the liberalization and computerization of the TFL sector is desirable by industry leaders of the region. The research proposals can help TFL authorities, decision-makers, and leaders to make investment decisions regarding logistics and transport infrastructure.

**Key words**: logistics and transport infrastructure, regional economic growth (NUTS 2 UE).

## 1. INTRODUCTION

Education, the quality of health care, the average life expectancy, productivity, innovation - all those factors that have a major impact on development are visible only to researchers, while the state of the infrastructure is evident to everyone at first glance. Developed countries have good high-speed roads, fast railways, widespread Internet access, etc. unfortunately, in poorer countries, we experience the opposite. The precise research shows that there are very strong links between infrastructure development and economic development, as shown in Fig. 1.

It is necessary to answer the question whether the infrastructure affects economic growth, or is it vice versa. There is also another key question: do the high density of roads, the size of warehouse space, the number of intermodal trans-shipment terminals, telecommunication networks support the development, or are they a natural, but side-by-side components of the development process? If this first dependency exists, then the development of a particular infrastructure is of great importance, as it strengthens the foundations of economic development. If there is mainly the second dependency; the development of infrastructure should be treated in terms of the increase in standard of living - which of course is also of great importance for public sector decisions, but not as great as the impact of infrastructure on the pace of development. Available studies show that infrastructure development supports economic growth - De Haan and Romp (2007). [1] The increase in the GDP resulting from the expansion of infrastructure is conditional, i.e. it depends also on other changes made in the country / region. The level of economic development is determined by the political, social and economic institutions that promote innovation, competition, social and political activity, and protects civil and economic rights. The key propagator of such a view is, among others, Daron Acemoglu. [2]

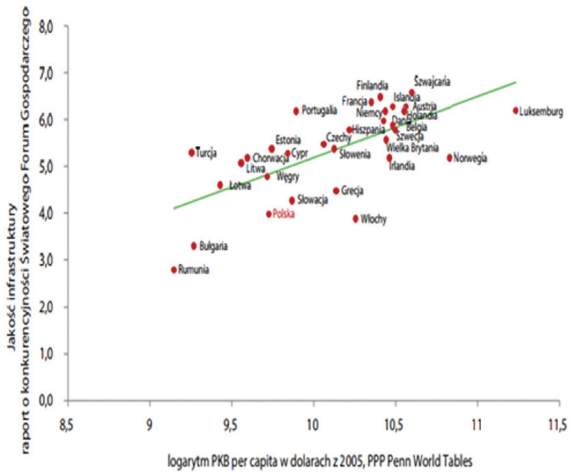


Fig. 1 Correlation between infrastructure quality and the GDP

Source: White Paper for Infrastructure, p. 123. Available at: http://www.dlainfrastruktury.pl/wp-content/uploads/2015/07/IDI_Biala_Ksiega.pdf

## 2. ECONOMIC GROWTH OF POLISH REGIONS / REGIONS IN THE CONTEXT OF LOGISTIC AND TRANSPORT CONDITIONS

Poland has undertaken a great deal of investment effort in the area of infrastructure in recent years. The rate of public investments, or their ratio to GDP, rose from an average of 3.4% in 1995-2006 to 5.2% in later years. Counting both the last five years and the last decade, Poland has been among the countries with the highest public investment in Europe, mainly due to the European Union funds. However, achieving a clear progress in infrastructure upgrading and quality will require maintaining a high level of targeted investment over many years.

***Tab.1*** *Economic performance of Polish regions, data on logistics and transport infrastructure of regions (data refer to 2016).*

