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INTRODUCTION

We are happy to invite you to get acquainted with the first issue of the new scientific and practical publication "Intellectualization of Logistics and Supply Chain Management".

We strongly believe that the launch of this magazine indicates the objective need to rethink a wide range of issues related to the development of theory and practice in logistics and supply chain management, awareness of the need to unite the scientific community and logistics practitioners, dissemination of modern knowledge and best practices for innovative development of the logistics services market.

The first issue of the magazine is published at a difficult time. The global coronavirus pandemic and the deep economic crisis have significantly worsened business activity in the world. Currently, global supply chains are collapsing, international trade is declining, and competition between global and regional logistics operators is intensifying. The most common thesis is that the world will never be the same again. Industry experts predict the emergence of new, more flexible and adaptive supply chain management strategies and approaches to logistics business process management. The trend towards collaborations, cooperation and unification of services is emerging, comprehensive proposals for clients are being developed. There is increasing talk about the need to build bimodal supply chains, which involves the development of different decision-making scenarios: the traditional approach - cost-effective efficiency, low risk, high predictability; a new approach "second mode" - rapid recognition of opportunities, adaptability, willingness to solve unexpected problems and look for new opportunities.

Radical transformations of the global and national markets for logistics services require appropriate scientific support. Logistics science has a special role to play in this process. Initiating the emergence of a new journal, we decided to focus on its coverage of problematic aspects of the formation and development of logistics systems at the micro, mezo and macro levels, supply chain management, digitization of logistics, methods and tools for optimizing processes in logistics and supply chains, sociopsychology relations and network interaction of enterprises using cloud technologies, artificial intelligence, e-learning, neural business process management systems, etc.

Therefore, we invite scientists, researchers and business representatives, as well as our colleagues from abroad, to cooperate and present the results of scientific research, to discus and debate on them, to work together to develop the scientific theory of logistics and promote mutual intellectual enrichment.

We hope that the new scientific publication will become a theoretical guide for young researchers and representatives of other fields.

HRYHORAK Mariia
Chief Editor

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MODELING OF REGIONAL FREIGHT FLOWS OF ROAD TRANSPORT IN UKRAINE

Lidiia Savchenko, Myroslava Semeryagina, Iryna Shevchenko "Modeling of regional freight flows of road transport in Ukraine". *A transport system can be defined as a complex system characterized by a random value of transport demand, variable weather and climatic factors, a set of characteristics of transport infrastructure, and a complex system of interconnections. One of the key modes of transport providing freight transport both in domestic and international traffic is road. Its mobility and the ability to deliver cargo from door to door is a unique competitive advantage over other modes of transport.*

To create an effective logistics infrastructure that meets the demand for domestic freight transport, first of all, information is needed on the needs for transport between regions of the country. Thus, it is necessary to look for mathematical approaches to modeling freight flows, combining their practical implementation using widely used software products (for example, MS Excel).

The purpose of the paper is to build effective multifactor regression models of demand for input and output transportation of goods by road for each region of Ukraine according to publicly available statistical data of the State Statistics Service of Ukraine.

The modern approach to modeling cargo flows requires fast processing of a large amount of statistical data. In addition, the method should be as universal as possible and capable of quick and simple changes under conditions of a change in statistical data. From this point of view, the most acceptable option can be considered to be the modeling of freight traffic using regression models based on correlation and regression analysis. In

general, the task is to find the dependence of the demand for transportation on the factors that influence it. Such factors in the existing models are connected with various macroeconomic indicators, as well as the distance of delivery.

The data of regional statistics of the State Statistics Service of Ukraine and data of the "Lardi-Trans" website as the most widely used by freight carriers and shippers were taken as the initial data for modeling.

A list of factors has been found that significantly influence the demand for freight transport by road between regions of Ukraine. A rating of influencing factors has been compiled, among which are the gross regional product, regional volumes of foreign trade in goods (imports) and gross regional product per one inhabitant of the region. The absolute values of the correlation coefficients are in the range 0.351-0.974. The lowest correlation coefficient is between the transportation distance and the demand for delivery, which proves a negligible relationship between the volume of regional transportation and the distance of delivery.

Multivariate regression models with thirteen, five and two factors of influence on demand are built. Accuracy parameter values are acceptable for all model variants. The normalized R-squared of the obtained models does not fall below 84%, and the average approximation error does not rise above 1.6%, which is an excellent performance of the models.

***Keywords**:* demand for freight transportation, regional transportation of goods by road, domestic transportation, modeling the demand for transportation, correlation-regression analysis, linear multivariate regression.

Лідія Савченко, Мирослава Семерягіна, Ірина Шевченко "Моделювання регіональних вантажопотоків автомобільного транспорту в Україні". *Транспортну систему можна визначити як складну систему, яка характеризується випадковою величиною транспортного попиту, змінними погодно-кліматичними факторами, набором характеристик транспортної інфраструктури та складною системою взаємозв'язків. Одним з ключових видів транспорту, що забезпечує вантажні перевезення як у внутрішньому, так і міжнародному сполученні, є автомобільний. Його мобільність та можливість доставки вантажу «від дверей до дверей» є унікальною конкурентною перевагою перед іншими видами транспорту.*

Для створення ефективної логістичної інфраструктури, що забезпечує попит на внутрішні вантажні перевезення, перш за все необхідна інформація про потреби в перевезеннях між регіонами країни. Таким чином, необхідно шукати математичні підходи до моделювання вантажопотоків, комбінуючи їх практичну реалізацію з використанням широко використовуваних програмних продуктів (наприклад, MS Excel).

Метою статті є побудова ефективних багатофакторних регресійних моделей попиту на вхідні та вихідні перевезення вантажів автомобільним транспортом для кожної області України за загальнодоступними статистичними даними Державної служби статистики України.

Сучасний підхід до моделювання вантажопотоків вимагає швидкої обробки значної кількості статистичних даних. Крім того, метод має бути максимально універсальним та здатним до швидких та простих змін у разі зміни наявних статистичних даних.

Найбільш прийнятним варіантом з цієї точки зору може вважатися моделювання вантажопотоків з використанням регресійних моделей на основі проведення кореляційно-регресійного аналізу. У загальному вигляді задача полягає в знаходженні залежності попиту на перевезення від факторів, що на нього визначальний вплив. Такими факторами є макроекономічні показники, а також відстань перевезення.

У якості вихідних даних взяті дані регіональної статистики та дані сайта «Ларді-Транс» як найбільш широко використовуваного у вантажоперевізників, відправників та замовників перевезень.

Знайдено фактори, що становлять значний вплив на попит на вантажні перевезення автотранспортом з та до областей України. Складено рейтинг факторів впливу, серед яких на перших позиціях Валовий регіональний продукт; Регіональні обсяги зовнішньої торгівлі товарами (імпорт) та Валовий регіональний продукт у розрахунку на одну особу. Абсолютні значення коефіцієнтів кореляції перебувають у діапазоні 0,351-0,974. Найнижчий коефіцієнт кореляції - між

відстанню перевезень та попитом на них, що доводить незначний зв'язок між обсягами регіональних перевезень та відстанню доставки.

Побудовано моделі багатофакторної регресії з тринадцятьма, п'ятьма і двома факторами впливу на попит. Значення параметрів точності є прийнятними для всіх варіантів моделей. Нормований R-квадрат отриманих моделей не опускається нижче 84%, а середня помилка апроксимації не піднімається вище 1,6%, що є відмінними показниками моделей.

Ключові слова: попит на вантажні перевезення, регіональні перевезення вантажів автомобільним транспортом, внутрішні перевезення, моделювання попиту на перевезення, кореляційно-регресійний аналіз, лінійна багатофакторна регресія.

Лидия Савченко, Мирослава Семерягина, Ирина Шевченко "Моделирование региональных грузопотоков автомобильного транспорта в Украине". *Транспортную систему можно определить как сложную систему, которая характеризуется случайной величиной транспортного спроса, переменными погодно-климатическими факторами, набором характеристик транспортной инфраструктуры и сложной системой взаимосвязей. Одним из ключевых видов транспорта, обеспечивающим грузовые перевозки как во внутреннем, так и в международном сообщении, является автомобильный. Его мобильность и возможность доставки груза «от двери до двери» является уникальным конкурентным преимуществом перед другими видами транспорта.*

Для создания эффективной логистической инфраструктуры, обеспечивающей спрос на внутренние грузовые перевозки, прежде всего необходима информация о потребностях в перевозках между регионами страны. Таким образом, необходимо искать математические подходы к моделированию грузопотоков, комбинируя их практическую реализацию с использованием широко используемых программных продуктов (например, MS Excel).

Целью статьи является построение эффективных многофакторных регрессионных моделей спроса на входные и выходные перевозки грузов автомобильным транспортом для каждой области Украины по общедоступными статистическим данным Государственной службы статистики Украины.

Современный подход к моделированию грузопотоков требует быстрой обработки большого количества статистических данных. Кроме того, метод должен быть максимально универсальным и способным к быстрым и простым изменениям в случае перемены статистических данных. Наиболее приемлемым вариантом с этой точки зрения может считаться моделирование грузопотоков с использованием регрессионных моделей на основе проведения корреляционно-регрессионного анализа. В общем виде задача состоит в нахождении зависимости спроса на перевозки от факторов, оказывающих на него влияние. Такими факторами в существующих моделях указываются различные макроэкономические показатели, а также расстояние перевозки.

В качестве исходных данных для моделирования взяты данные региональной статистики Государственной службы статистики Украины и данные сайта «Ларди-Транс» как наиболее широко используемого у грузоперевозчиков и грузоотправителей.

Определен перечень факторов, составляющих значительное влияние на спрос на грузовые перевозки автотранспортом между областями Украины. Составлен рейтинг факторов влияния, среди которых на первых позициях валовый региональный продукт, региональные объемы внешней торговли товарами (импорт) и валовый региональный продукт в расчете на одного жителя области. Абсолютные значения коэффициентов корреляции находятся в диапазоне 0,351-0,974. Самый низкий коэффициент корреляции - между расстоянием перевозок и спросом на них, что доказывает незначительную взаимосвязь между объемами региональных перевозок и расстоянием доставки.

Построены модели многофакторной регрессии с тринадцатью, пятью и двумя факторами влияния на спрос. Значения параметров точности являются приемлемыми для всех вариантов моделей. Нормированный R-квадрат полученных моделей не опускается ниже 84%, а средняя ошибка аппроксимации не поднимается выше 1,6%, что является отличными показателями моделей.

Ключевые слова: спрос на грузовые перевозки, региональные перевозки грузов автомобильным транспортом, внутренние перевозки, моделирование спроса на перевозки, корреляционно-регрессионный анализ, линейная многофакторная регрессия.

Introduction. The transport system can be defined as a complex system characterized by a random variable of transport demand, variable weather and climatic factors, a set of characteristics of transport infrastructure and a complex system of relationships. The main purpose of the transport system is to meet the demand of the population, business and government agencies for transport services. The correspondence between the capabilities of the transport system and the demand for its services is determined by the balance of demand and capacity of the transport system. In this regard, it is very important to accurately determine the demand for transport services.

In the text of the National Transport Strategy of Ukraine for the period up to 2030 [1] the priority of the industry as one of the most important in the national economy is identified. The volume of freight traffic directly reflects the financial and economic condition of the country and its regions, as well as a marker of trends in the business environment.

One of the key modes of transport that provides freight in both domestic and international traffic is road. Its mobility and ability for door-to-door delivery is a unique competitive advantage over other modes of transport. Transportation by other modes of transport mostly needs the involvement of road in the first and last stages of the delivery process. Thus, modeling the demand for transportation of goods by road is an urgent task, the correctness of the results of which depends on the quality of the whole process of transportation.

To create an effective logistics infrastructure that meets the demand for domestic freight transport, first of all, information is needed on the demand for transport between regions of the country.

Determination of real freight traffic is associated with a number of difficulties. The most accurate is the method of direct accounting, which consists of a direct full survey of cargo-generating and cargo-absorbing points of the region. This method provides the most complete data for the characterization of traffic flows in a certain period of time. However, its disadvantage is the high labor intensity of data collection and processing. Unfortunately, the collection of such data involves direct interviewing, questioning each actual and potential point of departure and destination of cargo, which in reality is possible only in a small area (no more than a city microdistrict). The accounting of transported goods according to the nomenclature in organizations producing and consuming products, and in road transport enterprises, would certainly make it possible to easily collect the necessary information on freight traffic. However, at the moment in Ukraine there are no such reports for all enterprises, or access to them is limited. In addition, there is the problem of biased applications of consignors, lack of accounting for the frequency of transport and the weight of packages. The inaccuracy of accounting in the performed volumes of transportations in road transport enterprises also creates additional difficulties in determining the real traffic flows.

Thus, it is necessary to look for mathematical approaches to modeling freight traffic, combining their practical implementation using widely used software products (for example, MS Excel).

Analysis of the latest research. Basic principles and approaches to forecasting freight and passenger transportation are presented by the authors in [3]. Authors [7] considered the factors of influence on the evolution of transport systems, that is, they forecasted the trend regarding the volumes of transportation in dependence from factors of external environment. Analysis of trends in freight traffic in containers by the author [2] was carried out using econometric models built on the basis of time series analysis and correlation-regression analysis. Significant number of works (for example, [4]) dedicated to forecasting freight and passenger flows on the railway. It should be noted that despite identical objects (cargo), the principle of

forecasting demand for carriage by rail and road should be quite different due to the nature of functioning of these means of transport and the difference of the fields of their rational application.

Formulation of the purpose of the study. The purpose of the paper is to build effective multifactor regression models of demand for incoming and outgoing transportation of goods by road for each region of Ukraine according to publicly available statistical data of the State Statistics Service of Ukraine.

Presentation of the main research. The modern approach to modeling of cargo flows requires fast processing of a impressive amount of statistical data. In addition, the method should be as universal as possible and capable of quick and easy changes under the conditions of changes in current statistics.

From this point of view, the most acceptable option can be considered to be the modeling of freight traffic with regression models based on correlation and regression analysis.

Correlation-regression analysis is a set of statistical and mathematical methods used for quantitative analysis of the links between socio-economic phenomena and processes. A random variable is used as a dependent variable in regression analysis, and non-random variables are used as an independent variable.

Regression analysis is used when the relationships between variables can be quantified as some combination of these variables. The resulting combination is used to predict the value that can take the target (dependent) variable, which is calculated on a given set of values of input (independent) variables. In the simplest case, standard statistical methods, such as linear regression, are used.

The regression model includes the following parameters and variables:

- Unknown parameters denoted as {β};
- Independent variables, {X};
- Dependent variable, {Y}.

The function $y = f\left(x_1, x_2, ..., x_n\right)$, which describes the dependence of the conditional mean value of the result characteristic (dependent variable) on the given values of arguments (independent variables) $x_1, x_2, ..., x_n$, is called the regression equation.

Linear regression is described by a linear relationship between the studied variables:

$$y = \beta_0 + \beta_1 x_1 + ... + \beta_n x_n, \quad (1)$$

where y is the dependent variable;

$x_1, x_2, ..., x_n$ – independent variables;

$\beta_0 ... \beta_n$ - regression coefficients.

The solution of the mathematical equations of the relationship between the dependent and independent factors involves the calculation of their unknown parameters from the initial data - the coefficients β_0, $\beta_1 ...$, β_n. Determination of unknown regression coefficients [5], according to which the square of the deviation of the observed (statistical) values of the performance indicator y_c is minimized from the model (obtained by the constructed regression equation) values $y_p = f(x, \beta)$. The objective function, respectively, is the expression:

$$\sum_{i=1}^{n} (y_{ci} - y_{pi})^2 \to \min \quad (2)$$

The set of coefficients *{β},* which will provide the minimum of the objective function (2), is taken to describe the dependence of the resulting parameter y on the factors *{X}*.

Consider the stages of regression analysis.

1. Task formulation. At this stage, preliminary hypotheses about the dependence of the studied phenomena are formed. A set of factors is selected that can affect the resulting indicator.

2. Collection of statistical data. Arrays of dependent variable and independent variables are obtained.

3. Formulation of a hypothesis about the form of relationships. Choosing the form of the regression function.

4. Calculation of numerical values of parameters β of the regression equation.

5. Evaluation of the accuracy of regression analysis. Calculating the resulting error of the regression model.

6. Interpretation of the obtained results. The obtained results of regression analysis are compared with previous hypotheses. The correctness and plausibility of the obtained results are evaluated.

