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IDENTIFICATION OF FACTORS RELATED TO TRANSPORT ENTREPRENEURSHIP INFLUENCING THE ECONOMIC DEVELOPMENT OF UKRAINE

Summary. The integration of Ukraine's economy into the European space requires the dynamic and balanced development of all its sectors, especially the transport sector. The purpose of the research is to identify the factors related to transport entrepreneurship that affect the economic development of Ukraine, in particular regarding the formation of added value (gross regional product). The paper presents the author's definition of transport entrepreneurship as an independent, systematic, and risky entrepreneurial activity in providing transport services. The results revealed a negative trend in the formation of the added value of the transport enterprises of Ukraine, both in terms of value and as a percentage of GDP. This prompted the authors to determine the factors affecting the formation of gross added value (gross regional product) by transport enterprises of Ukraine to further develop proposals aimed at their activation. Four models were created in the first stage of the research to achieve the goal. These models are based on gross regional product in transport, warehousing, postal and courier activities; gross regional product in transport, warehousing, and postal and courier activities per capita; gross value added in transport, warehousing, and postal and courier activities; and gross value added in transport, warehousing, and postal and courier activities per capita. In the second stage of the research, the fifth model with the highest correlation coefficients was built, which made it possible to identify the factors of negative and positive influence on the formation of gross added value (gross regional product) by transport enterprises in Ukraine. Based on the results, a number of measures are proposed to stimulate factors of positive influence and neutralize negative influence. The proposed tools for identifying the factors related to transport entrepreneurship that affect the economic development of Ukraine can serve as markers for the formation of the country's post-war strategy in the field of transport entrepreneurship.

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1. INTRODUCTION

Transport is one of the most important branches of any economy, and it provides the transport needs of the economy and the population. In the conditions of globalization and integration of international markets, increasing the geographic mobility of the population and the development of public consumption, the role of transport infrastructure is growing. Transport infrastructure is a determining component of socio-economic development of both individual regions and the country as a whole. The integration of Ukraine's economy into the European space requires dynamic and balanced development of all its branches, especially transport and transport infrastructure. Thus, enterprises of the transport industry in Ukraine occupy an important place among non-financial corporations.

The rapid development of innovation in the global transport economy is leading to the spread of safer roads with electronic devices for drivers, unmanned trucks, and blockchain logistics, as well as the widespread introduction of artificial intelligence systems. Infrastructure has a significant impact on the formation of social, human, and cultural capital. In addition, transport infrastructure affects the economic development of the region, especially rural areas. Transport infrastructure stimulates the modernization of agricultural production, improves the lives of rural residents, and guarantees the sustainable multifunctional development of the rural region.

In general, infrastructure directly or indirectly affects the achievement of all sustainable development goals [1]. There are many definitions of sustainable development, but in essence, sustainable development has three dimensions: economic, environmental and social [1]. The general strategy of sustainable development contains strategic goals on which the concept of sustainable development of transport (planning concept) is based. The planning concept contains a long-term comprehensive plan of action aimed at achieving these strategic goals.

Economists have identified the impact of transport on growth and innovation. In particular, transportation stimulates the search for innovation by finding new products [2], expands geographic markets for entrepreneurs, and increases the referral of ideas by bringing people together [3]. In the new economic realities, transport infrastructure contributes to the development of the country's regions.

The expansion of transport infrastructure is one of the most important factors in the development of local and regional territories. The presence of an extensive transport infrastructure contributes to the development of territories with their own potential, using the opportunities available to them. And for the implementation of planned programs, such territories can attract funds from the European Union (EU). Conversely, an insufficiently branched infrastructure can be reflected in the degradation of the region and the deterioration of the living conditions of its inhabitants [4].

The advantages of a developed transport infrastructure are spatial structure and mobility. In addition, transport infrastructure is a vital socio-economic asset [4]. The integration of spatial systems, as well as the organization of economic space, are fundamental advantages of transport infrastructure. Thus, at the end of 2020, there were 98,030 transport business entities in Ukraine [5].

The era of the first great economists includes studies of the influence of transport infrastructure on the choice of the form of entrepreneurship followed at the local and regional levels. Thus, at the beginning of the 20th century, it was determined that the minimization of transport costs was the optimal location of the enterprise [6]. In the 1990s, reports presented research on transport infrastructure and its impact on economic activity. These reports considered the development of transport entrepreneurship as a driving force of the economic activity of the country [6].

The formation of state programs is carried out taking into account such a political tool as transport infrastructure. This tool allows for the regulation of disparities and inequalities and promotes economic growth. Transport infrastructure is the most powerful tool for stimulating the world economy, which requires a significant share of public spending [7]. In addition, financing the development of transport infrastructure is an effective public expenditure, as it has a number of benefits. For instance, it increases market and labor mobility, accelerates access to services and the opening of the export market, reduces social injustice, improves social welfare, saves time, and reduces the operating costs of businesses [7]. The development of transport infrastructure contributes to the spatial expansion of the market, which provides economies of scale.