| Voivodeship | GDP billion in USD | GDP billion in PLN | % | Road density index Length of national roads and motorways km / 100 km² surface | Network density indicator Railway line length km / 100 km² | Warehouse area thous. sqm 2016 / under construction | | Number of intermodal trans-shipment terminals |
|---|---|---|---|---|---|---|---|---|
| Poland | 524 billion USD | 1,888 billion PLN | 100% | 0.97 | 6.2 | 31,267 | 748 | 29 |
| Lower Silesia | 44.6 | 160.48 | 8.5% | 1.1-1.5 | 8.8 | 1,995 | 99 | 3 |
| Kuyavia-Pomerania | 23.1 | 83.1 | 4.4% | 1.1-1.5 | 6.7 | 1,798 | - | |
| Lublin | 20.5 | 73.6 | 3.9% | 0.0-0.5 | 4.1 | 2,513 | 41 | 1 |
| Lubusz | 11.5 | 41.5 | 2.2% | 1.6-2.0 | 6.6 | 1,399 | - | |
| Lodzkie | 32 | 115.1 | 6.1% | <2.0 | 5.9 | 1,822 | 99 | 3 |
| Lesser Poland | 40.9 | 147.2 | 7.8% | 1.1-1.51 | 7.2 | 1,519 | 60 | 3 |
| Masovia | 116.4 | 419.1 | 22.2% | 0.6-1.0 | 4.7 | 3,556 | 107 | 2 |
| Opole | 11 | 39.6 | 2.1% | 0.6-1.0 | 8.1 | 942 | - | |
| Subcarpathia | 20.5 | 73.6 | 3.9% | 0.0-0.5 | 5.5 | 1,785 | - | 1 |
| Podlasie | 11.5 | 41.5 | 2.2% | >0.5 | 3.2 | 2,019 | - | |
| Pomerania | 29.9 | 107.6 | 5.7% | 0.6-1.0 | 6.7 | 1,832 | 66 | 5 |
| Silesia | **65** | **234.1** | **12.4%** | **<2.0** | **16** | 1,234 | 75 | 5 |
| Swietokrzyskie | 12.6 | 45.3 | 2.4% | >0.5 | 6.2 | 1,172 | - | |
| Warmia-Masuria | 14.2 | 50.9 | 2.7% | 0.6-1.0 | 4.6 | 2,418 | - | 1 |
| Greater Poland | 50.9 | 183.1 | 9.7% | 1.1-1.5 | 6.3 | 2,983 | 184 | 4 |
| West Pomerania | 19.9 | 71.7 | 3.8% | 1.1-1.5 | 5.2 | 2,289 | 17 | 1 |

Source: GUS, Transport Wynik działalności w 2016r, Warszawa 2017. https://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/

Available at:
https://www.gddkia.gov.pl/mapa-stanu-budowy-drog_slaskie; http://stat.gov.pl/files/gfx/portalinformacyjny/pl/defaultaktualnosci/5511/9/14/1/transport_wyniki_dzialalnosci_2014.pdf;
http://stat.gov.pl/statystyka-regionalna/rankingi-statystyczne/powierzchnia-wedlug-wojewodztw/
http://www.logistyka.net.pl/bank-wiedzy/transport-i-spedycja/item/download/79326_6e9d7c343065c2b8f3aa3017b78da4db

***Tab. 2*** *Voivodeship balance of carriage of goods by car transport in thousands of tonnes 2016 (Results of representative survey)*

| thousand tonnes | Delivered | | | | Received | | | | Transport balance (active + adverse -) |
|---|---|---|---|---|---|---|---|---|---|
| | total | within the voivodship | to other voivodships | abroad | total | within the voivodship | from other voivodeships | from abroad | |
| POLAND | 1,143,779 | 718,141 | 352,658 | 72,980 | 1,134,372 | 718,141 | 352,658 | 63,573 | + 9,407 |
| Lower Silesia | 121,256 | 86,334 | 26,167 | 8,755 | 116,150 | 86,334 | 23,289 | 6,527 | + 5,106 |
| Kuyavia-Pomerania | 53,846 | 29,486 | 20,915 | 3,445 | 53,180 | 29,486 | 20,601 | 3,093 | + 666 |
| Lublin | 47,548 | 30,314 | 15,301 | 1,933 | 46,886 | 30,314 | 14,902 | 1,670 | + 662 |
| Lubusz | 33,477 | 18,973 | 9,115 | 5,389 | 35,650 | 18,973 | 13,033 | 3,644 | - 2,173 |
| Lodzkie | 65,933 | 31,612 | 29,876 | 4,445 | 65,976 | 31,612 | 29,393 | 4,971 | - 43 |
| Lesser Poland | 70,940 | 44,443 | 22,089 | 4,408 | 71,868 | 44,443 | 23,148 | 4,277 | - 928 |
| Masovia | 135,797 | 90,415 | 38,027 | 7,355 | 147,538 | 90,415 | 48,318 | 8,805 | - 11,741 |
| Opole | 42,192 | 22,286 | 17,582 | 2,324 | 40,341 | 22,286 | 16,381 | 1,674 | + 1,851 |
| Subcarpathia | 44,340 | 30,263 | 11,735 | 2,342 | 50,023 | 30,263 | 17,641 | 2,119 | - 5,683 |
| Podlasie | 38,601 | 25,271 | 11,242 | 2,088 | 38,286 | 25,271 | 11,767 | 1,248 | + 315 |
| Pomerania | 77,597 | 54,029 | 20,293 | 3,275 | 76,378 | 54,029 | 19,735 | 2,614 | + 1,219 |
| Silesia | **150,219** | **100,176** | **40,270** | **9,773** | **146,190** | **100,176** | **36,262** | **9,752** | **+ 4,029** |
| Swietokrzyskie | 50,208 | 22,412 | 26,657 | 1,139 | 35,288 | 22,412 | 12,013 | 863 | + 14,920 |
| Warmia-Masuria | 48,445 | 33,521 | 13,484 | 1,440 | 46,508 | 33,521 | 12,182 | 805 | + 1,937 |
| Greater Poland | 115,203 | 69,743 | 36,687 | 8,773 | 118,501 | 69,743 | 40,401 | 8,357 | - 3,298 |
| West Pomerania | 48,177 | 28,863 | 13,218 | 6,096 | 45,609 | 28,863 | 13,592 | 3,154 | + 2,568 |