7. Prediction of unknown values of the dependent variable.

When conducting regression analysis, a well-grounded choice of not only the type (mathematical form) of the dependencies used, but also the factors themselves, is of great importance. That is why it is desirable to carry out correlation-regression analysis. In addition to the above steps of regression analysis it must be added the stage of estimating the correlation between the dependent and each independent variable. The degree of relationship (correlation) between the dependent and independent variables is determined using the correlation coefficient:

$$r_{xy} = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 (y_i - \bar{y})^2}}, \qquad (3)$$

where r_{xy} is the correlation coefficient between the dependent variable *y* and the independent variable *x;*

x_i, y_i – the $i\text{-}th$ value of the independent and dependent variables;

$\bar{x}$, $\bar{y}$ – the average value of the independent and dependent variables. Only those independent variables that have high values of the correlation coefficient (usually more than 0.5 in absolute value) are left in the regression model.

In general, the task is to find the dependence of the demand for transportation on the factors that have a decisive influence on it. These factors are macroeconomic indicators. For freight transportation, this is the gross domestic product, the volume of production by industry, the volume of imported and exported goods. When forecasting passenger traffic, the main factors are the size, mobility of the population, income and tariffs for transport services. The time factor is highlighted as significant, in which all the ongoing economic and social processes and factors influencing them are accumulated [3]. In the work [7] as a factor of the external environment was taken the GDP, which reflects the efficiency of the economy. The GDP factor is also used to predict freight traffic on the railroad by the author [4], indicating a clear mutual influence of these two factors on each other.

Since the purpose of the paper is to model the demand for road freight transport between the regions of Ukraine, the data of regional statistics [8] should be taken as initial data. As for the resulting factor - the demand for transportation, we use the data of the site "Lardi-Trans" as the most widely used by carriers, shippers and customers (Table 1).

Table 1. Demand for transportation to and from the regions of Ukraine (daily statistics "Lardi-Trans" [6])

Region of Ukraine	Number of orders for transportation from the region	Number of orders for transportation to the region
Vinnytsia	128	114
Volyn	29	56
Dnepropetrovsk	318	162
Donetsk	34	41
Zhytomyr	96	71

Transcarpathian	17	57
Zaporozhye	163	153
Ivano-Frankivsk	8	44
Kyiv	1069	653
Kirovograd	39	170
Luhansk	33	35
Lviv	47	107
Mykolayivska	61	45
Odessa	117	101
Poltava	107	189
Rivne	70	58
Sumy	22	41
Ternopil	61	147
Kharkiv	166	149
Kherson	98	69
Khmelnytsky	43	62
Cherkasy	45	44
Chernivtsi	19	28
Chernihiv	24	21
Total, orders	2814	2617
Average value, orders	117.3	109.0

Source: Compiled by the authors

Since correlation-regression analysis is used in the article to model demand, we must find factors that have a significant impact on the resulting indicator (demand). The State Statistics Service of Ukraine systematically presents information on the regions of Ukraine, which could potentially have an impact on the demand for road freight:

1) Gross regional product (million UAH), latest data for 2018;

2) Gross regional product per capita (UAH), latest data for 2018;

3) Number of legal entities by region, latest data as of January 1, 2021;

4) Population as of December 1, 2020 (current population);

5) Population as of December 1, 2020 (permanent population);

6) Freight transportation by road in the region in 2020, thousand tkm;

7) Freight transportation by road in the region in 2020, thousand tons;

8) Regional volumes of foreign trade in goods in January-October 2020 (exports, thousand US dollars);

9) Regional volumes of foreign trade in goods in January-October 2020 (imports, thousand US dollars);

10) Regional volumes of foreign trade in services for 9 months of 2020 (exports, thousand US dollars);

11) Regional volumes of foreign trade in services for 9 months of 2020 (imports, thousand US dollars);

12) Volumes of manufactured construction products and indices of construction products in 2020, UAH million.

Another factor used in modeling the demand and volume of traffic for both cargo and passengers is always the distance of transportation. To model the demand for transportation to and from the regions, the average distances of transportation between all regions were calculated (Fig. 1).

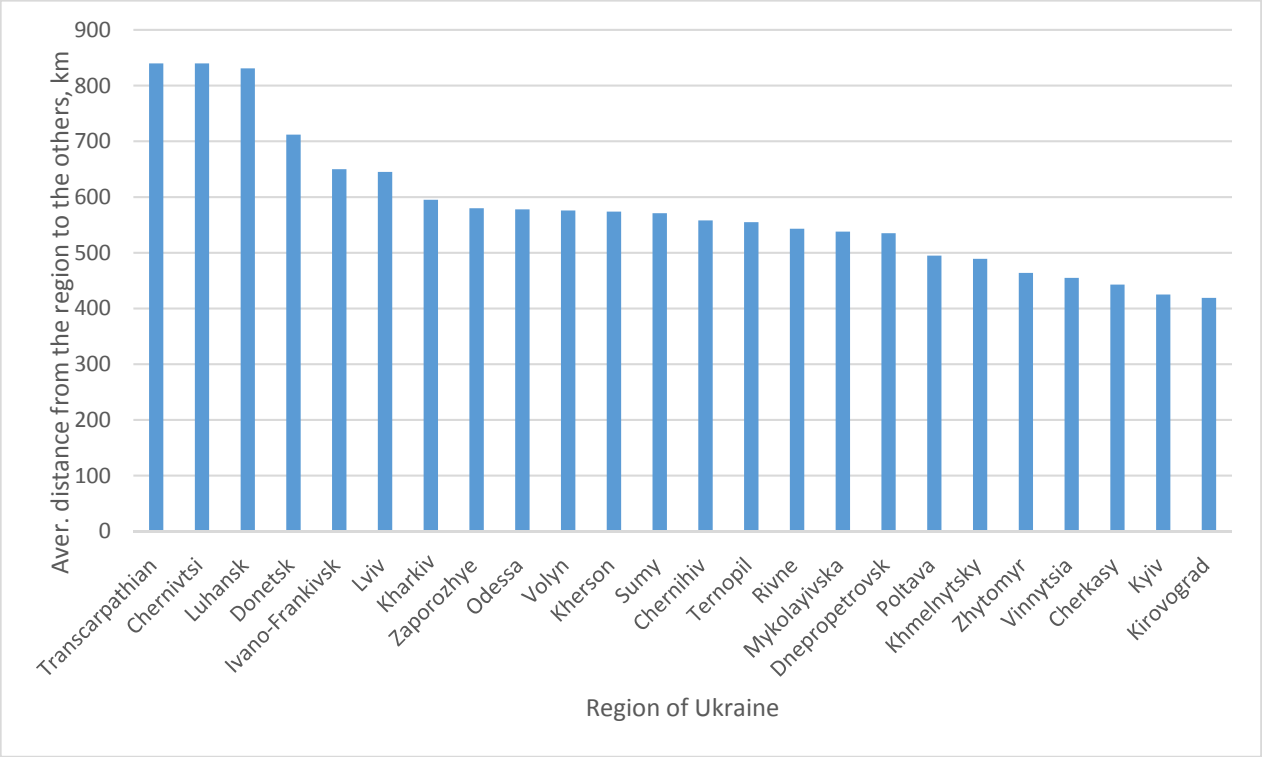


Figure 1 – Rating of regions of Ukraine in relation to the average distance of delivery to other regions

Source: compiled by the authors

Analyzing Fig. 1, it can be assumed that in regions with large average distances of connections with other regions (Transcarpathian, Chernivtsi, Luhansk, etc.), domestic transportation or transportation between neighboring oblasts will be more developed. Whereas regions that have relatively small average distances of connections with other regions (Kirovohrad, Kyiv, Cherkasy, etc.) will have a more extensive network of connections with all regions of Ukraine. However, this assumption must be verified by correlation analysis.

Here are all the statistics for each region of Ukraine, which are publicly available and updating with some regularity (Table 2).

Table 2. Regional statistics that may have an impact on the volume of road transport to and from the region of Ukraine

Region	Gross regional product (UAH million), latest data for 2018.	Gross regional product per capita (UAH), latest data for 2018.	Number of legal entities by region, latest data as of January 1, 2021	Population per 1 December 2020 (current population)	Population as of December 1, 2020 (permanent population)	Freight transport by road in the region in 2020, thousand tkm	Freight transport by road in the region in 2020, thousand tons	Regional volumes of foreign trade in goods in January-October 2020 (exports, thousand US dollars)	Regional volumes of foreign trade in goods in January-October 2020 (imports, thousand US dollars)	Regional volumes of foreign trade in services for 9 months of 2020 (exports, thousand US dollars)	Regional volumes of foreign trade in services for 9 months of 2020 (imports, thousand US dollars)	Volumes of manufactured construction products and indices of construction products in 2020, UAH mln.	The average distance from the region to other areas, km
	1	2	3	4	5	6	7	8	9	10	11	12	13
Vinnytsia	111498	71104	33012	1530930	1523845	1004447.4	5428.9	1164104.9	452562.5	117159.4	28888.1	10731.3	455.2
Volyn	60448	58297	22897	1028062	1025334	2054934.2	4792.9	530265.9	1056962.4	62854.3	21724.3	2513.7	576.0
Dnepropetrovsk	369468	114784	103645	3146125	3142816	2846710.3	20889.4	6235536.8	3728578.2	121241.4	157767.0	17756.9	535.4
Donetsk	192256	45959	91822	4103490	4090605	477847.7	19150.4	3237089.0	1211423.0	59970.2	56381.5	10122.7	712.4
Zhytomyr	77110	62911	32046	1196996	1197765	462201.4	3044.5	539426.5	426725.7	56840.2	7775.6	2075.2	463.6
Transcarpathian	52445	41706	24137	1250767	1247934	4218056	5301.9	1095201.8	1012004.7	217563.2	18478.8	1905.8	840.4
Zaporozhye	147076	85784	48725	1669239	1668450	915655.6	3960.4	2392645.1	993194.3	127978.3	20489.13	2723	579.7
Ivano-Frankivsk	78443	57033	29459	1362132	1359406	1108184.9	9199.2	628021.8	508437.9	42472.9	17698.5	3743.3	650.1
Kyiv	1031229	395618	413128	4751881	4704795	8339948	40753.5	11589891.1	21351356.7	3150834.8	1938283.14	55490.6	425.1
Kirovograd	64436	67763	25348	921695	915280	651488.9	4643.6	730598.0	203125.9	17095.0	8467.56	1366.7	418.7
Luhansk	35206	16301	41344	2122914	2118317	400129	1225.3	107562.8	170199.2	15862.1	30637.28	669.6	831.1
Lviv	177243	70173	74475	2499711	2481341	4050253	12155.3	1882326.6	2792077.1	424529	56875.32	14142	644.6
Mykolayiv	79916	70336	49939	1109932	1109217	1085824.9	6835.8	1757653.7	646778.1	254409.14	14062.93	3139.7	537.9
Odessa	173241	72738	86456	2370134	2359074	2076435.8	8818.6	1078699.4	1642397.9	621113.15	209865.26	27925.5	578.0
Poltava	174147	123763	34608	1373517	1365679	1560473.2	7403.7	1807864.4	949267.0	28788.66	65018.35	8146.4	495.2
Rivne	56842	49044	23918	1149221	1148161	1883216.6	4061.2	387869.8	300628.3819	52473.21	19584.03	3265.4	543.3
Sumy	68489	62955	25128	1055053	1052861	681840	1624	725067.9	696884.7	17656.52	17122.73	1660.2	571.4
Ternopil	49133	46833	22771	1031521	1028270	918505.8	3796	366078.7	329292.3	76222.39	7539.4	2561	555.4
Kharkiv	233321	86904	83170	2637037	2621401	2491370.5	10655.2	1160753.8	1455952.1	284570.98	37023.87	14356.2	594.7
Kherson	55161	52922	29680	1018484	1017052	755484.4	3199.1	225241.8	292176.2	23716.08	12421.23	1241.5	574
Khmelnytsky	75646	59583	30474	1245167	1242004	1095859.6	6241.3	496033.6	400786.1	17999.82	11766.18	6472.1	489.4
Cherkasy	93315	76904	29848	1180189	1176560	1599965.3	5663.3	685448.9	349155.3	30404.99	15523.28	2519.8	442.6
Chernivtsi	33903	37441	16356	897295	894230	653127.3	1155.3	130633.4	137583.8	33409.22	2671.01	2056.6	840
Chernihiv	70624	69725	23062	978434	969892	964744.7	1338.6	652492.2	289754.0	22400.8	24164.24	2440.2	558.0

Source: Compiled by the authors

The correlation between the factors and daily demand for transportation to and from the regions of Ukraine is evaluated in Table. 3. To do this, the formula (3) was used, which in Excel is implemented with the CORREL function.

Table 3. Correlation coefficients between the volume of traffic to and from the regions of Ukraine and regional statistics

Region	Gross regional product (UAH million), latest data for 2018.	Gross regional product per capita (UAH), latest data for 2018.	Number of legal entities by region, latest data as of January 1, 2021	Population per 1 December 2020 (current population)	Population as of December 1, 2020 (permanent population)	Freight transport by road in the region in 2020, thousand tkm	Freight transport by road in the region in 2020, thousand tons	Regional volumes of foreign trade in goods in January-October 2020 (exports, thousand US dollars)	Regional volumes of foreign trade in goods in January-October 2020 (imports, thousand US dollars)	Regional volumes of foreign trade in services for 9 months of 2020 (exports, thousand US dollars)	Regional volumes of foreign trade in services for 9 months of 2020 (imports, thousand US dollars)	Volumes of manufactured construction products and indices of construction products in 2020, UAH mln.	The average distance from the region to other areas, km
	1	2	3	4	5	6	7	8	9	10	11	12	13
Transportation from the region	0.974	0.967	0.961	0.696	0.694	0.801	0.862	0.928	0.969	0.939	0.963	0.887	-0.351
Transportation to the region	0.930	0.954	0.909	0.627	0.624	0.784	0.813	0.866	0.929	0.909	0.924	0.848	-0.409

Source: Compiled by the authors

Let's make a rating of independent variables (factors of influence) on demand for transportation from and to regions of Ukraine (Fig. 2). For convenience of visual representation of material, the name of the factor is replaced by its number (Tab. 3).

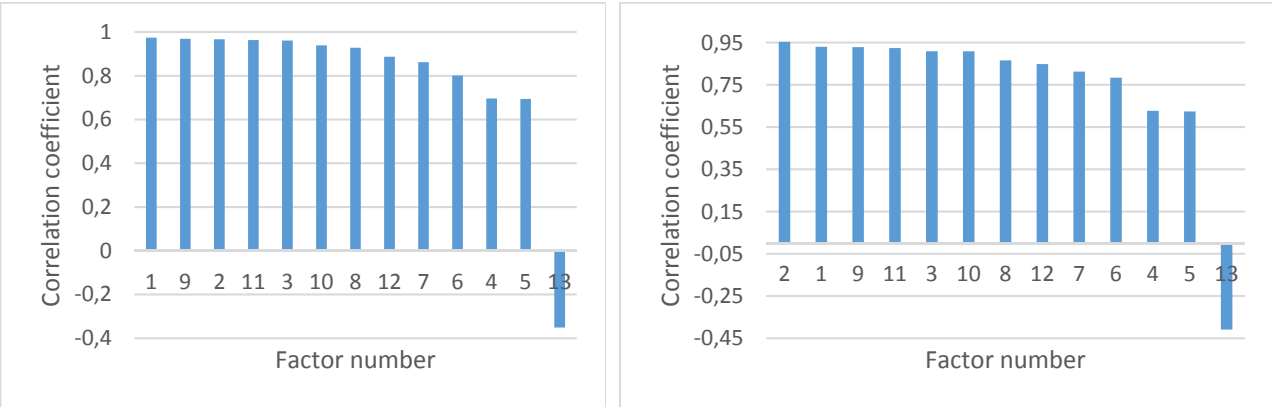


Figure 2 – Correlation coefficients of demand for freight transport by road from thirteen factors: a) from the regions of Ukraine; b) to the regions of Ukraine
Source: compiled by the authors

It can be seen that the difference between the rating of the most important factors influencing the demand for transportation from and to the regions is insignificant and is observed only in the first three factors. For the demand for

transportation from the regions, the most influential factors are 1) Gross regional product; 2) Regional volumes of foreign trade in goods (imports); 3) Gross regional product per capita. Whereas for the demand for transportation to the regions the most influential factors are 1) Gross regional product per capita; 2) Gross regional product; 3) Regional volumes of foreign trade in goods (imports). Absolute values of correlation coefficients are in the range of 0.351-0.974 (demand for transportation from the regions) and 0.409-0.954 (demand for transportation to the regions). It can prove that all thirteen factors have a significant impact on the demand for transportation both from and to the Ukrainian regions. The lowest and rather insignificant correlation coefficient between the demand for transportation and the distance is surprising. After all, the distance of transportation has always been one of the determining factors in modeling the demand for transportation of both goods and passengers. The research conducted here proves that the formation of demand for regional transportation in Ukraine is almost without the influence of the factor of the distance between the points of departure and receipt. In addition, the distance factor is the only one of others that has a negative correlation coefficient. This indicates the inverse relationship between the demand for transportation and its distance. This conclusion is quite logical, because with increasing distance, the demand for transportation should fall, and vice versa. Such interdependence is based on the desire to save money and time, because long-distance transportation is more expensive than short-distance one.