The development of transport infrastructure is the driving force of economic prosperity. Also, transport infrastructure is a direct and indirect driver of economic growth [8, 9]. The indirect impact of developed transport infrastructure on economic growth is important. In particular, the development of transport infrastructure stimulates the development of secondary industries aimed at ensuring direct investment [9]. There are three key advantages that show that the choice of infrastructure is important for economic growth [8]: - facilitating technology transfer between economies; - increasing the overall productivity of production units; - increasing the profitability of transport enterprises. Thus, increasing the profitability of transport enterprises can be achieved by optimizing sales volumes, optimizing production and delivery costs.

A developed transport infrastructure is of crucial importance when choosing the geographical location of an enterprise. Therefore, it is the driving force of the economic development of the region [10]. Widely developed transport infrastructure can stimulate the development of the region by increasing economic activity in the region and strengthening its competitiveness. In particular, a necessary condition for the attractiveness of the region for potential investors and businesses is the development of road infrastructure and its compatibility with the main communication highways. In addition, the development of transport infrastructure can facilitate the migration of skilled labor.

According to economists, the decisive factors for the management of the region are the developed transport infrastructure. In particular, communication accessibility and free movement of business are key factors for the development of the region. A study of the transportation system and its connection with the surrounding territories was presented by Rodrigue et al. [11]. They noted that all places are located relative to each other. However, location is not constant, as transport developments change the level of accessibility (and therefore connectivity between) locations.

Roland Berger, an authoritative management consultant, in his paper analyzing the current state of logistics and transportation, used the term FreightTech. This term is defined as the process of using destructive ideas in the field of intelligence in order to automate and integrate the logistics industry to ensure its transparency and increase its efficiency [12]. FreightTech consists of three elements: research, automation, and integration. In addition, the paper presents two more important conclusions. The first is that the future logistics ecosystem will be based on low/zero emissions. The second is that e-commerce companies and start-ups are more innovative and adaptable to future challenges and, therefore, can become key players in logistics markets, creating fierce competition [12]. McKinsey takes a similar view. In its most recent report, this company presented a program for financing start-ups in the field of logistics [13]. According to the conclusions of this report, venture capital has a high interest in green technologies of enterprises in the field of logistics. Industry funding grew by 76% from 2014 to 2019, with total investments in the industry reaching US$10 billion in 2019, up from US$400 million in 2014. Thus, the pace of financing logistics start-ups is 17 times greater than the overall growth rate of venture capital. According to the conclusions of the report, investments were made in all logistics areas.

Thus, entrepreneurship is the driving force behind the development of any economy. Considering the impact of transport on the modern world, it is very important to investigate what transport entrepreneurship is and what areas of activity it contains. Transport entrepreneurship is represented by transport services, which are grouped according to a number of characteristics [14]:

1. According to the relationship with the main activity of enterprises: transportation (i.e., they include an element of transportation); non-transport services.
2. According to the type of consumer to whom the service is provided: external (provided by a non-transport company); internal (provided by another transport company).
3. According to the nature of the activity related to the provision of a certain service (e.g., technological, commercial, informational). There are a number of features characteristic of such a concept as “service” (including transport service).

Digital cargo platforms are a factor in the development of entrepreneurship in the retail network. This development is caused by rapid technological development, which reflects significant changes in the process of using transport services. For example, platforms like Uber, Lyft, and Bolt have partially replaced personal transportation. It is also predicted that this trend will be observed in freight transportation. Frehe et al. used the term crowd logistics to indicate the provision of carrier services by ordinary people for a small fee [15]. As a rule, the technological platform acts as a provider of crowd

logistics services and as an intermediary between the beneficiary and the provider of transport services. Technological innovations that have entered everyday life (for example, radio frequency identification, GPS, and the widespread use of smartphones) have become key prerequisites for the development of the crowd logistics concept. Thus, crowd-logistics services are provided by technology companies and not by classic logisticians or forwarders. In addition, this type of service is based on the principles of the circular economy or sharing economy [16].

The trend of development of technological platforms in the USA and Europe has caused the emergence of digital freight forwarders. The main goal of digital forwarders is to optimize the transport process and the competitive struggle to regain market share from classic forwarders [17, 18].

An analysis of the latest research in the field of transport entrepreneurship revealed a scientific gap regarding the definition of this term. Thus, this paper presents the author's definition of this concept. According to the authors of this paper, transport entrepreneurship is an independent, systematic, risky business activity conducted in the field of providing transport services (such as the transportation of goods and passengers, loading and unloading operations, storage of goods, preparation of means of transport, provision of means of transport on terms of lease or hire, delivery of new and repaired vehicles, transport and forwarding services and other services. The purpose of this paper is to identify the factors related to transport entrepreneurship that affect the economic development of Ukraine. This is a critical topic because the development of transport infrastructure drives the development of entrepreneurship in Ukraine, especially in the post-war period.