*Source: GUS, Transport Wynik działalności w 2016r, Warszawa 2017. Available at https://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/; gov.pl/obszary-tematyczne/transport-i-lacznosc/[1]/transport_wyniki_dzialalnosci_2016%20(2).pdf pp.205,206*

Poland[1] experienced economic growth of approximately 1.8% of GDP in 2016. Regions: Lesser Poland, Greater Poland, Silesia and Lower Silesia contributed above all to this growth, as shown in Table 1. These regions are highly industrialized but also the most developed regarding logistic and transport infrastructure, and taking in consideration computerization in / for the TFL sector (Table 1).

Table 2 and Figure 2 show the voivodeship balance of carriage of goods by truck in thousands of tonnes.

Among all regional economies, Silesian entrepreneurs most give and receive loads in tonnes, similar high results show analysis of transport operations in the territory of the region in tonne-kilometres.[4] The results may be even higher due to the strengthening of the region's leading industries and intelligent specialization.[5] Despite Poland's economic slowdown, the Silesian region plays an important role in domestic economic growth. Leading industries of the region and, above all, automotive (road vehicles and spare parts) show a positive increase in production and sales (mainly-export). Table 3 presents revenues and employment in the largest automotive companies located in the region. Road and rail transport remains the preferred solution for transporting goods in this sector. The industry also uses air transport to carry on board computers, electrical machinery and equipment (4% of all transport costs in this industry, the cost of air transport).

The economic successes of the region and individual enterprises belonging to the leading branches of the region have not only contributed

[1] Data on carriage of goods by car transport concerns the entire car transport, i.e., commercial and commercial transport in the public and private sectors. The survey carried out using the representative method was carried out in accordance with the provisions of Regulation (EU) No 70/2012 of the European Parliament and of the Council of 18 January 2012 on statistical returns in respect of the carriage of goods by road. The vehicle lot drawing service for 2016 was prepared on the basis of the obtained records from the Central Register of Vehicles at the end of September and December 2015 and March and June 2016.The sample was sampled 4 times a year. The population was divided into layers. The stratification criteria were the province and 12 categories of vehicles: • 8 categories of trucks, i.e. trucks in four age groups and broken down into payloads below 6 tonnes and 6 tonnes and more; • 4 categories of tractor units, i.e. tractor units in four age groups. In this way, 192 layers in the research sample of 13.0 thousand were obtained. The confidence level for the tests is α = 95%