For the next stage - regression analysis - we will transfer the daily demand obtained from the one-time statistics of "Lardi-Trans" into the annual one, multiplying it by the number of working days in a year (251). A regression analysis was carried out using the "Regression" tool of the "Data Analysis" add-in for MS Excel spreadsheets. The analysis results are shown in Fig. 3 and Fig. 4.

RESULTS

Regression statistics	
Multiple R	0.996
R-square	0.993
Normalized R-square	0.983
Standard error	6955.482
Observations	24

ANOVA

	df	*SS*	*MS*	*F*	Significance of F
Regression	13	65869905471.2	5066915805.5	104.734	0.000
Residuals	10	483787245.3	48378724.5		
Total	23	66353692716.5			

	Coefficients	Standard error	t-statistic	P-Value	Lower 95%	Upper 95%	Lower 99.0%	Upper 99.0%
Y-intersection	61602.722	23999.435	2.567	0.028	8128.649	115076.795	-14458.031	137663.475
Variable X 1	0.66859	0.179	3.728	0.004	0.269	1.068	0.100	1.237
Variable X 2	-0.65344	0.272	-2.401	0.037	-1.260	-0.047	-1.516	0.209
Variable X 3	-0.36900	0.485	-0.761	0.464	-1.450	0.712	-1.906	1.168
Variable X 4	-0.97183	0.611	-1.591	0.143	-2.332	0.389	-2.907	0.964
Variable X 5	0.96527	0.616	1.567	0.148	-0.407	2.338	-0.987	2.918
Variable X 6	-0.00116	0.003	-0.343	0.738	-0.009	0.006	-0.012	0.010
Variable X 7	-1.75311	0.847	-2.070	0.065	-3.640	0.134	-4.437	0.931
Variable X 8	0.00001	0.004	0.003	0.998	-0.008	0.008	-0.012	0.012
Variable X 9	-0.00671	0.006	-1.033	0.326	-0.021	0.008	-0.027	0.014
Variable X 10	0.05463	0.043	1.272	0.232	-0.041	0.150	-0.082	0.191
Variable X 11	0.07424	0.051	1.466	0.173	-0.039	0.187	-0.086	0.235
Variable X 12	-1.25481	0.733	-1.712	0.118	-2.888	0.378	-3.578	1.068
Variable X 13	-41.664	21.869	-1.905	0.086	-90.390	7.063	-110.972	27.644

Figure 3 – Regression analysis - data from the regions
Source: compiled by the authors

RESULTS

Regression statistics	
Multiple R	0.966
R-square	0.933
Normalized R-square	0.846
Standard error	12459.303
Observations	24

ANOVA

	df	*SS*	*MS*	*F*	Significance of F
Regression	13	2.17E+10	1.67E+09	10.7468	0.0003
Residuals	10	1.55E+09	1.55E+08		
Total	23	2.32E+10			

	Coefficients	Standard error	t-statistic	P-Value	Lower 95%	Upper 95%	Lower 99.0%	Upper 99.0%
Y-intersection	55527.9	42990.012	1.292	0.226	-40259.784	151315.650	-80719.139	191775.004
Variable X 1	0.494	0.321	1.538	0.155	-0.222	1.210	-0.524	1.512
Variable X 2	-0.315	0.488	-0.646	0.533	-1.401	0,771	-1.860	1.230
Variable X 3	-1.120	0.869	-1.290	0.226	-3.056	0.815	-3.874	1.633
Variable X 4	0.569	1.094	0.520	0.614	-1.868	3.007	-2.897	4.036
Variable X 5	-0.564	1.104	-0.511	0.620	-3.023	1.895	-4.062	2.933
Variable X 6	-0.004	0.006	-0.683	0.510	-0.018	0.009	-0.023	0.015
Variable X 7	-0.183	1.517	-0.121	0.906	-3.563	3.198	-4.991	4.625
Variable X 8	0.000	0.007	0.066	0.949	-0.015	0.016	-0.021	0.022
Variable X 9	-0.005	0.012	-0.409	0.691	-0.031	0.021	-0.042	0.032
Variable X 10	0.103	0.077	1.334	0.212	-0.069	0.274	-0.141	0.347
Variable X 11	0.029	0.091	0.321	0.755	-0.173	0.231	-0.258	0.317
Variable X 12	-1.593	1.313	-1.213	0.253	-4.518	1.332	-5.754	2.568
Variable X 13	-40.10	39.173	-1.024	0.330	-127.382	47.185	-164.250	84.052

Figure 4 – Regression analysis - data to the regions
Source: compiled by the authors

The results obtained allow us to make the following conclusions. Since the values of the multiple correlation coefficient are 0.996 and 0.966 (for the demand for transportation from and to the region, respectively), which is more than the accepted boundary value of 0.7, we can say about a strong relationship between the dependent value (demand for freight transportation by road between regions of Ukraine) and selected thirteen factors. The values of the adjusted coefficient of determination mean that, respectively, 98.3 and 84.6% of the variations in the demand for transportation from and to the region are explained by the variation of the selected thirteen factors, and the remaining 1.7 and 15.4% are explained by other factors unaccounted in this regression model. The values obtained are high and acceptable for decision making. The next block is analysis of variance. The Fisher test is used to check the statistical significance of the regression equation as a whole. The actual values of the criterion are 104.7 and 10.8 with the corresponding significance levels of about 0. Thus, the actual values of the Fisher test significantly exceed the significance levels, which means that the regression equation can be recognized as statistically significant with a very high probability. The next section contains information about the values of the regression coefficients. The resulting models are follows:

- annual demand for transportation from the region:

$$y = 61602,7 + 0,67x_1 - 0,65x_2 - 0,37x_3 - 0,97x_4 + 0,97x_5 - 0,001x_6 - \\ -1,75x_7 + 0,0001x_8 - 0,01x_9 + 0,06x_{10} + 0,07x_{11} - 1,26x_{12} - 41,66x_{13}$$

- annual demand for transportation to the region:

$$y = 55527,9 + 0,49x_1 - 0,32x_2 - 1,12x_3 + 0,57x_4 - 0,56x_5 - 0,004x_6 - \\ -0,18x_7 + 0,0001x_8 - 0,01x_9 + 0,1x_{10} + 0,03x_{11} - 1,59x_{12} - 40,1x_{13}$$

The free coefficient of the equation can be considered as the value of the demand for regional transportation, which does not depend on the selected factors. Surprisingly, the coefficients in the equations do not always coincide in sign with the corresponding correlation coefficients. The obtained values are checked for statistical significance using the Student's t-test. The p-value column contains the significance levels at which the regression coefficients are considered statistically significant different from zero. The limiting value in practice is usually considered to be 0.05 (95% probability). If the actual p-value is less than the limiting, the regression coefficient is considered statistically significant. It can be seen that such a condition is satisfied for a small number of factors. According to p-values, only the coefficients at x_1 and x_2 are statistically significant for modeling demand from the region (values 0.004 and 0.037). None of the regression coefficients that model demand to regions are statistically significant. To increase the significance of the regression coefficients, the number of factors should be reduced by removing those of them that have the greatest pairwise correlation. It should be noted that the regression coefficients can also be obtained using the LINEST function in MS Excel. However, the function does not provide additional information about the resulting model; thus, information about the R-square estimates, Fisher's tests, t-statistics, etc. will have to be obtained using additional calculations, including using MS Excel functions. To reduce the number of independent regression variables, we will carry out a correlation analysis - calculate the matrix of pair correlation coefficients. For this purpose, we use the Correlation tool of the Data Analysis in MS Excel Spreadsheet Add-in. The correlation matrix is presented in Table 4 and Table 5.

Table 4. Pairwise correlations matrix (demand for transportation from the region)

	Transportation from the region	1	2	3	4	5	6	7	8	9	10	11	12	13
Transportation from the region														
1	0.974													
2	0.967	0.963												
3	0.961	0.983	0.937											
4	0.696	0.804	0.631	0.817										
5	0.694	0.801	0.628	0.814	1.000									
6	0.801	0.833	0.808	0.826	0.612	0.609								
7	0.862	0.940	0.847	0.927	0.891	0.890	0.788							
8	0.928	0.962	0.905	0.932	0.811	0.810	0.782	0.946						
9	0.969	0.972	0.962	0.980	0.714	0.711	0.866	0.886	0.919					
10	0.939	0.933	0.934	0.966	0.673	0.669	0.860	0.832	0.850	0.978				

11	0.963	0.950	0.957	0.970	0.673	0.670	0.822	0.846	0.881	0.990	0.984			
12	0.887	0.929	0.870	0.933	0.804	0.801	0.810	0.887	0.854	0.895	0.910	0.889		
13	-0.351	-0.306	-0.436	-0.238	0.013	0.015	-0.104	-0.225	-0.263	-0.257	-0.239	-0.270	-0.273	

Source: compiled by the authors

Table 5. Pairwise correlations matrix (demand for transportation to the region)

	Transportation to the region	1	2	3	4	5	6	7	8	9	10	11	12	13
Transportation to the region														
1	0.930													
2	0.954	0.963												
3	0.909	0.983	0.937											
4	0.627	0.804	0.631	0.817										
5	0.624	0.801	0.628	0.814	1.000									
6	0.784	0.833	0.808	0.826	0.612	0.609								
7	0.813	0.940	0.847	0.927	0.891	0.890	0.788							
8	0.866	0.962	0.905	0.932	0.811	0.810	0.782	0.946						
9	0.929	0.972	0.962	0.980	0.714	0.711	0.866	0.886	0.919					
10	0.909	0.933	0.934	0.966	0.673	0.669	0.860	0.832	0.850	0.978				
11	0.924	0.950	0.957	0.970	0.673	0.670	0.822	0.846	0.881	0.990	0.984			
12	0.848	0.929	0.870	0.933	0.804	0.801	0.810	0.887	0.854	0.895	0.910	0.889		
13	-0.409	-0.306	-0.436	-0.238	0.013	0.015	-0.104	-0.225	-0.263	-0.257	-0.239	-0.270	-0.273	

Source: compiled by the authors

It can be observed that from all factors, only the 13th is independent from the other factors (although there is some connection with factor 2).

We offer the following method of successive exclusion of factors from the model:

1. Find the largest number in the matrix of pairwise correlations.

2. Of the two factors, the pair of which has the maximum value of pair correlation, leave in the model the factor that has the greatest value of the correlation with the final (dependent) factor.

3. Repeat the procedure of steps 1-2 until the regression coefficients are significant according to the p-value or a sufficient level of accuracy is achieved (for example, an acceptable average approximation error is obtained):

$$\bar{\varepsilon} = \frac{1}{n}\sum_{i}\left|\frac{y_{\phi i} - y_{mi}}{y_{\phi i}}\right| \cdot 100\%,$$

where $y_{\phi i}$ - i-th value of the statistical series of the dependent quantity;

y_{mi} - i-th value of the theoretical series of the dependent quantity, calculated using the obtained regression equation.

There are three variants of the regression model were considered:

- with the maximum number of factors (thirteen);
- with five factors;
- with two factors.

The reduction of the obtained basic model with thirteen factors was carried out using the described above algorithm. The linear regression equations obtained using the above technique, as well as the characteristics of the models, are grouped in Table 6 and Table 7.

Table 6. Regression analysis from the regions

	13 factors	5 factors	2 factors
List of factors in the model	1-13	1, 4, 6, 12, 13	1, 13
Regression model	$y = 61602,7 + 0,67x_1 - 0,65x$ $-0,37x_3 - 0,97x_4 + 0,97x_5 -$ $-0,001x_6 - 1,75x_7 + 0,0001x_8$ $-0,01x_9 + 0,06x_{10} + 0,07x_{11} -$ $-1,26x_{12} - 41,66x_{13}$	$y = -956,3 + 0,35x_1 - 0,02x$ $-0,004x_6 - 0,08x_{12} + 20,24$	$y = 6867,2 + 0,25x_1 - 25,7$
Normalized R-square, %	98.3	96.6	94.8
Checking Fisher's criterion	Regression equation as a whole is statistically significant	Regression equation as a whole is statistically significant	Regression equation as a whole is statistically significant
Significant factors according to p-value	1. 2	1. 4	1
Average approximation error, %	1.18	1.54	1.14

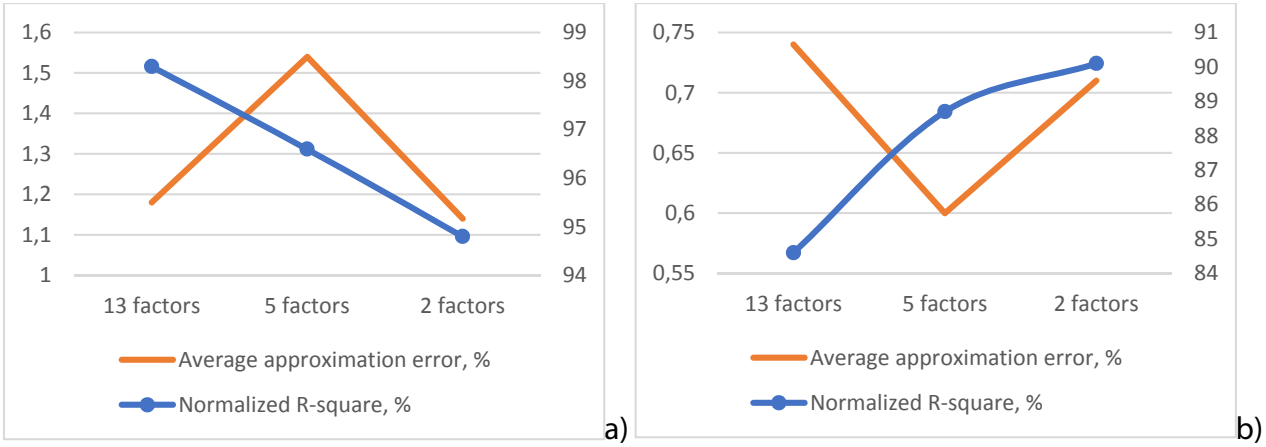
Source: compiled by the authors

Table 7. Regression analysis to the regions

	13 factors	5 factors	2 factors
List of factors in the model	1-13	2, 4, 6, 12, 13	2, 13
Regression model	$y = 55527,9 + 0,49x_1 - 0,32$ $-1,12x_3 + 0,57x_4 - 0,56x_5 -$ $-0,004x_6 - 0,18x_7 + 0,0001$ $-0,01x_9 + 0,1x_{10} + 0,03x_{11} -$ $-1,59x_{12} - 40,1x_{13}$	$y = -4376 + 0,39x_2 + 0,0008$ $+0,0005x_6 + 0,11x_{12} - 3,79x_1$	$y = -7684,2 + 0,43x_2 + 2,2$
Normalized R-square, %	84.6	88.7	90.1
Checking Fisher's criterion	Regression equation as a whole is statistically significant	Regression equation as a whole is statistically significant	Regression equation as a whole is statistically significant
Significant factors according to p-value	-	2	2
Average approximation error, %	0.74	0.60	0.71

Source: compiled by the authors

The normalized R-square and the average approximation error were analyzed for the three scenarios (Fig. 5)



a) b)

Figure 5 – Values of parameters of regression model accuracy for three scenarios of modeling of demand for freight transportations by road transport: a) from the regions; b) to the regions

Source: compiled by the authors

It can be observed that the values of the accuracy parameters are acceptable for all six variants of the models. The normalized R-square does not fall below 84%, and the average approximation error does not rise above 1.6%. If the decision on the best variant of the regression equation is made on the basis of the average error of approximation, then for modeling of demand from the regions it is necessary to choose two-factor model, and for modeling of demand for the regions - five-factor. If the optimality criterion is a normalized R-square, the best choice for modeling the demand from the regions will be a 13-factor model, and for modeling the demand for the region - a two-factor.