2. MATERIALS AND METHODS

The authors used a simple linear regression to investigate the factors influencing the formation of gross value added (gross regional product) in the scope of transport entrepreneurship in Ukraine. An algorithm for modeling the relationship between two variables (Y and X) was used for the analysis. In this case, Y is to be predicted using X. The mathematical formula of linear pairwise regression is

$$y_1 = \beta_0 + \beta_1 x_i + \varepsilon_i \quad , \tag{1}$$

where β_0 and β_1 – constants (model parameters) to be determined;
ε_i (u_i) – model error.

Any adequate model has a certain amount of error, so estimates of model parameters are written with a diacritical sign:

$$\hat{Y}_i = \hat{b}_0 + \hat{b}_1 X_i \tag{2}$$

and the model error is defined as

$$\hat{e}_i = Y_i - \hat{Y}_i \quad . \tag{3}$$

To determine the parameters of the model in the study, we used the method of least squares. The essence of this method is to select the parameters of the model under which the sum of the squares of deviations (residual sum of squares [RSS]) from the real values will be minimal.

$$RSS = \sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2 = \sum_{i=1}^{n} (Y_i - \hat{b}_0 - \hat{b}_1 X_i)^2 \tag{4}$$

The parameters of the model are determined by the following formulas:

$$\hat{b}_1 = \frac{\sum_{i=1}^{n} (Y_i - \bar{Y})(X_i - \bar{X})}{\sum_{i=1}^{n} (X_i - \bar{X})^2} \quad ; \tag{5}$$

$$\hat{b}_1 = \frac{Cov(x, y)}{Var(x)} \quad ; \tag{6}$$

$$\hat{b}_0 = \bar{Y} - \hat{b}_1 \bar{X} \quad . \tag{7}$$

The method of least squares was used to determine the parameters of the model. For the correct interpretation of the coefficients of the model, the following requirements were met:

- normality – the values of the dependent variable are normally distributed at fixed values of the independent variables;
- independence – the values of the dependent variable must be independent of each other;
- linearity – the dependent variable is linearly related to the independent variables;
- homoscedasticity – the variance of the dependent variable is constant at different values of the independent variables.

One of the most important indicators of model efficiency is root mean squared error (RMSE), which evaluates the overall accuracy of the model:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n}} \quad . \tag{8}$$

Similar to RMSE is the residual standard error (RSE), in which the indicator of the number of predictors (p) is used:

$$RSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n-p-1}} \quad . \tag{9}$$

The coefficient of determination measures the explanatory part of the variation in the data in the model. In other words, it shows how the model values match the real ones:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} = 1 - \frac{Var(\hat{u})}{Var(y)} = \frac{Var(\hat{y})}{Var(y)} \quad . \tag{10}$$

It is important to assess the relationship between the two variables. For this, the correlation coefficient can be used:

$$r = \frac{\sum(x_t - \bar{x})(y_t - \bar{y})}{\sqrt{\sum(x_t - \bar{x})^2}\sqrt{\sum(y_t - \bar{y})^2}} \quad . \tag{11}$$

A T-test (Student's test) determines the statistical significance of model parameter estimates (the hypothesis that the model parameter is equal to "zero" is tested). The larger the value of the t-test (and the lower the p-value), the more significant the predictor is. The critical value of the t-test is determined from the corresponding Student's distribution tables, in which the column is defined as the confidence probability (α) and the row is defined as the degree of freedom (n-m). The critical p-value is 0.05.

The information base for calculating the model is statistical data for the regions of Ukraine for the last five statistical periods. The correlation study was conducted on the basis of RStudio, a free and open integrated development environment for R, a programming language for computational statistics and data visualization. Three analytical software packages were downloaded to solve the tasks in RStudio:

- tidyverse – a block of analytical packages that allow the user to work with specific data and include data packages for visualization, working with tables, data frames, reading R files, functional programming, data conversion, and working with time variables.
- ggplot2 and GGally, which extends the capabilities of ggplot2 by adding features to simplify the integration of geometry and data conversion.

3. RESULTS AND DISCUSSION

The development of transport entrepreneurship plays a systemic role in achieving many of the UN Sustainable Development Goals. Thus, the contribution of transport entrepreneurship to GDP growth is

systematically growing. Over the past decade, it has grown from 98.9 billion UAH to 362.6 billion UAH (i.e., by almost 3.7 times), which is evidence of sufficiently dynamic and effective development (Tab. 1).