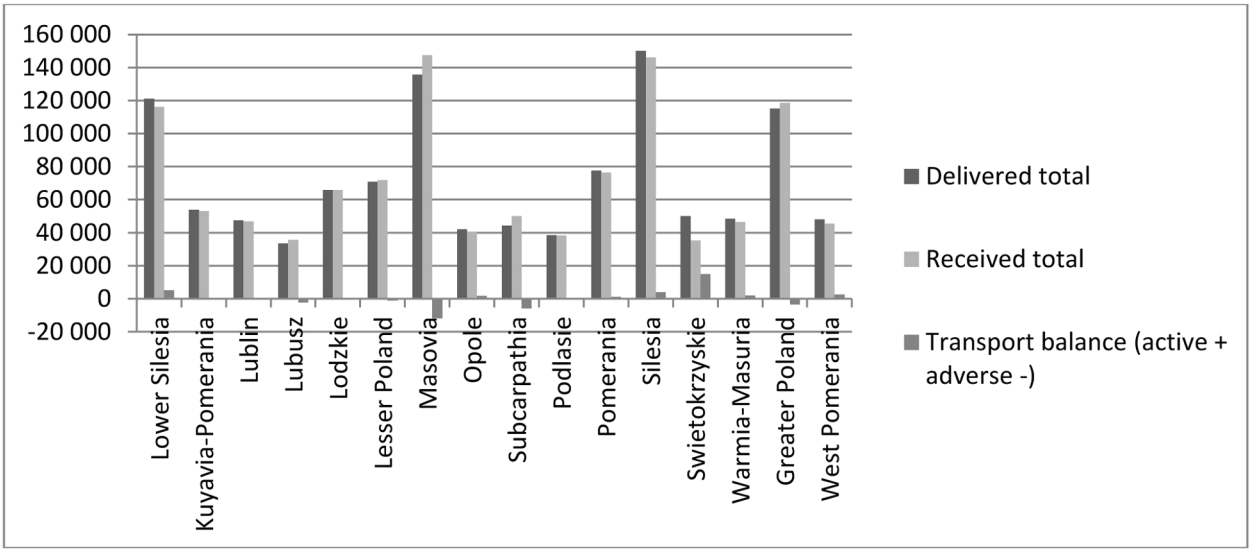


Fig. 2. *Voivodeship balance of carriage of goods by car transport in thousands of tonnes 2016 r.Source: Own study based on: GUS, Transport Wynik działalności w 2016r, Warszawa 2017.*

*Avaiable at https://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/*[2]

to the logistic and transport infrastructure, which is described in Table 1. In the region, 1,349 transport companies and logistic operators cooperate. [7] In the province the best logistic operators distinguished by the WTO2, providing LP4 services are present. The implementation of regional legislative and IT solutions has played a minor role. In the current Transport Strategy for Silesia, attention is drawn to the achievement of regional transport integration that will translate into regional economic growth. On October 7, 2017, a metropolitan union was established of 41 municipalities called the Upper Silesia-Zagłębiowska Metropolis[3]. The metropolitan union started with the reform of communication and new investment in infrastructure, which will lead to increased opportunities and competitiveness of selected businesses in which the region specializes. Logistics and transport infrastructure has proved to be one of the important factors affecting the economy of this region. The links associated with logistics and transport infrastructure include freight forwarding, storage, settlement (payment), payment management and many other functions. Transport and logistics infrastructure stakeholders include state and private companies, public-private consortia managing infrastructure, logistic operators, shippers, carriers, service agents and customs officials who are working today in Silesia by establishing clusters of the TFL sector and operating on integrated IT platforms.

## 3. RESEARCH METHODOLOGY

The research focuses on the relationships between the volume of freight (tonnes of freight transported in the region); the hard infrastructure of the region (density of roads and motorways, density of railway networks, size of warehouse space, number of intermodal trans-shipment terminals); and the influence of transport volumes on the

[2] Data on carriage of goods by car transport concerns the entire car transport, i.e., commercial and commercial transport in the public and private sectors. The survey carried out using the representative method was carried out in accordance with the provisions of Regulation (EU) No 70/2012 of the European Parliament and of the Council of 18 January 2012 on statistical returns in respect of the carriage of goods by road. The vehicle lot drawing service for 2016 was prepared on the basis of the obtained records from the Central Register of Vehicles at the end of September and December 2015 and March and June 2016.The sample was sampled 4 times a year. The population was divided into layers. The stratification criteria were the province and 12 categories of vehicles: • 8 categories of trucks, i.e. trucks in four age groups and broken down into payloads below 6 tonnes and 6 tonnes and more; • 4 categories of tractor units, i.e. tractor units in four age groups. In this way, 192 layers in the research sample of 13.0 thousand were obtained. The confidence level for the tests is α = 95%

[3] The area of the metropolis extends over an area of 2.3 thousand. There live near 2.3 million inhabitants, i.e. half of the population of the whole province. There are over 200 thousand. Companies that produce a total of 8 percent. of GDP of the country (source: Business Zone Dziennik Zachodni. July / August 2017).