The perspectives of the research should be the choice of the best regression equation that would describe the demand for regional transportation in Ukraine. After that, it will be possible to create a matrix of demand for transportation between all regions of Ukraine.

Conclusions. Regional freight transportation by road ensures the satisfaction of demand for goods within the country and is necessary for the smooth operation of manufacturing and service enterprises. Forecasting the demand for transportation between regions and the subsequent planning and organization of freight flows are important economic tasks. In this regard, reliable mathematical models are needed to predict regional freight traffic by road transport based on annual (quarterly) statistical data for the regions of Ukraine.

The performed correlation-regression analysis made it possible to establish the functional dependences of the demand for road transportation of goods to and from the Ukrainian region, namely, the multiple regression equations. The main factors that have the greatest impact on interregional transportation are determined, and a comparative analysis of models with thirteen, five and two linear regression factors is carried out. Indicators of errors and reliability allow us to speak about the sufficient accuracy of the model in relation to real data obtained using the platform for the search for cargo and transport "Lardi-Trans".

References

1. «Pro skhvalennia Natsionalnoi transportnoi stratehii Ukrainy na period do 2030 roku». Rozporiadzhennia Kabinetu Ministriv Ukrainy vid 30 travnia 2018 r. № 430-r. [Electronic resource]. – Access mode: https://zakon.rada.gov.ua/laws/show/430-2018-p#Text.
2. Avtomonova L.Yu. Prognozirovanie ob'Yomov konteynernyih perevozok s ispolzovaniem ekonometricheskih modeley. *Sistemnyiy analiz i logistika*. 2018. #1(16). p.60-69.
3. Borisevich V.I., Kandaurova G.A., Kandaurov N.N. i dr. Prognozirovanie i planirovanie ekonomiki: Ucheb. posobie. Mn. Interpresservis; *Ekoperspektiva*. 2001. 380 s.
4. Gulamov A. A. Prognozirovanie ob'Yomov perevozok gruzov na uzbekskoy zheleznoy doroge. *Izvestiya Peterburgskogo universiteta putey soobscheniya*. 2010. #1. [Electronic resource]. – Access mode: https://cyberleninka.ru/article/n/prognozirovanie-obyomov-perevozok-gruzov-na-uzbekskoy-zheleznoy-doroge.
5. Ivashchuk O.T. ta in. Ekonomiko–matematychne modeliuvannia: navchalnyi posibnyk. Ternopil: *Ekonomichna dumka*, 2008. 701 s.
6. Lardi-Trans. [Electronic resource]. – Access mode: https://lardi-trans.com.
7. Lynnyk I. E., Sanko Ya.V. Shchodo vyznachennia vplyvu zmin zovnishnoho seredovyshcha na evoliutsiiu transportnykh system. *Skhidnoukrainskyi zhurnal peredovykh tekhnolohii*. 2012. 5/3 (59). S. 14 – 16.
8. State Statistics Service of Ukraine. [Electronic resource]. – Access mode: http://ukrstat.gov.ua.

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PHILOSOPHY OF APPLIED RELIABILITY AND SAFETY OF UKRAINE NEW TRANSPORT INFRASTRUCTURE

Ihor Gameliak, Andrij Dmytrychenko, Ihor Vakarchuk. «Philosophy of applied reliability and safety of Ukraine new transport infrastructure». *Summarizes experience and identifies strategic directions of the new transport infrastructure; contained methodology of ensuring the development and implementation competitive projects and services of new transport infrastructure; case of competitive projects and services of new transport infrastructure is presented, taking into account legal and educational and research support. Systematization of terminology is the basis for use in the wording of projects and changes to laws and regulations regarding the requirements of reliability and safety of infrastructure facilities and further theory development and practice of infrastructure projects. The use and involvement domestic raw materials and road operators for network development of cement concrete roads in Ukraine from the southeast to the northwest will provide long-term, within 25-30 years, prospect of building this network, which is qualitative guarantee changes in employment, rural development and efficiency of the national economy. Smart Stop Point projects take into account the trends of modern philosophy in architecture and construction, local identity, ethnic styles and motifs, geographical and weather conditions, limitations caused by the COVID-19 pandemic, autonomy, energy efficiency, inclusion, urban connectivity, suburban and long-distance control systems. Proposed a new principles of scheduled repairs of hard coatings with different operation modes and operating conditions are breakthrough in the dual use of certain types materials, products and technologies, both civilian and military, and meets the interests of national security and defense of Ukraine. Designing schemes and urgent measures*

for the dispersion of transport and passenger flows in the event of illegal interference in the operation of infrastructure facilities are efficient, effective, safe, can be monitored and connected to urban, suburban and intercity control systems. A comprehensive system of monitoring and control reliability and safety of infrastructure facilities also provides continuous monitoring, assessment and changes in the condition of airfields and road surfaces. Training, retraining, raising and improving the skills of managers and specialists in reliability and safety in transport is an important step to ensure transport functioning road complex of Ukraine.

***Keywords**:* reliability, safety, object of transport infrastructure, object of airport infrastructure, standard, cement concrete, international corridors, highways and local transport networks, traffic and passenger flows, strategic infrastructure projects, smart stop point.

Ігор Гамеляк, Андрій Дмитриченко, Ігор Вакарчук. «Філософія прикладної надійності та безпеки нової транспортної інфраструктури України». *Узагальнено досвід та визначені стратегічні напрями нової транспортної інфраструктури; викладено методологію забезпечення розробки та впровадження проєктів та послуг; представлено кейс конкурентоздатних проєктів та послуг, з врахуванням правового та навчально-дослідного супроводу. Систематизація термінології є основою для нормативно-правових актів з надійності та безпеки інфраструктурних об'єктів. Вітчизняна сировина для розбудови цементбетонних доріг України забезпечить на 25-30 років перспективу будівництва, є гарантом зайнятості населення, розвитку села і ефективності національної економіки. Інтелектуальні зупинки враховують філософію архітектури, локальну ідентичність, етнічні стилі та мотиви, географічні, погодні умови, обмеження викликані пандемією COVID-19, автономність, енергоефективність, інклюзію, підключення диспетчерського управління. Нові принципи ремонтів жорстких покриттів за різних режимів роботи, умов експлуатації мають проривний характер подвійного використання, цивільного й військового призначення, відповідає інтересам національної безпеки та оборони України. Схеми, невідкладні заходи щодо розосередження транспортних та пасажиропотоків за умов протизаконного втручання у функціонування інфраструктурних об'єктів відрізняються ефективністю, безпечністю, моніторингом. Моніторинг і контроль надійності, безпеки інфраструктурних об'єктів забезпечує спостереження, оцінку, прогноз стану жорстких покриттів. Підготовка, підвищення кваліфікації спеціалістів з надійності та безпеки важливі для функціонування транспортно-дорожнього комплексу України.*

Ключові слова: надійність, безпека, об'єкт транспортної інфраструктури, об'єкт аеропортової інфраструктури, стандарт, цементбетон, міжнародні коридори, автомагістралі і місцеві транспортні мережі, транспортні та пасажирські потоки, стратегічні інфраструктурні проєкти, інтелектуальні зупинки.

Игорь Гамеляк, Андрей Дмитриченко, Игорь Вакарчук. «Философия прикладной надежности и безопасности новой транспортной инфраструктуры Украины». *Обобщен опыт, определены стратегические направления новой транспортной инфраструктуры; представлена методология обеспечения разработки и внедрения конкурентоспособных проектов и услуг; кейс конкурентоспособных проектов и услуг, с учетом правового и учебно-исследовательского сопровождения. Систематизация терминологии – основа для нормативно-правовых актов по надежности и безопасности инфраструктурных объектов. Отечественное сырье для сети цементобетонных дорог Украины обеспечат перспективу строительства, гарант занятости населения, развития села и эффективности национальной экономики. Умные остановки учитывают философию архитектуры, локальную идентичность, этнические стили и мотивы, географические, погодные условия, ограничения вызваны пандемией COVID-19, автономность, энергоэффективность, инклюзию, подключение к системе диспетчерского управления. Новые принципы ремонтов жестких покрытий с разными режимами работы, условий эксплуатации имеют прорывной характер двойного использования, гражданского и военного назначения, отвечает интересам национальной безопасности и обороны Украины. Схемы и неотложные меры по рассредоточению транспортных, пассажиропотоков при противозаконном вмешательстве в функционирование инфраструктурных объектов отличаются эффективностью, безопасностью, возможностью мониторинга. Мониторинг и контроль надежности, безопасности*

инфраструктурных объектов обеспечивают наблюдение, оценку и прогноз состояния. Подготовка, повышение квалификации специалистов по надежности, безопасности важны для функционирования транспортно-дорожного комплекса Украины.

Ключевые слова: надежность, безопасность, объект транспортной инфраструктуры, объект аэропортовой инфраструктуры, стандарт, цементобетон, международные коридоры, автомагистрали и местные транспортные сети, транспортные и пассажирские потоки, стратегические инфраструктурные проекты, умные остановки.

Introduction. Social change, legal complication, social, environmental and economic factors combined with the exacerbation of pandemic scenarios require to today's problems solution of survival and creative search for the development tomorrow's projects. These processes are especially aggravated in connection with the external aggression of the northern neighbor and military events in eastern Ukraine, which is a threat to the security of our existence and future generations. At the same time, breakthrough technologies in various sectors of the economy are aimed at overcoming negative effects of the environmental crisis. In particular, in the road transport sector - environmentally-oriented construction, repair and maintenance transport infrastructure. Risk management of creating new "green" technologies, cheaper construction, increasing reliability and durability due to resource-, energy-saving and rational use of nature. Unfortunately, due to objective and subjective factors, most effective and rational developments are not widespread in Ukrainian road construction practice. To avoid a no return point, above requires of immediate action to use the acquired system knowledge, make rational decisions and implement cost-effective, reliable and safe technologies in the area of transport and road infrastructure projects. Using many years of experience in scientific developments and their implementation, the authors for the first time combined knowledge systems and practices related automotive and road industries. This study reveals the relationship of educational, scientific and applied activities in the context of a comprehensive solution to urgent development issues of new transport Ukrainian infrastructure.

Analysis of recent researches and publications. 93 years ago, Ukrainian scientist V.I. Vernadsky wrote about "a sharp and terrible change in nature, reflection on it of the social changes experienced in human life" and the lack of "stability and the impression of age power" [1, p.620]. The issue of security is of particular importance for each sectors of our economy, because security is associated with the possible protection and preservation of life and is identified with the value and criterion development. West-201 [2] proved the areas in which public-private partnerships are appropriate to reduce the scale of economic and social consequences. A major reset [3] claims systematic analysis of the global crisis and a single strategy to create more inclusive and sustainable world of the future. Philosophical discourse on value problem regulation of security and sustainable human development and the analysis of value system and socio-cultural mechanism in [4] offers ways to optimize its functioning in Ukrainian society. Recently, there is a tendency to implement the accumulated knowledge and practices of various security in the educational processes educational institutions on the basis of many scientific and philosophical studies to understand the various threats and dangers in the XXI century. At the same time, the accumulated domestic experience of safety [5] is ignored, which requires a more careful consideration of the acquired thesaurus for the subject area and the use basic principles in creating modern concepts of safety road transport complex. Regulations analysis shows work of transport in Ukraine [6], should be used as basis for developing methods to

ensure and assess reliability and safety of transport systems and services. Implementation of the target program «large-scale construction» requires ensuring a comprehensive and basic country network with a high level road quality and reliability, road safety, deployment of intelligent transport systems, innovative technologies, telematics applications, management and regulatory measures for infrastructure management, efficient use of correlated transport infrastructure resources. with EU requirements [7, p. 192-194]. Also, among the priority state areas are: modernization and development airport infrastructure; development transport corridors; implementation transport initiatives "One Belt - One Road" and "Baltic Sea - Black Sea - Caspian Sea" for the efficiency transport network (TN), improving communication between countries and strengthening macro-regional cooperation and trade [8]. Scientists provide various interpretations essence of transport infrastructure and its features in terms of integration, which summarizes the main purpose of transport infrastructure - to ensure effective links between the subjects of industrial relations [9]. [10] deals with the advanced, synchronous and catching up model of formation, development and expansion of transport infrastructure of Ukraine and an alternative approach with active involvement of business in the implementation of priority projects. Unlike German highways, French highways, Italian highways, there are no European or world-class roads in Ukraine. The negative phenomenon of long-term colonization is that in the Ukrainian lands preference was given to the construction of military roads for the rapid mobilization / evacuation of necessary resources to / from the site of probable hostilities. According to the International Road Federation (Eurostat) and the European Concrete Pavement Association (EUPAVE) in developed countries, the share of cement concrete roads for highways is up to 65%, regional networks up to 40%. In Ukraine, only 1.5% of roads are paved with cement concrete. At the same time, foreign investors are ready to restore all our roads in 5 years. And then what? Construction of cement concrete roads should become a national idea, a strategic direction, defined by the following advantages: its raw materials (limestone, clay); appropriate capacity for the production of mixtures (in Ukraine, the six largest cement concrete plants in Europe, loaded with only 2/3 of the capacity); service life from 22 years; cement concrete is 2.5 times cheaper than asphalt concrete, which is 100% imported (https://www.youtube.com/watch?v=lLEFjisyui0&ab_channel=Espreso.TV).

At the same time, the Institute of Artificial Intelligence promotes the concept of artificial intelligence through annual, since 2015, seminars and conferences [11]. In the case of joint implementation projects in the management systems educational institutions, enterprises, organizations and institutions, such activities will be included in the Strategy as a basis for the introduction of mechanisms for the development and promotion of competitive products. New trends, expected challenges and next steps for managers of technology and service providers in 2021 are disclosed in [12]. Review of methods of using swarm intelligence algorithms [13; 14] allowed to carry out the comparative analysis application of various techniques swarm optimization for the decision set task of construction and optimization program-configured networks, taking into account various criteria and conditions of optimization. In particular, content on safety control, assessment, risk management, construction, operation, airport rehabilitation and airfield coverage should be identified, for example [15, 16].

At the same time, the coronavirus pandemic and lockdown have made adjustments in our daily lives: from the habit of "non-collective" work to dependence on a regime of complete remote "presence" and created a paradox that is strikingly different from established processes in all sectors economy and business model of educational

and scientific segment in particular. It is urgent to bring the results of education and science to the requirements of economy and to provide transport and road complex with qualified personnel. The precondition for the presupposition of the results of this work was the scientific afternoon research during 2002-2020 at the Department of Airports of the National Transport University (NTU).

The purpose and objectives of the study The purpose of the work is to present case of long-term areas implementation in competitive infrastructure projects / services in Ukraine and their management, taking into account legal and training and research support.

According to purpose, following tasks are solved:

- generalization experience and definition of strategic directions in new transport infrastructure;
- providing a methodology for competitive projects / services by new transport infrastructure;
- implementation competitive projects / services of new transport infrastructure.

Basic material and results. Since 2002, the Department of Airports of NTU has introduced scientific, technical and experimental developments and applied research on:

- technologies of airfield / road cement concrete and asphalt concrete coverings;
- infrastructure network of intelligent public transport facilities;
- operation of airfield / road cement-concrete and asphalt-concrete coverings and their maintenance with use anti-ice chemical reagents;
- diagnostics of airfield / road cement-concrete and asphalt-concrete coverings with use of thermal imaging non-destructive testing defects.

The analysis was performed recent research and publications and generalization of scientific and applied results at the Department of NTU Airports, confirmed by numerous acts of implementation, allowed to establish long-term strategic directions implementation of competitive projects / services new transport infrastructure of Ukraine for development, design, construction, operation, modernization, modernization objects of transport infrastructure (OTI), objects of airport infrastructure (OAI) and airfield constructions (AC).

1. Long-term priorities Ukraine's new transport infrastructure:

1.1. Regulatory and legal support of reliability and safety OTI, OAI and AC;

1.2. Development, design, construction, operation, modernization, utilization and monitoring of OTI, OAI and AC;

1.3. Optimization transport network and location of OTI and OAI;

1.4. Quality control regarding the reliability and safety of OTI, OAI and AC;

1.5. Dispersal passenger and transport flows under conditions of illegal interference in the functioning OTI and OAI;

1.6. Monitoring and management OTI, OAI and AC projects;

1.7. Training and advanced training of specialists in reliability and safety OTI, OAI and AC.

The methodology of realization each long-term priorities united systems of knowledge and practices adjacent motor and road branches, and the principle system knowledge and rational decision-making became the main for introduction economical, reliable and safe technologies concerning projects new transport infrastructure of Ukraine concerning development, designing, construction, operation, modernization, utilization and monitoring of OTI, OAI and AC.