Table 1

Value added formed by the subjects of transport entrepreneurship and its share in the GDP of Ukraine [5, 19]

Development indicators	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Value added by type of economic activity at prices of the previous year, billion UAH	98.9	104.5	100.9	135.0	156.7	191.2	227.3	264.9	312.6	362.6
Share of value added of transport in GDP, %	7.0	7.1	6.4	6.8	11.2	6.4	6.4	6.7	6.8	6.8

Indicators of the share of freight turnover and passenger turnover in% of GDP are used to assess the development of transport in Europe (in Ukraine, these indicators are not calculated by statistical authorities). The calculation of these indicators in Ukraine and comparisons with the EU-27 countries clearly show negative trends in the contribution of transport entrepreneurship to GDP (Tab. 2).

Table 2

Comparative assessment of the development of transport entrepreneurship in Ukraine and the EU-27 [19, 20, 21]

Development indicators	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Freight turnover, % to GDP	0.21	0.15	0.13	0.13	0.10	0.07	0.11	0.05	0.05	0.04
Growth rate of freight turnover in Ukraine,%	100.00	67.75	61.57	58.52	47.74	34.60	51.65	24.75	21.54	18.52
European Union – 27 countries, %	100.00	98.00	95.50	97.30	96.40	96.20	97.20	98.50	96.20	96.80
Passenger turnover, % to GDP	0.83	0.54	0.49	0.45	0.37	0.26	0.35	0.16	0.13	0.06
Growth rate of passenger turnover in Ukraine, %	100.00	64.62	58.37	54.40	44.76	31.27	41.90	18.75	15.17	7.77
European Union – 27 countries, %	100.00	98.00	96.80	95.80	95.20	95.00	95.30	93.60	92.40	92.70

The share of freight turnover in GDP has decreased over the past 10 years from 0.21% in 2012 to 0.04% in 2021. So, the growth rate of freight turnover in Ukraine was 18.52% in 2021. In the EU, this figure decreased by only 3.2% on average. The share of passenger turnover in GDP decreased from 0.83% in 2012 to 0.06% in 2021. So, the growth rate of passenger traffic in Ukraine was 7.77% in 2021.

In the first stage of this study, the factors influencing the formation of gross value added or gross regional product in the scope of transport entrepreneurship were identified by building four models to assess the performance indicator (Y), for which the following factors were determined:

Y1 – gross regional product in transport, warehousing, and postal and courier activities (**GRP**);
Y2 – gross regional product in transport, warehousing, and postal and courier activities per capita (**GRP_reg**);
Y3 – gross value added in transport, warehousing, and postal and courier activities (**GVA**);
Y4 – gross value added in transport, warehousing, and postal and courier activities per person (**GVA _reg**).

For factor characteristics, all models were previously selected:
- average number of full-time employees of enterprises of economic activity "Transport, warehousing, and postal and courier activities" by region (**regular employees**);
- freight transportation by road by region (**freight**);
- the share of cargo transportation by road transport enterprises in road transport by region (**freight_mte**);
- freight turnover of road transport by regions (**freight_traffic**);
- share of freight turnover of motor transport enterprises in the freight turnover of road transport by region (**freight_traffic_mte**);
- average distance of transportation of one ton of cargo by motor transport by region (**distance**);
- average distance of transportation of one ton of cargo by motor transport enterprises by region (**distance_mte**);
- transportation of passengers by road (buses) by region (**passenger**);
- transportation of passengers by road (buses) in long-distance traffic by region (**passenger_intercity**);
- transportation of passengers by road (buses) in suburban traffic by region (**passenger_commuter**);
- passenger turnover of road transport (buses) by region (**passenger_turnover**);
- number of gas stations by region (**gas_stations**).

All models reflect a single pattern of factors and performance characteristics. The best model was selected by determining the weights by p-value. The coefficient of determination (multiple R-square), the coefficient of determination, the t-test, the F-statistic, the standard error (RMSE), and the mean absolute error (MAE) were adjusted (Tab. 3).

Table 3

Brief description of the results of model development

Factors and criteria	Model 1	Model 2	Model 3	Model 4
The most important factors (by p-value (Pr (> | t |)))				
regular employees	∨		∨	
freight	∨	∨	∨	∨
freight_mte				
freight_traffic	∨	∨	∨	∨
freight_traffic_mte		∨		∨
distance	∨	∨	∨	∨
distance_mte				
passenger			∨	
passenger_intercity	∨	∨	∨	∨
passenger_commuter				
passenger_turnover	∨	∨	∨	∨
gas_stations	∨	∨	∨	∨
Performance indicators of the model				
Multiple R-squared	0.945	0.906	0.945	0.903
Adjusted R-squared	0.939	0.896	0.940	0.892
p-value	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16
F-statistic	160.4	90.37	161.6	86.74
RMSE	5899.7	2555.1	2570.1	1143.4
MAE	4375.9	2086.8	1886.4	928.0

The least significant factors were “freight_mte,” “freight_traffic_mte,” and “distance_mte.” These factors reflect the performance of motor transport enterprises in Ukraine. As the share of traffic in Ukraine by transport companies is relatively low (as is their share in freight turnover), the model did not show a significant impact of these factors on the performance indicator. The factor “passenger_commuter” was also insignificant (i.e., in the models, long-distance passenger traffic is more important for performance than suburban passenger traffic).