Tab. 3 Income and employment in the largest automotive companies located in the Silesian region. (Name of the company / Located / Income from sell / Employment)

| Nazwa przedsiębiorstwa | Siedziba | Przychody ze sprzedaży | Zatrudnienie |
|---|---|---|---|
| Fiat Auto Poland S.A. | Bielsko-Biała | 14113720 | 4857 |
| Fiat Powertrain Technologies Poland Sp. z o.o. | Bielsko-Biała | 3440421 | 1130 |
| TRW Polska Sp. z o.o. | Częstochowa | 2468591 | 4473 |
| Grupa Magneti Marelli w Polsce | Sosnowiec | 2340300 | 2733 |
| Hutchinson Poland Sp. z o.o. | Żywiec | 1328660 | 3768 |
| TRW Steering System Poland Sp. z o.o. | Czechowice-Dziedzice | 1117768 | 874 |
| Nexteer Automotive Poland Sp. z o.o. | Tychy | 1074358 | 1125 |
| Tenneco Automotive Polska Sp. z o.o. | Rybnik | 977887 | 1093 |
| TI Poland Sp. z o.o. | Bielsko-Biała | 65386 | 1391 |
| Nemak Polnad Sp. z o.o. | Bielsko-Biała | 597552 | 727 |
| Brembo Poland Sp. z o.o. | Dąbrowa Górnicza | 578272 | 952 |
| Moto-Profil Sp. z o.o. | Chorzów | 505873 | 469 |

Source: Tkocz M., „Encyklopedia województwa śląskiego", Tom 1(2014), Available at http://ibrbs.pl/mediawiki/index.php/Przemys%C5%82_wojew%C3%B3dztwa_%C5%9Bl%C4%85skiego

economy of the region, gross (GDP) generated by the region. The additional study (where the original data from the survey was used), confirmed that the volume of sales of selected industries, in which the region specialized, is influenced by modern IT and legislative solutions. The main objective of the research was to find answers to three research questions, i.e.:

- What are the main factors (hard infrastructure) contributing to the growth of transport by land?
- What is the relationship between increased transport by land, and the economic performance of the region?
- Which of the modern solutions of intelligent logistics and transport infrastructure contribute to the growth of sales of leading regional enterprises?

Research questions are interesting and worth answering. In the article, the lack of research on the link between some factors related to the volume of land transport and logistics infrastructure and economic efficiency at regional level was recognised and addressed. In this study, for the purposes of responding to these questions, the secondary data presented in Tables 1 and 2 was taken into consideration, as well as the same data from the previous five years (panel data covering the years 2012- 2016 in Polish voivodeships) were subjected to statistical processing. Primary research has also been conducted among managers to identify the

most important modern solutions affecting cargo size, followed by sales revenue, transaction costs reduction (private capital productivity). The research aim to confirm the following three hypotheses:

H1 a: There is a positive correlation between the 1. density of roads, 2. density of rail networks, 3. size of warehouse space, 4. number of available intermodal cargo terminals, 5. volume of freight in tonnes (hypothesis is to be confirmed by analysis of correlation of variables / statistical data for all regions of Poland from five years 2012-2016).

H1 b: The increase in the number of intermodal trans-shipment terminals X% results in an increase in the volume of freight transport in the regions by X% - (The hypothesis is to confirm the regression analysis of variables / statistics for all regions of Poland from five years 2012-2016).

H2: The logistic and transport development of Silesia (taking into account all the above variables concerning the Silesian region) contributed to the growth of regional GDP. However, the further development of "hard" logistics and transport infrastructure depends only on selected elements (regression has shown the highest influences regional GDP growth).

H3: IT and legislative solutions ("soft" logistic and transport infrastructure) will increase the productivity of private capital and thus contribute to the growth of the regional BKB (hypothesis is confirmed by analysis of qualitative data collected during the surveys conducted by the automotive sector managers located in Silesia) . The research model is shown in Figure 3.