2. Methodology development and implementation projects / services by new transport infrastructure of Ukraine:

2.1. The methodology regulatory and legal support on the issues of reliability and safety OTI, OAI and AC is based on the experience since 1994 on development of modern regulatory and technological framework transport legislation of Ukraine in terms of motor transport and road industries,

social standards and social guarantees; resolutions of the Cabinet of Ministers of Ukraine regarding provision of passenger transport services, holding a tender for passenger transportation, development highways; orders of the Ministry of Infrastructure of Ukraine regarding the organization of passenger and luggage transportation, control over compliance with traffic safety rules; state, branch building norms, standards, etc .;

- taken into account the results of systematization terms, their concepts and definitions as a basis for use in drafting projects and changes to regulations, state, industry building codes, standards for further development theory and practice of infrastructure projects.

2.2. The methodology development, design, construction, operation, modernization, utilization and monitoring OTI, OAI and AC is based on the experience since 1990 on the national idea to building a network cement concrete highways of Ukraine [17] using and involving domestic raw materials and road operators to form efficient network from southeast to northwest and provide shortest cities connections, Fig.1;

– taken into account the long-term perspective construction network of cement-concrete roads for 25-30 years, which is a guarantee of qualitative changes in the sphere of employment, rural development and efficiency of the national economy of Ukraine.

Figure 1 – Integration schemes for international corridors, highways and local transport networks,

Source: developed by the authors

2.3. The method optimization transport network and location of OTI and OAI is based on the experience since 1996 conducting a comprehensive study of demand for transportation under direct contracts for scientific and technical work in the cities: Dnepropetrovsk, Zaporizhia, Ivano-Frankivsk, Kyiv, Konotop, Kremenchuk, Lviv, Mariupol, Rivne, Simferopol, Chernihiv and since 2005 the study traffic intensity and composition of traffic flows on the roads M-14, M-19, H-07 [18], Fig. 2;

– taken into account passenger flows and traffic intensity, composition of traffic flows for optimization of the transport network and location of BTI and OAI of the new transport infrastructure of Ukraine.

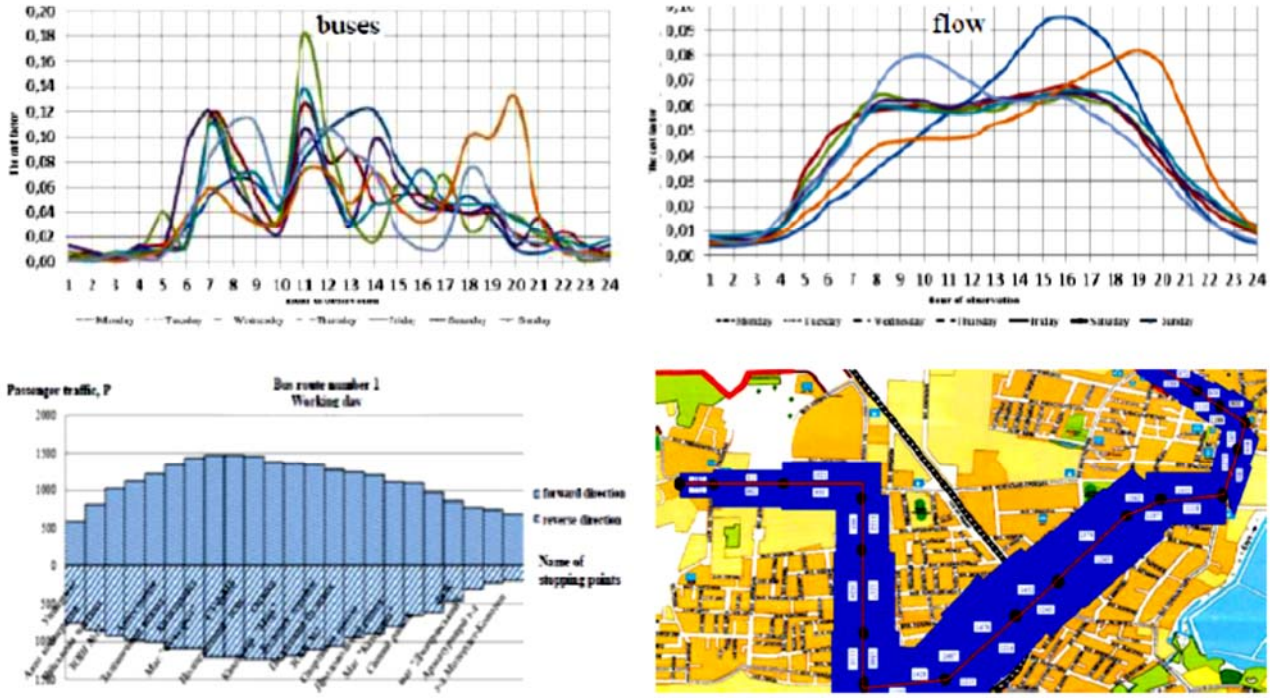

Figure 2 – Examples of research results of traffic and passenger flows
Source: developed by the authors

2.4. The methodology of reliability and safety OTI, OAI and AC is based on the experience since 2016 on economic contract topics and new principles scheduled repairs of hard coatings and the use basalt-plastic reinforcement in construction of OTI, OAI, AC Donetsk, Zhytomyr, Zakarpattia, Zaporizhia, Kyiv, Kyiv , Lviv, Mykolaiv, Odesa, Kharkiv and Kherson regions;

- taken into account quality control of life cycle from development technical task to production, construction and operation OTI, OAI and AC.

2.5. The dispersal method of passenger and transport flows is based on the conditions of illegal interference in functioning OTI and pre-developed schemes and urgent measures for their dispersal;

- taken into account principles of efficiency, effectiveness, safety, monitoring and connection to the city, suburban and intercity control systems.

2.6. The methodology of monitoring and project management OTI, OAI and AC is based on the experience of diagnostics airfield / road cement concrete and asphalt concrete coatings using thermal imaging and non-destructive testing defects and swarm intelligence technology. On sectoral analytical structure transport and road complex for monitoring and expert assessment by government decisions, development alternative infrastructure projects and programs in related sectors of transport and road management for quality decision-making at the strategic, tactical and operational levels of infrastructure projects and programs, shows in [19];

- taken into account using of innovative technologies and the combination of SWOT-analysis methods and qualimetric approach for making rational design decisions based on expert assessments.

2.7. The method of training and retraining specialists in reliability and safety OTI, OAI and

AC is based on the experience since 2002 by systematic educational, scientific and applied activities of the Department of Airports of NTU on the implementation educational programs "Airports, airfield structures and facilities" and "System Analysis in transport infrastructure";

- synthesis of educational and professional programs "Airports, airfield structures and structures" and "System analysis in transport infrastructure" by the Faculty of Transport Construction of NTU to promote the idea of double diploma / degree after successful completion of joint educational program of certain cycle / level of higher education.

It is necessary to use methods on the basis of the research site in Kyiv region, which has 43 OTI [20, p. 501], where to introduce all the latest technical means and technologies with counter-spread in the areas of "East - West", "North - South". Rationale for the selected region is determined by the geographically advantageous location relative to the main transport routes / international transport corridors and its administrative significance for other regions of country.

Taking into account the urgency of the theory, methodology and applied aspects of complex solution priority directions by new transport infrastructure of Ukraine, a system of technological proposals has been developed, Fig. 3.

3. Technological offers of competitive projects / services:

3.1. The system "Letter of the law, UA" preparation of draft versions and amendments to laws and regulations regarding requirements for reliability and safety OTI, OAI and AC.

Innovative aspects and benefits: systematization terminology is the basis for use in legislation and regulations and further development theory and practice of infrastructure projects.

3.2. System "Recovery Path, UA" for development network of cement concrete highways of Ukraine in order to form an effective network from southeast to northwest and provide the shortest connection to the city.

Innovative aspects and benefits: use domestic raw materials for the manufacture plastic cement concrete, reliability, durability and low cost.

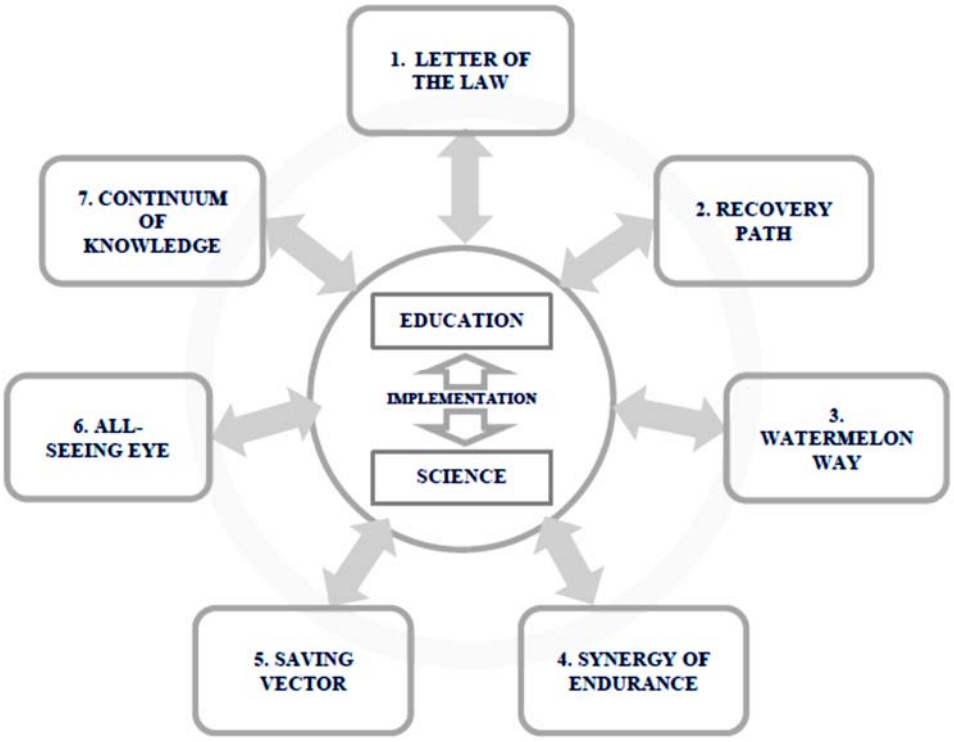

Figure 3 – System of strategic infrastructure projects

Source: developed by the authors

3.3. System "Watermelon Way, UA" design of intelligent stops "Khersonochka" for routes of public passenger transport in the Kherson region, Fig. 4. Possible design for other regions of Ukraine by classes, length, area, volume, capacity depending on the size of passenger traffic, vehicle models and configurations of transport network, taking into account local identity / ethnic styles and motives, geographical / weather conditions, etc. (taken into account restrictions caused by the COVID-19 pandemic).

Innovative aspects and benefits: the stop works only with the vehicles registered in the system; autonomy; energy efficiency; inclusion; connection possibility to city, suburban and long-distance control systems; trends in modern philosophy of architecture and construction, complementing globalization and localization.

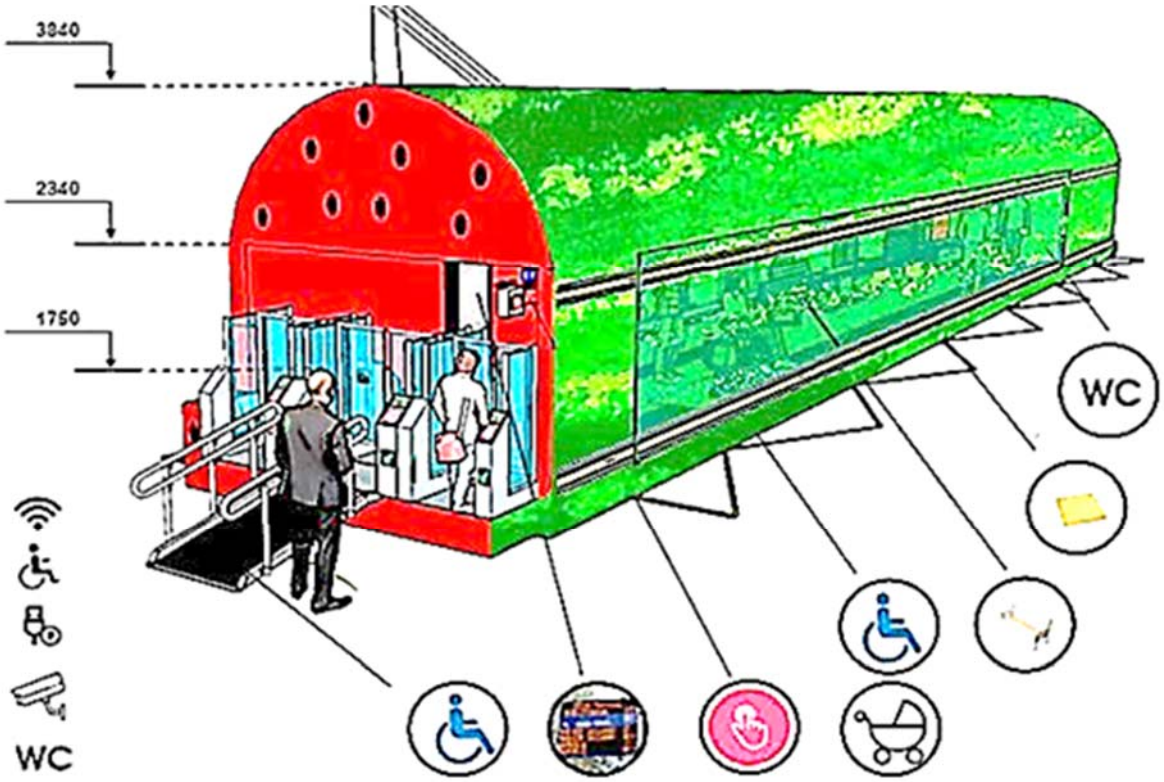

Figure 4 – Smart stop point
Source: developed by the authors

3.4. "Synergy of Endurance, UA" system for reliability and safety OTI, OAI and AC for use in load-bearing structures with different operating modes and operating conditions; has a breakthrough nature of dual use certain types of materials, products and technologies, both civilian and military, and is in the interests of national security and defense.

Innovative aspects and benefits: Offered a new performance principles planned repairs of rigid coverings taking into account with kind and development degree of their destructions. The project implementation will reduce the cost of road maintenance, increase traffic safety, improve environmental conditions. Advantages of cement-concrete coverings: application of high-strength concretes increases bearing capacity by 18 - 30% that increases covering service life to 3 times; absence of track phenomenon; less heating due to the light surface; possibility of processing and reuse; availability of domestic raw materials. Advantages basalt and fiberglass fittings: full corrosion resistance, lower weight, greater tensile strength, resistance to aggressive environments.

3.5. System "Saving Vector, UA" design of schemes of dispersal of transport and passenger flows under the condition of illegal interference in the functioning infrastructure facilities of transport modes.

Innovative aspects and benefits: Pre-designed schemes and urgent measures for dispersal transport and passenger flows (taking into account the limitations caused by the COVID-19 pandemic) and they are efficient, effective, safe, can be monitored and connected to urban, suburban and intercity control systems.

3.6. "All-seeing eye, UA" system for monitoring and control of reliability and safety OTI, OAI and AC (taking into account the requirements for the use of swarm intelligence algorithms for monitoring the reliability and safety OTI, OAI and AC).

Innovative aspects and benefits: comprehensive scientific and information system of regulated continuous, long-term observations, assessment and changes in the condition of airfield and road surfaces in order to identify negative changes and make recommendations for their elimination or weakening.

3.7. The system of "Continuum of knowledge, UA" training / retraining, training / improvement of managers and specialists in reliability and safety OTI, OAI and AC, taking into account the synthesis of various educational and professional programs to promote the idea a double degree after successful completion of higher education.

Innovative aspects and benefits: implementation of the principles "why we learn - we put into practice" and "talents are not renewed continuously, but are supported by the heritage of generations" for the training of modern, qualified specialists in reliability and safety in transport.

Conclusions. Defining long-term priorities and ensuring the methodology of development and implementation by new transport infrastructure of Ukraine allowed to present a case of competitive infrastructure projects / services, taking into account legal and training support.

1. Systematization of terminology is the basis for use in the wording projects and amendments to laws and regulations regarding requirements of reliability and safety infrastructure facilities and further development of the theory and practice infrastructure projects.

2. The use and involvement domestic raw materials and road operators to build a network of cement concrete roads of Ukraine from southeast to northwest will provide long-term, within 25-30 years, the prospect of building this network, which is a guarantee of quality changes in employment, rural development and efficiency national economy.