Given the above discussion, Model 5 was created with the relevant factors and performance:

Y1 – gross regional product in transport, warehousing, and postal and courier activities, UAH mln. (**GRP**);

X1 **–** average number of full-time employees of enterprises of economic activity “Transport, warehousing, postal and courier activities” by region, thousand persons (**regular employees**);

X2 **–** transportation of goods by road by region, million tons (**freight**);

X3 **–** freight turnover of road transport by regions, million tkm (**freight_traffic**);

X4 **–** average distance of one ton of cargo by road by region, km. (**distance**);

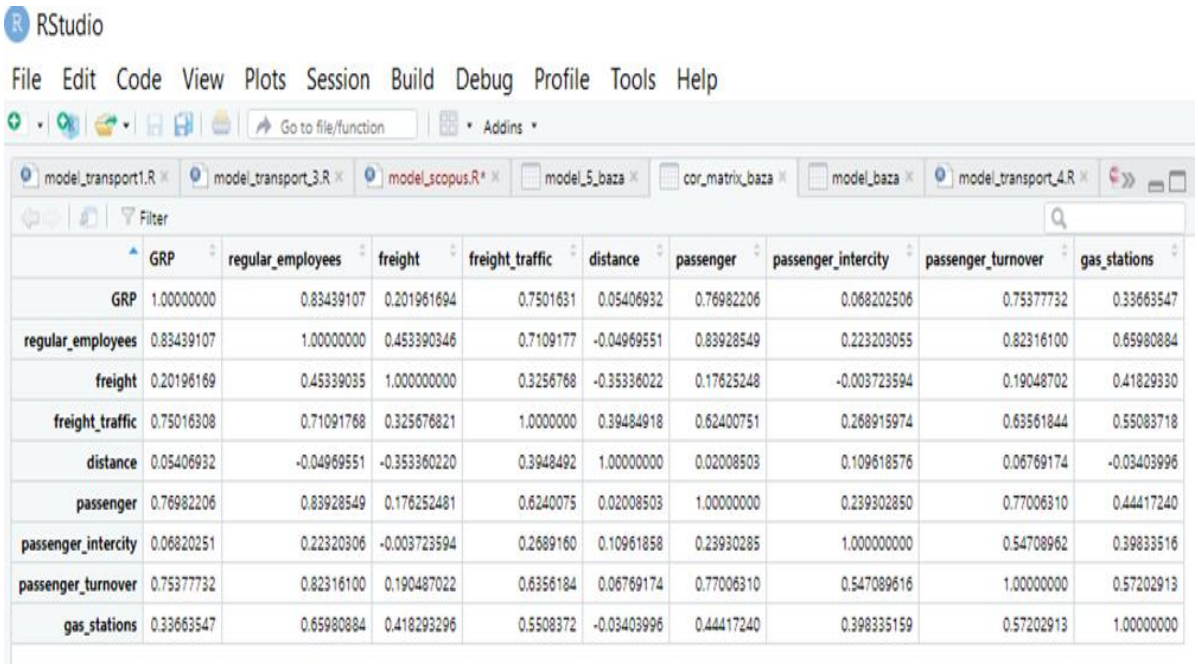
X5 **–** transportation of passengers by road (buses) by region, million passengers (**passenger**);

X6 **–** transportation of passengers by road (buses) in long-distance traffic by region, million passengers (**passenger_intercity**);

X7 – passenger turnover of road transport (buses) by regions, million passengers/km (**passenger_turnover**);

X8 **–** the number of gas stations by region, units (**gas_stations**).

We now conduct a detailed analysis of the proposed model. We start by calculating and analyzing the correlation coefficient (Figs. 1–3).



	GRP	regular_employees	freight	freight_traffic	distance	passenger	passenger_intercity	passenger_turnover	gas_stations
GRP	1.00000000	0.83439107	0.201961694	0.7501631	0.05406932	0.76982206	0.068202506	0.75377732	0.33663547
regular_employees	0.83439107	1.00000000	0.453390346	0.7109177	-0.04969551	0.83928549	0.223203055	0.82316100	0.65980884
freight	0.20196169	0.45339035	1.000000000	0.3256768	-0.35336022	0.17625248	-0.003723594	0.19048702	0.41829330
freight_traffic	0.75016308	0.71091768	0.325676821	1.0000000	0.39484918	0.62400751	0.268915974	0.63561844	0.55083718
distance	0.05406932	-0.04969551	-0.353360220	0.3948492	1.00000000	0.02008503	0.109618576	0.06769174	-0.03403996
passenger	0.76982206	0.83928549	0.176252481	0.6240075	0.02008503	1.00000000	0.239302850	0.77006310	0.44417240
passenger_intercity	0.06820251	0.22320306	-0.003723594	0.2689160	0.10961858	0.23930285	1.000000000	0.54708962	0.39833516
passenger_turnover	0.75377732	0.82316100	0.190487022	0.6356184	0.06769174	0.77006310	0.547089616	1.00000000	0.57202913
gas_stations	0.33663547	0.65980884	0.418293296	0.5508372	-0.03403996	0.44417240	0.398335159	0.57202913	1.00000000