The aim of the research is to provide practical guidance for decision makers in the area of logistic and transport policy of the region of Silesia dedicated to the region's leading industrial sectors. Identifying factors that improve the logistic and transport competitiveness of the region will help guide further projects and investments, which may have an impact on the region's future economic performance. Policy makers may place emphasis on the development of selected infrastructure elements, or the building of soft skills in the TFL sector (e.g. transport efficiency through the development of intelligent transport management technologies,

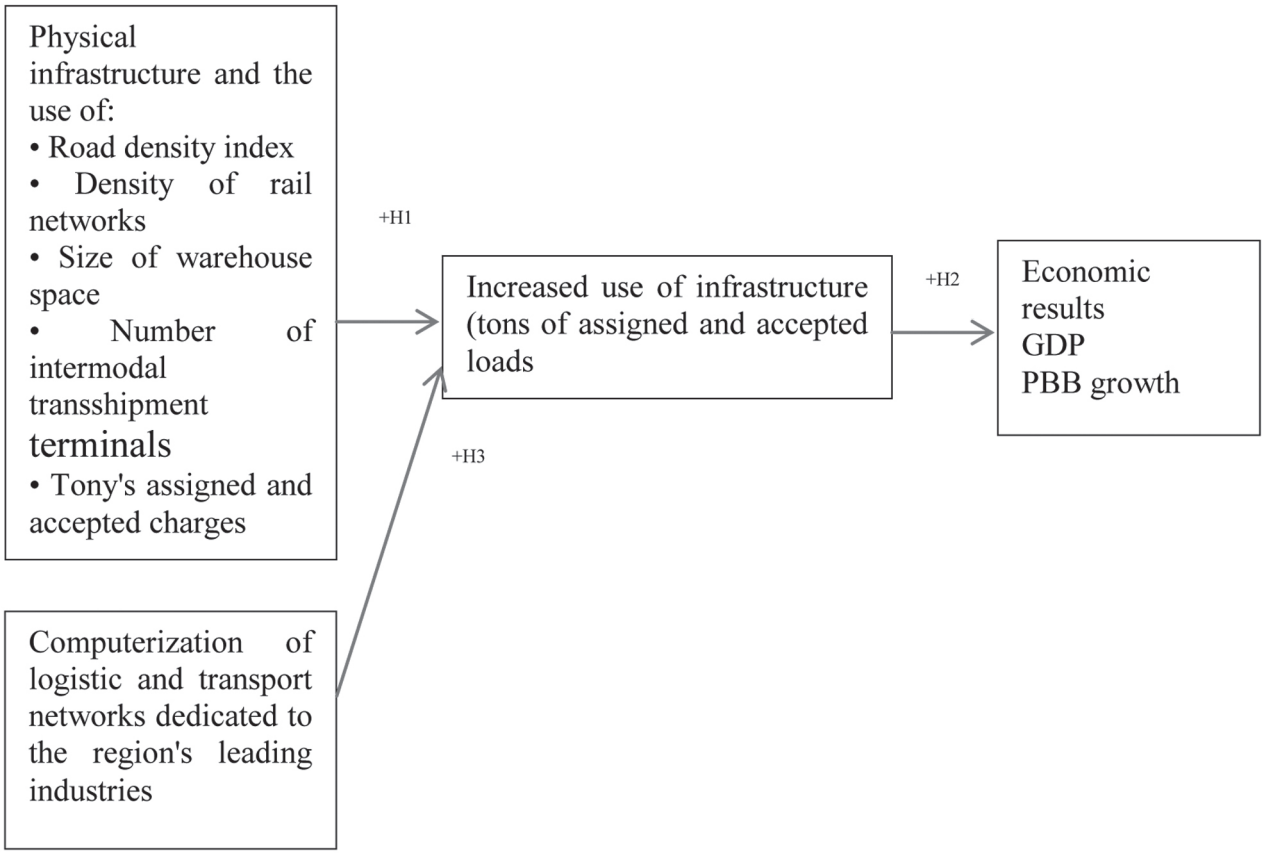


***Fig. 3*** *Research model*
*Source: Own study*

smart knowledge technology systems, transport efficiency through the development of intelligent transport management systems, Intelligent Knowledge Systems, technical and IT facilities for shippers).[5] The paper underlines the need for a partnership dialogue among all stakeholders in the investment process. Therefore, the environment of transport managers and logistics of the leading Silesian industry was examined.