3. Smart Stop Point projects take into account the trends of modern philosophy of architecture and construction, local identity, ethnic styles and motifs, geographical and weather conditions, limitations caused by the COVID-19 pandemic, autonomy, energy efficiency, inclusion, connectivity to urban, suburban and intercity control systems management.

4. The proposed of new principles scheduled repairs of hard coatings with different modes of operation and operating conditions are breakthrough in the dual use certain types of materials, products and technologies, both civilian and military, and meets with interests of national security and defense of Ukraine.

5. Design schemes and urgent measures for the dispersion of transport and passenger flows in the event of illegal interference in the functioning infrastructure facilities are characterized by efficiency, effectiveness, safety, monitoring and connection to urban, suburban and intercity control systems.

6. A comprehensive system for monitoring and controlling the reliability and safety of infrastructure facilities also provides continuous monitoring, assessment and changes in condition of airfield and road surfaces.

7. Training, retraining, advanced training and improvement managers and specialists in reliability and safety in transport is an

important step to ensure the functioning of transport and road complex of Ukraine.

Список літератури

1. Вернадський В. І. Листування з українськими вченими. Кн. 1: А. Г. Загородній, О. С. Онищенко [та ін.]. К., 2011. 824 с. URL :https://shron1.chtyvo.org.ua/Vernadskyi_Volodymyr/Vybrani_naukovi_pratsi_akademika_V_I_Vernadskoho_t2_kn1.pdf?PHPSESSID=olf85830gr9f68rt2gsigrujj4. (дата звернення: 01.03.2021)

2. Event – 201 (2019) // The Johns Hopkins Center for Health Security in partnership with the World Economic Forum. URL: https://www.center/ forhealthsecurity.org/event201/. (дата звернення: 01.03.2021)

3. Schwab K., Malleret T. COVID-19: The Great Reset (2020) // ISBN Agentur Schweiz (July 9, 2020). 280 p. URL: https://www.amazon.com/gp/product/B08CRZ9VZB?ref=knfdg_R_pape_pew. (дата звернення: 01.03.2021)

4. Горлинський В. Філософія безпеки і сталого людського розвитку: ціннісний вимір // Парапан: 2011. URL: http://arhe.com.ua/product/flosofja-bezpeki-stalogo-ljudskogo-rozvitku-cnnsnij-vimr/. (дата звернення: 01.03.2021)

5. Лазуренко В. Чумацтво в історії України // RSS: 2015. URL: https://novadoba.com.ua/17689-chumactvo-v-istoriyi-ukrayiny-istoriya-poyavy-socialnyy-sklad-chumacki-slobody.html. (дата звернення: 01.03.2021)

6. Аулін В. Нормативно-правове забезпечення надійності функціонування транспортних систем в Україні // Вісник ЖДТУ. 2016. № 2 (77). URL: http://dspace.kntu.kr.ua/jspui/handle/123456789/ 5171.(дата звернення: 01.03.2021)

7. Розвиток транспорту з метою відновлення і зростання української економіки : наукова доповідь / за ред. О. Никифорук // Київ : НАН України, ДУ «Ін-т економіки та прогнозування НАН України», 2018. – 199 с.

8. Інтегровані транспортні коридори Європа – Азія. Матеріали Міжнародної транспортної конференції, 08.09.2016, Одеса, Україна. URL: https://mtu.gov.ua/news/27610.html. (дата звернення: 01.03.2021)

9. Лавренюк Н. Поняття транспортної інфраструктури в умовах інтеграційних процесів Україна – ЄС // Юридичний Вісник, 2018/4. С. 82-88. URL: http://yurvisnyk.in.ua/v4_2018/15.pdf. (дата звернення: 01.03.2021)

10. Карась О. Стратегічні напрями формування, розвитку та розширення транспортної інфраструктури України // Nauka innov. 2019, 15 (6). С. 23-33. URL: https://doi.org/10.15407/scin15.06.023. (дата звернення: 01.03.2021)

11. Штучний інтелект та інтелектуальні системи – 2020 (AIIS'2020). XX міжнародна науково-технічна конференція. URL: https://www.youtube.com/watch?v=rRrNaEx9aiM&ab_channel=Штучнийінтелект. (дата звернення: 01.03.2021)

12. Top Priorities for Tech & Service Providers: Leadership Vision for 2021. Emerging trends, expected challenges and next steps for tech & service provider leaders in 2021. URL: https://www.gartner.com/en/publications/top-priorities-for-tech-service-providers-leadership-vision-2021. (дата звернення: 01.03.2021)

13. Chakraborty A. and Kar A.K. Swarm Intelligence: A Review of Algorithms // Nature-Inspired Computing and Optimization, 2017. P. 475-494. DOI:10.1007/978-3-319-50920-4_19. (дата звернення: 01.03.2021)

14. Manjarres A.V., Sandoval L.G.M., Suárez M.J.S. Data mining techniques applied in educational environments: Literature review // Digital Education Review 33, 2018. P. 235-266. URL: https://www.researchgate.net/publication/327134062. (дата звернення: 01.03.2021)

15. H. Wang, L. Guo, X. Chen. Airfield Pavement Management Framework using a Multi-Objective Decision Making Process. Department of Civil and Environmental Engineering, Rutgers, The State University of New Jersey Piscataway. CAIT-UTC-REG 6: Final report. September, 2019. 30 p. URL: https://drive.google.com/file/d/108mbOA0RNXquVrtNroV7IsIqtPZijQ7d/view.(дата звернення: 01.03.2021)

16. L. Tomić, O. Čokorilo, D. Macura. Runway pavement inspections using drone – safety issues and associated risks. URL: DOI: http://dx.doi.org/10.7708/ijtte.2020.10(3).02. (дата звернення: 01.03.2021)

17. Gameliak I.P., Dmytrychenko A.M. Perspectives of development highways network in Ukraine // Automobile roads and road construction. Scientific and Technical Journal. Iss. 107. 2020. P. 78-89. URL: http://publications.ntu.edu.ua/ avtodorogi_i_stroitelstvo/107/78.pdf. (дата звернення: 01.03.2021)

18. Gameliak I.P., Raykovsky V.F. Determination of traffic intensity and composition of traffic on public highways // Automobile roads and road construction. Scientific and Technical Journal. Iss. 107. 2020. P. 13-22. URL: http://publications./ ntu.edu.ua/avtodorogi_i_stroitelstvo/107/13.pdf. (дата звернення: 01.03.2021)

19. Dmitriev M.M. Vakarchuk I.M., Sutuga I.A. (2021) System Analysis in Transport Infrastructure // Automobile Roads and Road Construction. Kyiv: NTU, 2021. Issue 109. P. 147-156. DOI: 10.33744/0365-8171-2021-109-147-156. (дата звернення: 01.03.2021)

20. Дмитрієва О.І. Державне регулювання інноваційного розвитку транспортної інфраструктури: дис. ... д-ра екон. наук : 08.00.03. Укр. держ. ун-т залізн. трансп. Харків, 2020. 525 с. (дата звернення: 01.03.2021)

References

1. Vernads′kyy V. I. Lystuvannya z ukrayins′kymy vchenymy. Kn. 1: A. H. Zahorodniy, O. S. Onyshchenko [ta in.]. K., 2011. 824 p. URL: https://shron1.chtyvo.org.ua/Vernadskyi_Volodymyr/Vybrani_naukovi_pratsi_akademika_V_I_Vernadskoho_t2_kn1.pdf?PHPSESSID=olf85830gr9f68rt2gsigrujj4. (accessed: 01.03.2021) [in Ukrainian]

2. Event – 201 (2019) // The Johns Hopkins Center for Health Security in partnership with the World Economic Forum. URL: https://www.center/ forhealthsecurity.org/event201//. (accessed: 01.03.2021)

3. Schwab K., Malleret T. COVID-19: The Great Reset (2020) // ISBN Agentur Schweiz (July 9, 2020). 280 p. URL: https://www.amazon.com/ gp/product/B08CRZ9VZB?ref=knfdg_R_pape_pew. (accessed: 01.03.2021)

4. Horlyns′kyy V. Filosofiya bezpeky i staloho lyuds′koho rozvytku: tsinnisnyy vymir // Parapan: 2011. URL: http://arhe.com.ua/product/flosofja-bezpeki-stalogo-ljudskogo-rozvitku-cnnsnij-vimr/. (accessed: 01.03.2021) [in Ukrainian]

5. Lazurenko V. Chumatstvo v istoriyi Ukrayiny // RSS: 2015. URL: https://novadoba.com.ua/17689-chumactvo-v-istoriyi-ukrayiny-istoriya-poyavy-socialnyy-sklad-chumacki-slobody.html. (accessed: 01.03.2021) [in Ukrainian]

6. Aulin V. Normatyvno-pravove zabezpechennya nadiynosti funktsionuvannya transportnykh system v Ukrayini // Visnyk ZHDTU. 2016. № 2 (77). URL: http://dspace.kntu.kr.ua/jspui/handle/123456789/ 5171. (accessed: 01.03.2021) [in Ukrainian]

7. Rozvytok transportu z metoyu vidnovlennya i zrostannya ukrayins′koyi ekonomiky : naukova dopovid′ / za red. O. Nykyforuk // Kyyiv : NAN Ukrayiny, DU «In-t ekonomiky ta prohnozuvannya NAN Ukrayiny», 2018. – 199 c. [in Ukrainian]

8. Intehrovani transportni korydory Yevropa – Aziya. Materialy Mizhnarodnoyi transportnoyi konferentsiyi, 08.09.2016, Odesa. URL: https://mtu.gov.ua/news/27610.html. (accessed: 01.03.2021) [in Ukrainian]

9. Lavrenyuk N. Ponyattya transportnoyi infrastruktury v umovakh intehratsiynykh protsesiv Ukrayina – YES // Yurydychnyy Visnyk, 2018/4. C. 82-88. URL: http://yurvisnyk.in.ua/v4_2018/15.pdf. (accessed: 01.03.2021) [in Ukrainian]

10. Karas′ O. Stratehichni napryamy formuvannya, rozvytku ta rozshyrennya transportnoyi infrastruktury Ukrayiny // Nauka innov. 2019, 15 (6). C. 23-33. URL: https://doi.org/10.15407/scin15.06.023. (accessed: 01.03.2021) [in Ukrainian]

11. Shtuchnyy intelekt ta intelektual′ni systemy – 2020 (AIIS'2020). XX mizhnarodna naukovo-tekhnichna konferentsiya. URL: https://www.youtube.com/watch?v=rRrNaEx9aiM&ab_channel=Штучнийінтелект. (accessed: 01.03.2021) [in Ukrainian]

12. Top Priorities for Tech & Service Providers: Leadership Vision for 2021. Emerging trends, expected challenges and next steps for tech & service provider leaders in 2021. URL: https://www.gartner.com/en/publications/top-priorities-for-tech-service-providers-leadership-vision-2021. (accessed: 01.03.2021)

13. Chakraborty A. and Kar A.K. Swarm Intelligence: A Review of Algorithms // Nature-Inspired Computing and Optimization, 2017. P. 475-494. DOI:10.1007/978-3-319-50920-4_19. (accessed: 01.03.2021)

14. Manjarres A.V., Sandoval L.G.M., Suárez M.J.S. Data mining techniques applied in educational environments: Literature review // Digital Education Review 33, 2018. P. 235-266. URL: https://www.researchgate.net/publication/327134062. (accessed: 01.03.2021)

15. H. Wang, L. Guo, X. Chen. Airfield Pavement Management Framework using a Multi-Objective Decision Making Process. Department of Civil and Environmental Engineering, Rutgers, The State University of New Jersey Piscataway. CAIT-UTC-REG 6: Final report. September, 2019. 30 p. URL: https://drive.google.com/file/d/108mbOA0RNXquVrtNroV7IsIqtPZijQ7d/view. (accessed: 01.03.2021)

16. L. Tomić, O. Čokorilo, D. Macura. Runway pavement inspections using drone – safety issues and associated risks. URL: DOI: http://dx.doi.org/10.7708/ijtte.2020.10(3).02. (accessed: 01.03.2021)

17. Gameliak I.P., Dmytrychenko A.M. Perspectives of development highways network in Ukraine // Automobile roads and road construction. Scientific and Technical Journal. Iss. 107. 2020. P. 78-89. URL: http://publications.ntu.edu.ua/ avtodorogi_i_stroitelstvo/107/78.pdf. (accessed: 01.03.2021)

18. Gameliak I.P., Raykovsky V.F. Determination of traffic intensity and composition of traffic on public highways // Automobile roads and road construction. Scientific and Technical Journal. Iss. 107. 2020. P. 13-22. URL: http://publications./ ntu.edu.ua/avtodorogi_i_stroitelstvo/107/13.pdf. (accessed: 01.03.2021)

19. Dmitriev M.M. Vakarchuk I.M., Sutuga I.A. (2021) System Analysis in Transport Infrastructure // Automobile Roads and Road Construction. Kyiv: NTU, 2021. Issue 109. P. 147-156. DOI: 10.33744/0365-8171-2021-109-147-156. (accessed: 01.03.2021)

20. Dmytriyeva O.I. Derzhavne rehulyuvannya innovatsiynoho rozvytku transportnoyi infrastruktury: dys. ... d-ra ekon. nauk : 08.00.03. Ukr. derzh. un-t zalizn. transp. Kharkiv, 2020. 525 c. (accessed: 01.03.2021) [in Ukrainian]

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LOGISTICAL SUPPORT FOR SUSTAINABLE DEVELOPMENT OF THE REGION

Sergiy Gritsenko, Mykyta Drach. "Logistical support for sustainable development of the region". *The purpose of the study is to develop recommendations for sustainable development of infrastructure in the region. The article considers the role of logistical support for sustainable development of the region. The object of the study is the process of logistical support for sustainable development of the region through investment, as a system of public-private relations for the development of sustainable infrastructure. Public-private relations will promote global demand and activity in the short term, lay the foundations for sustainable long-term growth. The research methods are: comparative economic analysis - to study the current situation in Ukraine, assess the contribution of different companies to the sustainable development of infrastructure and support it in the regions where they are based, to summarize the advantages and disadvantages; cartographic analysis - to clearly illustrate current trends in the functioning of international transport corridors that pass through the territory of Ukraine. The strengths and weaknesses of Ukraine's sustainable development have been identified. Substantiated legal and organizational procedures of public-private relations in the region. The key advantages and risks of the state and enterprises during public-private relations are identified. The main tasks of logistical support and sustainable development of the region are revealed, the logistic infrastructure of the regions is assessed. The potential development of transport infrastructure as one of the main factors of formation of sustainable development of the region is substantiated. National goals for creating sustainable development of regions are highlighted. The scientific novelty of the obtained results is to determine a rational form of interaction between companies and local authorities to create conditions for sustainable infrastructure development in the regions.*

Keywords*:* logistical support; sustainability; public-private relations; transport infrastructure; national strategy goals.

Сергій Гриценко, Микита Драч. «Логістична підтримка сталого розвитку регіону». *Метою дослідження є розробка рекомендацій щодо забезпечення сталого розвитку інфраструктури регіону. У статті розглянуто роль логістичної підтримки сталого розвитку регіону. Об'єктом дослідження виступає процес логістичної підтримки сталого розвитку регіону за рахунок*

інвестицій, як системи державно-приватних відносин для розвитку сталої інфраструктури. Державно-приватні відносини сприятимуть глобальному попиту та активності в короткостроковій перспективі, закладуть основи для сталого довгострокового зростання. Методами дослідження є: порівняльно–економічний аналіз - для вивченні поточної ситуації в Україні, оцінки внеску різних компаній в сталий розвиток інфраструктури та підтримки її в регіонах, де вони базуються, для узагальнення переваг та недоліків; картографічного аналізу – для наочної ілюстрації сучасних тенденцій функціонування міжнародних транспортних коридорів, які проходять територією України. Визначено сильні і слабкі сторони сталого розвитку України. Обґрунтовані нормативно-правові та організаційні процедури державно-приватних відносин в регіоні. Визначені ключові переваги та ризики держави і підприємств під час державно-приватних відносин. Розкрито основні завдання логістичної підтримки та сталого розвитку регіону, здійснено оцінку логістичної інфраструктури регіонів. Обґрунтовано потенційний розвиток транспортної інфраструктури, як одного з головних факторів формування сталого розвитку регіону. Виділено національні цілі по створенню сталого розвитку регіонів. Наукова новизна одержаних результатів полягає в визначенні раціональної форми взаємодії компаній та місцевої влади для створення умов сталого розвитку інфраструктури в регіонах.