Fig. 1. Calculation of correlation coefficients

The graph of the correlation matrix shows the graphs of the distribution density, scattering diagrams, and correlation coefficients, as well as their statistical significance (the more stars near the coefficient, the greater the statistical significance of the factor). Thus, in this case, for the gross regional product, the statistically significant factors with the highest correlation coefficients are the average number of full-time employees (r = 0.834), passenger transport by road (r = 0.770), passenger turnover (r = 0.754), freight turnover transport (r = 0.750) and the number of gas stations (r = 0.337).

A similar situation is demonstrated by the heatmap correlation model (Fig. 3).

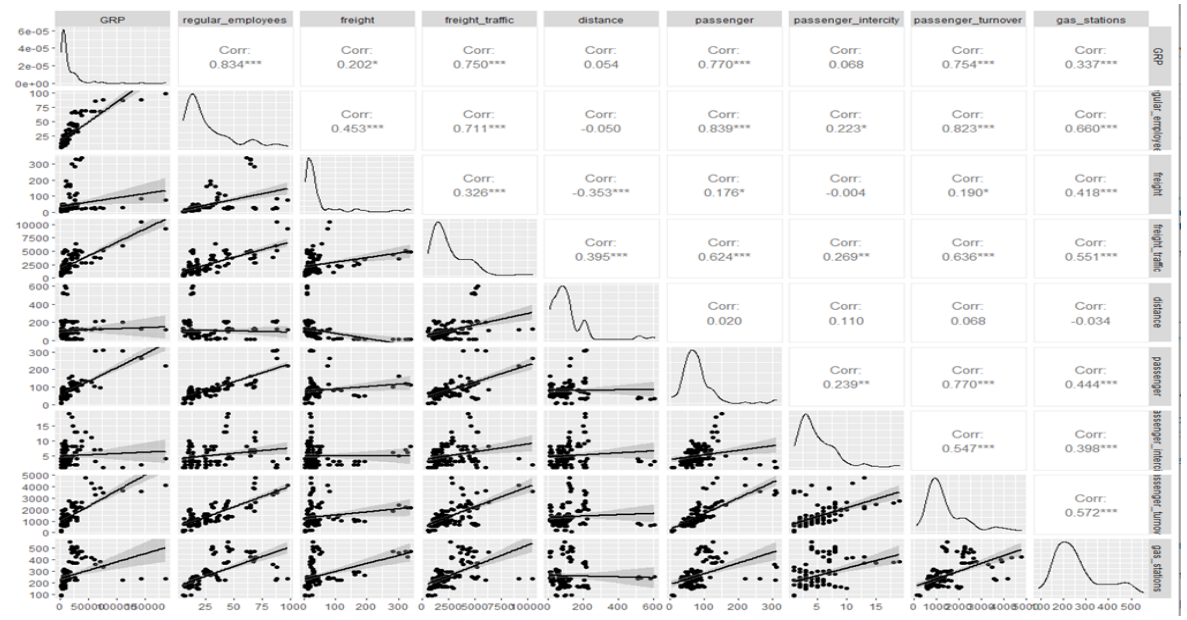


Fig. 2. Correlation matrix graph

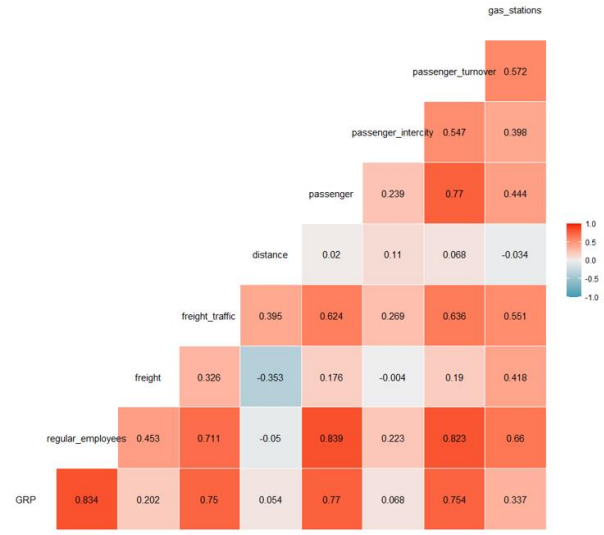


Fig. 3. Heatmap correlations (ggcorr (model_base, label = TRUE, label_round = 3))

```
Residuals:
   Min     1Q Median     3Q    Max
-19477  -3104    105   3049  36342

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)       8968.2219  2022.7509   4.434 2.12e-05 ***
regular_employees  697.4920    94.0938   7.413 2.19e-11 ***
freight           -101.2030    13.2823  -7.619 7.57e-12 ***
freight_traffic      9.4699     0.6827  13.871  < 2e-16 ***
distance           -64.0233     8.0722  -7.931 1.50e-12 ***
passenger          -69.8140    24.4706  -2.853  0.00513 **
passenger_intercity -1812.9211  265.5333  -6.827 4.19e-10 ***
passenger_turnover    10.5869    1.6426   6.445 2.74e-09 ***
gas_stations         -84.5624    8.4823  -9.969  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6566 on 116 degrees of freedom
Multiple R-squared:  0.9368,    Adjusted R-squared:  0.9324
F-statistic: 214.9 on 8 and 116 DF,  p-value: < 2.2e-16
```

Fig. 4. Basic parameters of mathematical models (where Estimate – model parameters; Std. Error – standard errors in estimating model parameters; t value – t-criterion, Student’s criterion; (Pr (> | t |) – method of estimating the determination of weight (significance of factors) by p-value, Multiple R-squared – coefficient of determination, Adjusted R-squared – adjusted coefficient of determination)

An important stage of this study is the analysis of interfactor correlation coefficients. A significant linear relationship was found between such factors as the average registered number of full-time employees and the traffic of road transport (r = 0.711), the average registered number of full-time employees and transportation of passengers by road transport (r = 0.839), and the average number of registered full-time employees and passenger traffic of road transport (buses) by region (r = 0.823). Thus, when organizing the process of managing one of these factors, it is advisable to take into account the expected change in the linearly dependent factor and the synergistic effect. Using the “summary” function, we calculated the main parameters of the model (Fig. 4).

The model has the following form:

$$Y = 8968{,}2 + 697{,}5X1 - 101{,}2X2 + 9{,}47X3 - 64{,}02X4 - 69{,}81X5 - 1812{,}9X6 + 10{,}59X7 - 84{,}56X8 \quad (12)$$