The impact of transport-logistics infrastructure development on business performance was investigated. The largest enterprises in the region were chosen because they are integrated into global supply chains, use global integrated production, supply and deliver just in time. Their answers may assist regional infrastructure managers but also logistic operators in making investment decisions.

The questionnaire survey was conducted using a direct survey conducted by an interviewer in an enterprise that agreed to participate in the survey. The study was conducted in two stages. The first one was a screening test and the other was a face-face (PAPI) survey. In screening, publicly available data (e.g. PKD, address) were used. In the second stage, respondents were presented with several solutions to streamline the logistics and transport system - solutions which are desirable in the more developed regions of the EU by the automotive industry and implemented by infrastructure managers or logistics operators. Table 5 shows the results of the evaluation of proposed solutions and was limited to the few most desirable. The sample size of the survey is 97 Silesian enterprises, which the EAC points to the relationship with the automotive industry (89 suppliers, 3 manufacturers, 75 dealers, 20 car services).

## 4. STATISTICAL PROCESSING OF DATA - COGNITIVE APPLICATIONS

By testing hypothesis H1a, correlation analysis of all variables (dependent and independent) was performed in this study. Table 4 shows the correlation of variables.

Based on the results presented in the table, all variables are positively correlated, but almost none of them have reached a correlation coefficient greater than 0.50. The cognitive conclusions of the correlation analysis are that: there is a high positive correlation between the size of the storage area and the volume of freight transported, as well as the density of the roads and the size of the loads. Studies have shown a significant relationship between the volume of freight and regional GDP. No significant correlation was found between the density index of the railway network and the volume of freight transported and between the number of intermodal trans-shipment terminals and the volume of freight transported.

By testing hypothesis H1b, the least squares regression was performed using panel data - the independent variable (tonnage transported in tonnes) and the dependent variable (regional GDP). The regression analysis was based on the following assumptions: $Yi = b1X1 + b2X2 + ... b16X16 + a$, where Yi: Y1 = regional cargo sizes, Yi = regional GDP, and b, equation coefficients. It was recognized that an increase in the volume of carried loads by 1% resulted in an increase in regional GDP by 0.37%.

A regression analysis could be performed in which independent variables will be divided into the volume of loads transported in each region (transmitted and received). Also, the separate regression analyses for independent variables could be performed, i.e. road density in each region, density of rail networks in each region, size of warehouse space in each region, number of intermodal trans-shipment terminals available in each region. An in-depth regression analysis could suggest to regional authorities / managers of regional infrastructure that the elements of infrastructure are important for the increase in the volume of cargoes and, consequently, the growth of regional GDP.

By performing a multi-component regression analysis, the elements of infrastructure could be identified that contribute the most to the growth of freight transport in e.g. Silesia region.

Expenditure planning on an infrastructure element (the method of regression analysis requires historical data) must be verified by a research of current needs analysis. Firstly, the infrastructure could be changed within a short time (e.g. saturation of the market with storage space). Secondly, the expectations of entrepreneurs are evaluated by changing market conditions. Therefore, in the next qualitative study, the leading Silesian industry i.e. automotive was analysed and the largest companies were selected for research. The logistics and transport solutions, which are dedicated to the industry and operate in other countries, were

***Tab. 4*** *Variable correlation indices*

| Variables | Road density | Road density Density of the railway network | Size of surface storage | The quantity of intermodal trans-shipment terminals available | The amount of freight carried in tons | Regional GDP | Growth of regional GDP |
|---|---|---|---|---|---|---|---|
| Road density | 1 | | | | | | |
| Density of the railway network | -0.08 | 1 | | | | | |
| Size of surface storage | 0.46 | 0.06 | 1 | | | | |
| The quantity of intermodal trans-shipment terminals available | 0.08 | 0.18 | 0.43 | 1 | | | |
| The amount of freight carried in tons | 0.67 | 0.34 | 0.54 | 0.23 | 1 | | |
| Regional GPD | 0.43 | 0.42 | 0.41 | 0.38 | 0.51 | 1 | |
| Growth of regional GDP | 0.32 | 0.15 | 0.24 | 0.31 | 0.39 | 0.29 | 1 |

Source: Own study based on GUS dataAvaiable at: https://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/

presented and assessed by ranking their suitability for raising the productivity of private capital. Table 5 shows the results of this research.