Ключові слова: логістична підтримка; сталий розвиток; державно-приватні відносини; транспортна інфраструктура; національні цілі стратегії.

Сергей Гриценко, Никита Драч. «Логистическая поддержка устойчивого развития региона». *Целью исследования является разработка рекомендаций относительно обеспечения устойчивого развития инфраструктуры региона. В статье рассмотрена роль логистической поддержки устойчивого развития региона. В качестве объекта исследования выступает процесс логистической поддержки устойчивого развития региона за счет инвестиций, как системы государственно-частных отношений для развития устойчивой инфраструктуры. Государственно-частные отношения будут способствовать глобальному спросу и активности в краткосрочной перспективе, заложат основы для постоянного долгосрочного роста. Методами исследования являются: сравнительно-экономический анализ - для изучении текущей ситуации в Украине, оценки вклада разных компаний в устойчивое развитие инфраструктуры и поддержки ее в регионах, где они базируются, для обобщения преимуществ и недостатков; картографического анализа - для наглядной иллюстрации современных тенденций функционирования международных транспортных коридоров, которые проходят территорией Украины. Определены сильные и слабые стороны устойчивого развития Украины. Обоснованы нормативно-правовые и организационные процедуры государственно-частных отношений в регионе. Определены ключевые преимущества и риски государства и предприятий во время государственно-частных отношений. Раскрыты основные задачи логистической поддержки и устойчивого развития региона, осуществлена оценка логистической инфраструктуры регионов. Обосновано потенциальное развитие транспортной инфраструктуры, как одного из главных факторов формирования устойчивого развития региона. Выделены национальные цели по созданию устойчивого развития регионов. Научная новизна полученных результатов заключается в определении рациональной формы взаимодействия компаний и местной власти для создания условий устойчивого развития инфраструктуры в регионах.*

Ключевые слова: логистическая поддержка; устойчивое развитие; государственно-частные отношения; транспортная инфраструктура; национальные цели стратегии.

Introduction. At the present stage of globalization, logistical support for sustainable development of the regions is one of the leading drivers of economic stability through multilevel ties and cooperation. Sustainable infrastructure is at the heart of the three challenges facing the global community: restoring global growth, achieving sustainable development goals, and protecting the future of the planet. The factors of infrastructural content that provide innovative development of the economy become of priority importance [1, p. 22]. Analysis of the state and problems of logistics

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infrastructure shows that it, as one of the most important components of the national logistics system, must ensure the movement of material, human, information, financial and service flows between cities and regions in a timely manner and in full, requires significant financial resources and integrated approach to planning and management of innovative development [2, p. 349]. Consolidated transportation schemes between the regions of Ukraine can demonstrate savings in transport costs, as well as reduce the harmful impact on the environment and transport infrastructure [3, p. 143]. The use of marketing and logistics tools within the threefold component of management levels in Ukraine: economic regions, regional logistics clusters, industrial parks will create a system of effective management of material and related flows, track daily changes in demand, technology, legislation in Ukraine and the world. transport capacity and inventories, which in general will contribute to the revival and sustainable development of the regions [4, p. 279].

The subject of research - theoretical, methodological and organizational and economic aspects of logistical support of sustainable infrastructure, which is important for achieving sustainable development goals due to the opportunities it creates for inclusive growth and access to basic services.

Kyiv is currently the administrative center, and the development of production is concentrated in the regions. Global corporations support the regions where their production is located, while the state helps corporations in the form of subsidies such as MHP Kyiv region, Astarta LLC Poltava region.

One of the main factors is socio-economic relations in the regions. Each region has its own characteristics and specifics that affect the formation of a single model for building a sustainable infrastructure for further development of the region in the future.

Another significant problem is the decline of some regions, due to the decline of industries based in these regions. Due to this factor and the inability of local authorities to solve problems independently, there is a need for cooperation with private enterprises, which allow to solve both the goals of eliminating problems and create a new opportunity to create conditions for new industries in these regions. It should be borne in mind that the benefits of working with private companies pose risks that can only worsen the situation.

The choice of infrastructure development and planning is long-term and complex, and is aimed at overcoming the effects of carbon impact, irrational use of land and water resources, which in the long run will form a sustainable model of future development.

The innovative nature of sustainable development of the region's economy is an important means of improving the quality of life, which will increase productivity and lay the foundation for future development prospects.

The aim of the study. Development of recommendations for sustainable development of infrastructure in the region.

In accordance with this goal, the following tasks were set and solved:

- to study the interaction of public-private development of relations to create the infrastructure of the region;
- analyze the country's national strategy for sustainable development in the regions;
- to determine the influence of corporations on the formation of the region's infrastructure.

The main material and results of the study. Sustainable development is development that meets the needs of today without affecting the ability of future generations to meet their own needs. Today we can divide the sustainable development of the regions of Ukraine into strengths and weaknesses. Strengths:

- Ukraine is one of the most natural resources in Europe.
- The middle location of Ukraine between the countries of East and West creates the potential for its successful development as a transit state. The main thing in this aspect is the following: transport logistics, mediation in

the assimilation, transformation and further retransmission of the best achievements of neighbors - knowledge, know-how, innovation [5].

Weaknesses of sustainable development of Ukraine:

- Ukraine has the most centralized system of government among Eastern European countries and is characterized by a low level of decentralization compared to developed countries in Europe and the world.

- The oligarchic structures of Ukraine have taken control of the regions, turned them into an instrument of self-interest, which is the greatest danger to the innovative development of the region with man-made pressure, as the profits of business owners are rental income from natural resources, redistribution of state property, creation of artificial monopolies. The presence of poorly structured managerial influences in the conditions of huge natural resources of Ukraine instead of providing competitive advantages, turns into a brake on the development of Ukraine's economy.

- Lack of energy market (gas, electricity, water) for enterprises in the region; high level of pollution in the cities of Kamyanske, Kryvyi Rih, Dnipro, Mariupol, Zaporizhia [6].

Weak innovative development during the crisis of 2014-2017 became a brake on the economic development of Ukraine and its regions. It is explained by inefficient interaction of science and production, reckless state policy in the field of innovation and innovative economy, lack of development of venture financing and real stimulation of entrepreneurship, as well as the reasons for the escalation of the Russian military conflict in eastern Ukraine, annexation of Crimea [7].

Normalization of the business climate is a prerequisite for increasing innovation activity in Ukraine. In addition, such general economic measures as competition and antitrust policy are an important condition for the formation of innovative (digital) economy.

Adherence to the above conditions, which were mentioned above, will allow the emergence of advanced development of the infrastructure of the regions. The availability of free capacity will allow the formation of new enterprises in the regions, which will lead to the development of an effective regional socio-economic system.

With all the positive aspects of the creation and development of infrastructure in the regions of Ukraine, a significant remark is the high capital intensity of infrastructure facilities. At the same time, a significant part of infrastructure structures, in particular social infrastructure facilities, can be unprofitable. And production infrastructure facilities may not reach the payback level for a long time, especially during the commissioning of the main production facilities.

In this regard, a special task in the direction of modernization and development of socio-economic infrastructure of the region is to find sources of financing for the construction and operation of infrastructure. A common practice around the world is public funding for the construction of infrastructure, and their use by state or "public" organizations. However, without attracting funds from private investors it is impossible to do [8, p. 155-156].

The mismatch between investment resources and the needs of the region, the country has led primarily to the emergence of projects with public-private relations (PPP).

In the regions of Ukraine, the private sector is increasingly becoming a valuable source of new technologies, quality management, investment capital, which makes it possible to involve it in a number of problematic projects and invest in modern technologies and equipment.

All this indicates that in most cases, large-scale and expensive projects that ensure the introduction of new scientific technologies and developments. However, such projects involve high risks that private business never takes, due to equivalences in the profitability of other less risky investments. Such facilities are usually financed by public funds of different levels (state, regional), but public funds are limited, and the available

opportunities to raise loans are not effective. In this regard, the state structures must ensure the creation of favorable conditions for attracting investment, which, in turn, provide for the solution of many previously unresolved legal issues: stable and reasonable taxation; rational customs policy; positive changes in the credit sphere; fight against corruption, non-economic factors slowing down development, bureaucratic arbitrariness, etc.

In other words, a full-fledged infrastructure for normal economic development must be created, which ensures adequate partnerships between the state and private business. To achieve these goals, in our opinion, it is reasonable to turn to the foreign experience of public-private relations (PPR) in the implementation of various, including investment projects [9].

For the development of WFD in the region it is necessary to conduct the following regulatory and organizational procedures:

- development of a common understanding and strategy for forming a partnership between the state and business structures;
- improvement of the regulatory and legislative framework for the creation of a package of regulations and bylaws;
- creation of an institutional organizational framework that will require the formation of various elements of the institutional environment;
- formation of a certain economic environment for the creation of partnerships;
- training of specialists in the field of partnership;
- creating a favorable public opinion for the implementation of the partnership;
- ensuring transparency of activities within the partnership.

Advantages of public-private relations:

Local authorities can involve private enterprises in the creation of socially significant projects, which in turn will provide an opportunity to develop public-private relations, as well as invest in the projects of this organization for infrastructure development.

For the private sector, the advantage is that by involving local authorities in the project, the company gets the opportunity to reduce the cost of creating the project and gain access to infrastructure, which will speed up the task.

The advantages on a practical basis include the cooperation of companies "Kernel", "Astarta", "Ukrlandfarming". Each of these companies helps to develop the regions where their branches are located. Kernel supports social projects with its own charitable foundation, Astarta runs educational programs for the rural population, and Ukrlandfarming invests a portion of its income through charitable foundations to support people of retirement age and develop infrastructure for them. In turn, companies receive support and support from the public, which also further affects relations with local authorities, and the example of Astarta also provides an opportunity to prepare future staff for their organization.

Risks that may arise during public-private relations:

State risks - is to attract even more resources than expected at the beginning of the project, which could lead to a budget deficit.

The risks that can befall companies are, first of all, the lack of trust in Ukraine, which leads to corruption schemes in the state system, as well as the possibility of terminating the contract, which may depend on the success of the company [11, p. 140-141].

Risks on a practical basis include the development of biogas production by MHP. In 2011, the company began to develop this area, but did not receive support from the authorities and currently continues to develop this area on its own [12].

Also in the formation of public-private relations should not forget about the transport infrastructure of the region, which can significantly affect the implementation of

plans to create joint projects, so we see it as one of the key elements in creating an effective multimodal transport and logistics system. This is important for Ukraine's comprehensive economic growth. Ukraine's geographical location in the center of Eastern Europe is a very favorable environment for the development of international trade.

Ukraine is also a global supplier of food products and a leading exporter of agricultural products, playing a vital role in ensuring food safety in the world. Given the importance of international trade and the impact of geopolitical developments on transport routes and costs, logistics will play an increasingly important role in the country's sustainable development.

Building an efficient logistics system provides an opportunity to develop not only foreign markets where Ukraine will be present, but also domestic markets. In domestic markets, there is potential for the emergence and development of private enterprises, which in turn will lead to the formation of public-private relations for the implementation of future projects.

Exports, imports and transit of goods take place in the transport and logistics system of Ukraine, which is dominated by railways for bulky goods and long-distance transportation. The country has 21,700 km of railways (of which more than 47% are electrified), 169,500 km of roads, 2,200 km of inland waterways (WWH) with 13 seaports (not including 5 in the Crimea) and 10 river ports, numerous warehouses (750 certified grain warehouses) and logistics centers to facilitate the production, storage and transportation of goods. This capacity allows to transport 1 billion tons of cargo by rail and 160 million tons through seaports per year. Ukraine is part of several international transport corridors, such as Corridors 3, 5, 7 and 9. of the Trans-European Transport Network (TEN-T), Corridors 3, 4, 5, 7, 8 and 10 of the Railway Cooperation Organization (RAO), and also part of the corridor Europe - Caucasus - Asia (TRACECA) (Fig.1.1) [13, p. 114-116].

Figure 1.1 - Scheme of ITC passage through the territory of Ukraine [13]

But such capacity is not fully utilized, and logistics companies are dealing with underdeveloped infrastructure, which is reflected in high logistics costs.

To improve the transport sector, it is necessary to attract, adapt and implement the experience of European countries, which will improve the state of transport in the transport infrastructure of the regions.

The general objectives should be as follows:

- elimination of administrative, technical, cross-border and other obstacles to international trade;

- development of a national transport flow modeling system and a program for the implementation of the National (priority) transport network of Ukraine;

- development of intermodal and multimodal services with the help of an efficient logistics system and timely solutions related to the interaction on the operation of tracks of different widths and other technical standards;

- updating the national strategy and program to improve road safety and continuing the implementation of planned measures.

The National Economic Strategy of Ukraine for the period up to 2030 was approved by the resolution of the Cabinet of Ministers of Ukraine dated 03.03.2021 № 179 [14].

The strategy envisages the gradual achievement of the goal of improving the welfare of the population. The first stage is the formation of competitive conditions for business and investment, as well as the restoration of confidence in state institutions. This will make it possible to win the competition for capital on the world market and, as a result, attract investment to modernize sectors of the economy.

Transformed and highly productive sectors of the region's economy will be able to compete effectively in the international market of goods and services with foreign countries, which will contribute to the growth of tax revenues and incomes.

A large domestic consumer market and an increase in tax revenues will contribute to the development of services and improve the quality of life of citizens in terms of education, health, environment, national security, culture and social security. This will contribute to the development of human potential - the main and most important potential in the XXI century, which Ukraine must systematically develop [14].

Therefore, this task is not easy. Successful implementation of this strategy requires fiscal, regulatory, institutional and organizational changes, as well as changes in the public sector. It also means changes in public-private relations. An important point for the implementation of this strategy is to improve skills and competence, as well as the involvement of private enterprises to help implement the strategy.

Solving problematic issues one by one will not bring effective changes, but will only provide an opportunity to improve the situation for a while. Therefore, Ukraine must implement a national strategy for sustainable development of the regions to address the complex tasks that will be identified in the main objectives to create conditions for sustainable development of regional infrastructure:

- Develop high-quality, reliable, sustainable and affordable infrastructure based on the use of innovative technologies, including environmentally friendly modes of transport.

- Ensure the expansion of the use of electric vehicles and the relevant infrastructure network.

- Ensure the availability of road transport infrastructure based on the use of innovative technologies, in particular through the expansion of forms of state participation in various infrastructure projects.

- To promote the accelerated development of high- and medium-tech sectors of the processing industry, which are

formed on the basis of the use of chains "education - science - production" and a cluster approach in the areas of: development of innovation ecosystem; development of information and telecommunication technologies (ICT); application of ICT in agriculture, energy, transport and industry; high-tech mechanical engineering; creation of new materials; development of pharmaceutical and bioengineering industries.

- Create a financial and institutional system (innovation infrastructure) that will ensure the development of research and scientific - technical (experimental) developments.

- Ensure Internet access, especially in rural areas.

- Ensure increased participation of young people in research.

- Ensure sustainable GDP growth through modernization of production, development of innovations, increasing export potential, introduction to foreign markets of products with a high share of value added.

- To increase the efficiency of production on the basis of sustainable development and the development of high-tech competitive industries.

- To increase the level of employment.

- Reduce the share of young people who do not work, study or acquire professional skills.

- Promote the provision of reliable and safe working conditions for all workers, in particular through the use of innovative technologies in the field of labor protection and industrial safety.

- Create institutional and financial opportunities for self-realization of the potential of the economically active part of the population and the development of the creative economy [15].

Conclusions. Ukraine has significant problems in creating the conditions and implementing the construction of infrastructure, which does not allow the regions to function as elements of the system that could ensure the development of the country now and rapid development in the future.

Public-private relations are one of the key elements for building a sustainable infrastructure of a region or regions. Local authorities need to build a mechanism for integrating a private enterprise into the region's infrastructure so that the enterprise's activities do not destroy both possible future plans for cooperation on projects and enable business development.

It also becomes clear that the country relies on the construction of transit corridors, due to the convenient geographical location, but forgets that if you build a large number of roads, you must not forget about the constant maintenance of roads, ie you need to abandon potholes, and replace all problem area, as well as creating conditions for the emergence of infrastructure near transit corridors for comfortable movement on them.

In order to achieve sustainable infrastructure development in the regions, it is necessary to implement the National Economic Strategy at an accelerated pace, taking into account the interests of each region, so that people can see what is a priority goal for the state. The country faces the task of choosing the optimal ratio of open economy and protection of its own markets. Local authorities need to create conditions for cooperation with higher education institutions to train staff to address the challenges of the strategy, both present and future.