The coefficient of determination is 93.68%, the accuracy of model prediction is 93.24%, and the p-value is <2.2e-16 (with a critical value of 0.05), which confirms the effectiveness of the mathematical model. At the same time, the variables X2, X4, X5, X6, and X8 have a negative effect on the resulting indicator. That is, as these factors increase, the gross regional product decreases.

Next, the confidence intervals for fashion is calculated (Fig. 5).

```
> confint(model_baza)
                          2.5 %       97.5 %
(Intercept)          4961.908876 12974.53493
regular_employees     511.127365   883.85672
freight              -127.510332   -74.89576
freight_traffic         8.117696    10.82220
distance              -80.011370   -48.03530
passenger            -118.281182   -21.34681
passenger_intercity -2338.843299 -1286.99884
passenger_turnover       7.333587    13.84028
gas_stations          -101.362754   -67.76210
```

Fig. 5. Confidence intervals of the model

As can be seen, the confidence intervals show that each of the selected factors does not exceed zero, which is very important from the point of view of model construction. Further, the selected factors are significant.

Next, we calculated the RMSE through the record in RStudio. As a result, RMSE = 6352.4. That is, our model has a significant error because RMSE indicates how much the value of the mathematical model deviates from the real values. However, given the density of distribution, and especially given the significant size of gross regional product in transport, warehousing, and postal and courier activities in major transport and logistics hubs of Ukraine, including Kyiv and Odesa, we consider such an error acceptable. Additionally, we calculated the mean absolute error (MAE), which was 4472.1. This also represents a significant error.

Thus, the overall performance of the model indicates that the selected factors are significant and that the model can be used for further calculations, though there is a possibility for significant error. It is not known what effect the interactions between model factors can be expected to have on the performance characteristic. To address this issue, we model the parameters of the new model while taking into account factors that have the highest correlation coefficients. In particular, the new model will include the average number of full-time employees (**regular employees**), road passenger transport (**passenger**), road passenger traffic (**passenger_turnover**), road freight traffic (**freight_traffic**), and number of gas stations (**gas_stations**).

We obtained a rather unexpected result, which can be an element of a separate study and analysis. It should be kept in mind that the model is based on data from the last five statistical periods (i.e., statistics before the COVID-19 period and the war in Ukraine. Additionally, we can calculate the accuracy of the model and compare the real GRP and mathematically calculated (fitted_GRP). To do this, we built a scattering diagram (Fig. 6).

Ideally, the scattering angle should be 45°. The diagram shows that the angle is within the allowable norms, as 93% of the points have an explanation of the variance, which again confirms the effectiveness of the proposed model.