The solutions demonstrate the need to co-create a second (virtual) logistics and transport infrastructure, where the main emphasis is on the development of information and knowledge. An important element of this infrastructure is the development of one element - tele informatics. In the new development economy which originates from works such as the Robert Lucas' Nobel Prize winner, such factors as channels of interaction between people, the multiplicity and ease of contact, the environment conducive to innovation, and the specialization of knowledge are taken into account. Based on the results of qualitative research it can be stated that the growth of transport will take place if the development budgets are transferred to the development of virtual infrastructure, in particular the development of IT systems supporting the integration of road and rail transport - intermodal transport.

## 5. CONCLUSIONS

Logistic and transport infrastructure plays an important role in the economic development. Good logistics and transport infrastructure supported by IT solutions can add positive effects in the form of rapid information flow and accumulation of knowledge. Infrastructure expenditure can be used by the authorities to support specific interest groups (leading industries in the region), which significantly improves private sector productivity, affecting the region's GDP. It should be remembered that spending on roads, railways and intermodal trans-shipment terminals is a major part of the cost of public capital, so it should be well justified and planned. The calculations proposed in the article may justify expenditure on particular elements of the infrastructure. In particular, this concerns investment issues in transport, communication, storage and location infrastructure, related to the location of traffic sources, the creation and modernization of communication systems in the region. [6]. It is worth noticing that by carrying out similar research for all regions (voivodeships of Poland), the development of one region (by spending on national roads and motorways or railways) takes place at the expense of other regions. It raises the questions if anything could be done to avoid it. Many point out to the negative answer. The optimistic aspect is that economic development takes place through many channels - development of innovation, entrepreneurship, etc.

Tab. 5 *Evaluation (the average of ratings from 1 to 10) illustrating the impact of the proposed solution on the productivity of private capital (sales growth, cost reduction)*

| Description of the solution | Evaluation of the solution |
|---|---|
| Digital and interactive map of current and future communication nodes (roads, highways, airports, logistics centres, maritime, railroads, trans-shipment terminals, their service industry preferences, accessibility, e-gate functions, IT services). Mom connected with the search engine of scheduled sea, rail, and tram - cargo connections. The tool intends to support long-term and short-term logistics network planning for projected flows of goods. | 10 |
| Regional data collection and transmission systems that improve the "visibility" of road, rail, trans-shipment load. Companies and logistics to the following could use this system: power their data transport systems (TMS), support systems for centralized management optimizing global supply chains and digitization processes. | 10 |
| A tool for training and planning of regional infrastructure, visualizing the actual and future deployment of transport nodes, factories to gather entrepreneurs' views on the future development of the economic and logistic transport network | 8.7 |
| Launch of regional, trans-regional and cross-border rail, inland shipping and inland-dedicated industries. This action is associated with a strong emphasis on reducing emissions and pollution. An additional solution is an open-standard groupware IT platform that is open to all users, accepting common load consolidation standards, which allows for the consolidation of business loads in one. | 8.7 |
| Regional control and data capture systems, including sensors, cameras and other connected devices, giving drivers the option of parking, detours, availability of equipment at gas stations and parking, etc. | 6.2 |
| An IT solution for a cross-industry project, called Industrial Data Space, which allows companies to exchange key information but keep them anonymous. The tool protects some potential proprietary information. This technology provides automatic validation of current data from various sources and integrates it in anticipation of future logistics and transport scenarios through simulation | 6.0 |
| Expanded logistic services search engine, which manages logistics provider data, also fulfils the functions of a regional transport exchange dedicated to the industry, organizing transport in a multimodal system with a unified form of communication dedicated to the industry. | 5.8 |
| A regional IT system that supports container management and general packaging for the industry such as the standard ISO container that can be rented and then back in a common pool for other industry companies. | 5.6 |
| The system showing the availability of the nearest intermodal trans-shipment terminal, the efficiency / performance of the terminal companies, the physical infrastructure, e.g. the size of the terminal area, the monitoring of transhipped goods | 8.2 |
| Co-financing and liberalization of the law of integrated road and rail transport (intermodal work and IT systems supporting integration. | 9.2 |

Source: Own study based on primary research

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