4. CONCLUSIONS

The factors influencing the formation of gross added value or gross regional product in the field of transport entrepreneurship in Ukraine were identified. Four models were created to achieve this goal, from which the results were determined: gross regional product in transport, warehousing, and postal and courier activities (GRP); gross regional product in transport, warehousing, and postal and courier activities per capita (GRP_reg); gross value added in transport, warehousing, and postal and courier activities (GVA); and gross value added in transport, warehousing, and postal and courier activities per capita (GVA_reg).

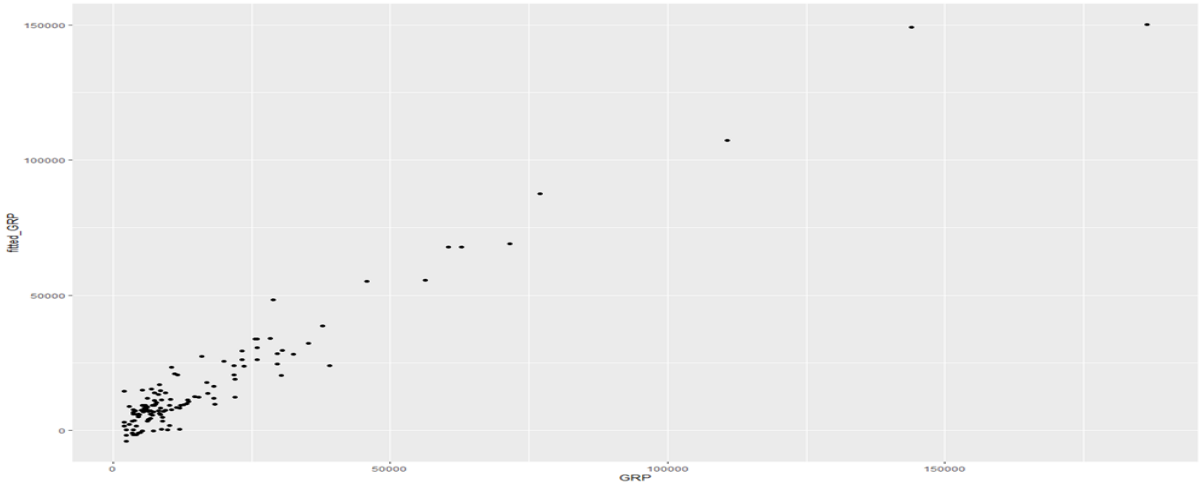


Fig. 6. Scatter plot of actual gross regional product (GRP) and estimated (fitted_GRP)

The end result of the modeling was Model 5 with the resultant feature Y1 – gross regional product in transport, warehousing, and postal and courier activities, UAH million (GRP) and the following predictors: X1 – the average number of full-time employees of enterprises of the economic activity "Transport, warehousing, postal and courier activities" by region, thousand persons (regular employees); X2 – transportation of goods by road by region, million tons (freight), X3 – freight turnover of road transport by region, million tons (freight_traffic); X4 – average distance of one ton of cargo by road by region, km. (distance); X5 – transportation of passengers by road (buses) by region, million passengers (passenger); X6 – transportation of passengers by road (buses) in long-distance traffic by region, million passengers (passenger_intercity); X7 – passenger turnover of road transport (buses) by region, million passengers/km (passenger_turnover); and X8 –number of gas stations by region, units (gas_stations).

It is substantiated that for forecasting value added (gross regional product), the most statistically significant factors (with the highest correlation coefficients) are the average number of full-time employees (r = 0.834), passenger transport by road (r = 0.770), passenger turnover of road transport (r = 0.754), freight turnover of road transport (r = 0.750), and the number of gas stations (r = 0.337).

The proposed tools for identifying the factors related to the influence of transport entrepreneurship on the economic development of Ukraine can be used as important markers for the formation of the country's post-war strategy in the field of transport entrepreneurship. Based on the results of the study, in particular, concerning the factors of the positive impact on gross regional product, it is advisable to:

- direct transport entrepreneurship in the scope of innovative training of full-time employees involved in the transport sector;
- introduce innovations to increase the freight turnover of road transport and the passenger turnover of road transport.

Based on the results related to the factors that have a negative impact on gross regional product, it is advisable to:

- increase the volume and cost of road transport in innovative ways (in particular, intelligent transport systems can find innovative ways to reduce road congestion and urban mobility, which significantly reduces transport costs);
- reduce the average distance of one ton of cargo due to innovative methods of logistics;
- introduce innovations in the transportation of passengers by road (buses), in particular in long-distance communication, which is currently economically unprofitable in Ukraine for the carrier or subsidized from local budgets;
- actively implement innovative solutions and develop networks that promote the development of the entire industry (e.g., vehicle-to-network, vehicle-to-grid, brain-to-vehicle, and platooning or grouping);
- invest in modern innovative gas stations.

Thus, the development of the transport sector of Ukraine's economy requires innovative rethinking based on the current study and the implementation of modern methods. Only on this basis are the radical modernization of the industry, the rapid growth of Ukraine's economy, and its international competitiveness possible.

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