People who are going to start their own business in the region need:

- to establish social relations with the local population;

- to establish contacts of fruitful cooperation with local authorities;

- create economic opportunities for the local population;

- to create conditions for the operation of the enterprise in this area;

- support the existing regional infrastructure and improve it;

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- after the creation of socio-economic relations, start training future staff for their own company;

- development of projects for the implementation of both cooperation with local authorities and promotion of its own brand in the region, etc.

The problem for the company may be the reluctance of local authorities to cooperate. For example, the introduction of biogas technologies by MHP [12]. In such cases, there are two options - to continue to implement the technology yourself or keep the technology for refinement, but then the company may lose the opportunity to be the first company to introduce this technology and get only losses or lower profits than it expected.

The main essence of the problem is the reluctance to introduce innovative technologies that the country has and can implement, but it does not happen: through monopolization, through laws, or through political factors. These factors are secondary, but not the main ones, leading to a slowdown in the development of the region first, and then the whole country. It is necessary to give the regions the opportunity to develop more independently, so that local authorities have clearly spelled out all possible solutions.

Another important aspect for the logistical support of sustainable development of the region is the improvement of three main elements: economic growth, social integration and environmental protection. These elements are complex and interdependent.

Creating conditions for learning and working in the field in all their forms and at all levels is a prerequisite for sustainable development. To achieve this, it is necessary to promote sustainable, inclusive and equitable economic growth that creates greater opportunities for all, reduces inequalities, raises basic living standards, improves logistics infrastructure, promotes equitable social development, and integrated and sustainable management of natural resources and ecosystems.

Список літератури

1. Гриценко С.І. Забезпечення конкурентоспроможності країни в контексті стратегії інновацій та модернізації промисловості на основі об'єднань по співпраці. Вісник економічної науки України. - 2017. №2 (33) – С. 22-27.

2. Григорак М.Ю. Інтелектуалізація ринку логістичних послуг: концепція, методологія, компетентність: монографія. К.: Сік Груп Україна, 2017. – 516 с.

3. Савченко Л.В., Гриценко С.І. Аналіз та класифікація можливих схем консолідованої доставки LTL вантажів. Вісник економічної науки України. - 2020. - № 2 (39). – С. 139-144.

4. Гриценко С.І. Розвиток регіонів України з урахуванням конкурентних переваг раціонального використання ресурсів в межах транспортно-логістичних кластерів: монографія. Strategic Management: Global Trends and National Peculiarities. – Collective monograph. – Poland: Publishing House «Baltija Publishing», 2019. – 712 p. (P 267-280).

5. Стратегічні виклики XXI століття суспільству та економіці України : монографія: у 3 т. / за ред. В.М. Гейця, В.П. Семиноженка, Б.Є. Кваснюка; Ін-т економіки та прогнозування Нац. акад. наук України, Укр. форум. – К. : Фенікс, 2007. – т. 3. – 555 с.

6. Дослідження техніко-економічних показників гірничо-добувних підприємств України та ефективності їх роботи в умовах змінної кон'юнктури світового ринку залізорудної сировини : монографія / [Є.К. Бабець, І.Є. Мельникова, С.Я. Гребенюк, С.П. Лобов] ; за ред. Є.К. Бабця / НДГРІ ДВНЗ «КНУ». – Кривий Ріг : Вид. Р.А. Козлов, 2015. – 319 с.

7. Хорольський В.П., Хорольський К.Д., Квітка Т.В. Формування інноваційної системи сталого розвитку регіону на засадах інтеграції в економіку країн Європейського Союзу. // Вісник Хмельницького національного університету. Економічні науки: наук. журнал. – 2019. - №2. - С. 255-262.

8. Шилепницький П.І. Державно-приватне партнерство як інструмент реалізації стратегії «зеленого» зростання // Сталий розвиток в умовах глобальних викликів: матеріали Всеукраїнської наук.-практ. Інтернет конф., Харків 7-8 квітня, 2017 р. / Харків. нац. ун-т міськ. госп-ва ім. О.М. Бекетова та ін. – Харків: ХНУМГ ім. О.М.Бекетова, 2017. – 333 с. – С. 155-157.

9. Щодо розвитку державно-приватного партнерства як механізму активізації інвестиційної діяльності в Україні : [аналітична записка] / Національний інститут стратегічних досліджень при Президентові України. URL: http://www.niss.gov.ua/articles/816/

10. Офіційний сайт компанії UkrLandFarming. URL:http://www.ulf.com.ua/ua/sustainability/regions_relations/

11. Державно-приватне партнерство як основний механізм розвитку інфраструктури регіону / Т. М. Кришталь // Сталий розвиток економіки. - 2013. - № 3. - С. 137-141.

12. МХП розпочав впровадження біогазових технологій ще у 2012 році. Сайт «Ukrinform»: веб-сайт. URL: https://cutt.ly/dcbbM3f

13. Приймук О.Р. Транспортна інфраструктура як ефективний елемент сталого розвитку країни: праці V Міжнародної науково-практичної конференції «Study of modern problems of civilization», 19-23 жовтня 2020 року, Осло, Норвегія. С. 114-116.

14. Про затвердження Національної економічної стратегії на період до 2030 року: Постанова Кабінету Міністрів України від 03.03.2021 р. №179. URL: https://www.kmu.gov.ua/npas/pro-zatverdzhennya-nacionalnoyi-eko-a179

15. Цілі сталого розвитку України. Сайт United Nations Ukraine: веб-сайт. URL: https://cutt.ly/Xcbbev0.

References

1. Gritsenko S.I. ZabezpechennyaKonkurentospromozhnostI kraYini v kontekstI strategIYi InnovatsIy ta modernIzatsIYi promislovostI na osnovI ob'Ednan po spIvpratsI. VIsnik ekonomIchnoYi nauki UkraYini. - 2017. #2 (33) – S. 22-27.

2. Grigorak M.Yu. IntelektualIzatsIya rinku logIstichnih poslug: kontseptsIya, metodologIya, kompetentnIst: monografIya. K.: SIk Grup UkraYina, 2017. – 516 s.

3. Savchenko L.V., Gritsenko S.I. AnalIz ta klasifIkatsIya mozhlivih shem konsolIdovanoYi dostavki LTL vantazhIv. VIsnik ekonomIchnoYi nauki UkraYini. - 2020. - # 2 (39). – S. 139-144.

4. Gritsenko S.I. Rozvitok regIonIv UkraYini z urahuvannyam konkurentnih perevag ratsIonalnogo vikoristannya resursIv v mezhah transportno-logIstichnih klasterIv: monografIya. Strategic Management: Global Trends and National Peculiarities. – Collective monograph. – Poland: Publishing House «Baltija Publishing», 2019. – 712 p. (P 267-280).

5. StrategIchnI vikliki HHI stolIttya suspIlstvu ta ekonomItsI UkraYini : monografIya: u 3 t. / za red. V.M. Geytsya, V.P. Seminozhenka, B.E. Kvasnyuka; In-t ekonomIki ta prognozuvannya Nats. akad. nauk UkraYini, Ukr. forum. – K. : FenIks, 2007. – t. 3. – 555 s.

6. DoslIdzhennya tehnIko-ekonomIchnih pokaznikIv gIrnicho-dobuvnih pIdpriEmstv UkraYini ta efektivnostI Yih roboti v umovah zmInnoYi kon'yunkturi svItovogo rinku zalIzorudnoYi sirovini : monografIya / [E.K. Babets, I.E. Melnikova, S.Ya. Grebenyuk, S.P. Lobov] ; za red. E.K. Babtsya / NDGRI DVNZ «KNU». – Krivіy RIg : Vid. R.A. Kozlov, 2015. – 319 s.

7. Horolskiy V.P., Horolskiy K.D., KvItka T.V. Formuvannya InnovatsIynoYi sistemi stalogo rozvitku regIonu na zasadah IntegratsIYi v ekonomIku kraYin Evropeyskogo Soyuzu. // VIsnik Hmelnitskogo natsIonalnogo unIversitetu. EkonomIchnI nauki: nauk. zhurnal. – 2019. - #2. - C. 255-262.

8. Shilepnitskiy P.I. Derzhavno-privatne partnerstvo yak Instrument realIzatsIYi strategIYi «zelenogo» zrostannya // Staliy rozvitok v umovah globalnih viklikIv: materIali VseukraYinskoYi nauk.-prakt. Internet konf., HarkIv 7-8 kvItnya, 2017 r. / HarkIv. nats. un-t mIsk. gosp-va Im. O.M. Beketova ta In. – HarkIv: HNUMG Im. O.M.Beketova, 2017. – 333 s. – S. 155-157.

9. Schodo rozvitku derzhavno-privatnogo partnerstva yak mehanIzmu aktivIzatsIYi InvestitsIynoYi dIyalnostI v UkraYinI : [analItichna zapiska] / NatsIonalniy Institut strategIchnih doslIdzhen pri PrezidentovI UkraYini. URL: http://www.niss.gov.ua/articles/816/

10. OfItsIyniy sayt kompanIYi UkrLandFarming. URL:http://www.ulf.com.ua/ua/sustainability/regions_relations/

11. Derzhavno-privatne partnerstvo yak osnovniy mehanIzm rozvitku Infrastrukturi regIonu / T. M. Krishtal // Staliy rozvitok ekonomIki. - 2013. - # 3. - S. 137-141.

12. MHP rozpochav vprovadzhennya bIogazovih tehnologIy sche u 2012 rotsI. Sayt «Ukrinform»: veb-sayt. URL: https://cutt.ly/dcbbM3f

13. Priymuk O.R. Transportna Infrastruktura yak efektivniy element stalogo rozvitku kraYini: pratsI V MIzhnarodnoYi naukovo-praktichnoYi konferentsIYi «Study of modern problems of civilization», 19-23 zhovtnya 2020 roku, Oslo, NorvegIya. C. 114-116.

14. Pro zatverdzhennya NatsIonalnoYi ekonomIchnoYi strategIYi na perIod do 2030 roku: Postanova KabInetu MInIstrIv UkraYini vId 03.03.2021 r. #179. URL: https://www.kmu.gov.ua/npas/pro-zatverdzhennya-nacionalnoyi-eko-a179

15. TsIlI stalogo rozvitku UkraYini. Sayt United Nations Ukraine: veb-sayt. URL: https://cutt.ly/Xcbbev0.

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MODELING OF TERRITORIAL DIFFERENTIATION BY TRANSPORT INFRASTRUCTURE LEVEL OF DEVELOPMENT

Cherednichenko Kostiantyn, Miroshnikova Julia. «Modeling of territorial differentiation by transport infrastructure level of development». *The research paper presents theoretical and practical aspects of differentiation of territories according to the level of transport infrastructure development. The purpose of the research is to develop a formalized approach to territorial differentiation according to the level of transport infrastructure development on the example of Ukrainian regions. The issues with the term of "transport infrastructure" are defined. Classical methodological approaches to transport infrastructure level of development assessment are described. The essence of the concept of "differentiation" and its meaning in the transport industry are revealed. The coefficients for assessing the provision of regions with transport infrastructure, transport network density coefficient and the assessment of transport network safety indicator are considered. On the basis of the considered coefficients and initial statistical data, the analysis of regions of Ukraine, based on a level of development of a transport infrastructure, was conducted. The inequality of transport infrastructure level of development (even within one country) is caused due to both objective (geographical location, resource potential) and subjective reasons (efficient use of resources, effectiveness of regional management). An integrated assessment in order to solve this task was formed. It is based on the apparatus of the methodology of decision-making in conditions of uncertainty. For the practical demonstration, the regions of Ukraine were differentiated, according to the level of transport infrastructure development. During the evaluation, it is possible to determine the factor with the greatest impact on the overall result by region. Improving the quantitative indicators that form the most influential qualitative assessment would lead to an increasement of the overall assessment. Thus, using the developed algorithm, it becomes possible to optimize the management of transport infrastructure development of a particular territory.*

Keywords*:* transport infrastructure, territorial differentiation, mathematical modeling, integrated assessment, transport safety, transport network density, carrying capacity.

Чередніченко Костянтин, Мірошнікова Юлія. «Модеюлювання диференціації територій за рівнем розвитку транспортної інфраструктури». *У статті викладені теоретичні та*

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практичні аспекти диференціації територій за рівнем розвитку транспортно інфраструктури. Метою даної роботи є розробка формалізованого підходу територіальної диференціації за рівнем розвитку транспортної інфраструктури на прикладі регіонів України. Розкрито проблематику та визначено термін «транспортна інфраструктура». Описано класичні методичні підходи до формування оцінок рівня транспортної інфраструктури та їх недоліки. Розкрито сутність поняття «диференціація» та її значення у транспортній галузі. Розглянуто коефіцієнти оцінки забезпеченості регіонів транспортною інфраструктурою. На базі розглянутих коефіцієнтів та вихідних статистичних даних був проведений аналіз регіонів України за рівнем розвитку транспортної інфраструктури. Нерівність рівня розвитку транспортної інфраструктури (навіть у межах однієї країни) обумовлена як об'єктивними (географічне розташування, ресурсний потенціал), так і суб'єктивними причинами (ефективне використання ресурсів, ефективність регіонального управління). Для вирішення даної проблеми була розрахована інтегральна оцінка. Базуючись на даній оцінці для практичної демонстрації розробленого алгоритму, було продиференційовано регіони України за рівнем розвитку транспортної інфраструктури. Використовуючи розроблений алгоритм, стає можливим оптимізувати управління розвитком транспортної інфраструктури певної території.

Ключові слова: транспортна інфраструктура, диференціація територій, щільність транспортної мережі, транспортна безпека, пропускна здатність, математична модель, інтегральна оцінка.

Чередниченко Константин, Мирошникова Юлия. «Моделирование дифференциации территорий по уровню развития транспортной инфраструктуры». *В статье изложены теоретические и практические аспекты дифференциации территорий по уровню развития транспортной инфраструктуры. Целью данной работы является разработка формализованного подхода территориальной дифференциации по уровню развития транспортной инфраструктуры на примере регионов Украины. Раскрыто проблематику и определение термина «транспортная инфраструктура». Описаны классические методические подходы к формированию оценок уровня транспортной инфраструктуры и их недостатки. Раскрыта сущность понятия «дифференциация» и его значение в транспортной отрасли. Рассмотрены коэффициенты оценки обеспеченности регионов транспортной инфраструктурой. На базе рассмотренных коэффициентов и исходных статистических данных был проведен анализ регионов Украины по уровню развития транспортной инфраструктуры. Неравенство уровня развития транспортной инфраструктуры (даже в пределах одной страны) обусловлена как объективными (географическое положение, ресурсный потенциал), так и субъективными причинами (эффективное использование ресурсов, эффективность регионального управления). Для решения данной проблемы была рассчитана интегральная оценка. Основываясь на данной оценке для практической демонстрации разработанного алгоритма, были оценены регионы Украины по уровню развития транспортной инфраструктуры. Используя разработанный алгоритм, становится возможным оптимизировать управление развитием транспортной инфраструктуры определенной территории.*

Ключевые слова: транспортная инфраструктура, дифференциация территорий, плотность транспортной сети, транспортная безопасность, пропускная способность, математическая модель, интегральная оценка.

Introduction. The transport system has significant importance for the modern economy, because other industries productivity and, as a consequence, the financial welfare of the state depends on it. The role of transport systems is constantly growing, especially during the implementation of large-scale international integration plans.

Transport infrastructure refers to the framework that supports transport system. This includes roads, railways, ports and airports. The inequality of transport infrastructure level of development (even within one country) is caused due to both objective (geographical location, resource potential) and subjective reasons (efficient use of resources, effectiveness of regional management).

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Literature review and problem statement. In modern scientific researches, "transport infrastructure" is interpreted in several aspects [1-5]. However, none of the considered approaches takes into account the impact of integration processes on transport infrastructure.

A general definition of transport infrastructure is formulated as a connecting element between production and consumption, which includes networks of connections of all modes of transport and facilities serving vehicles and communications (stations, airports, ports, etc.). It is also recommended to consider the transport infrastructure as a system of infrastructure by types of transport. Analysis of scientific research about transport infrastructure showed a variety of approaches to the assessment of its development level. Namely: the concepts of "transport network density" [6], "carrying capacity" [7], "transportation timing" [8] and "transport infrastructure provision". Most of the modern methods of transport infrastructure assessment, however, do not include transport safety and geographical location indicators.

Unfortunately, each approach analyzes only one factor, ignoring other indices that could potentially affect the overall level of transport infrastructure. The lack of integrated assessment could lead to a misinterpretation of the real level of development and, as a consequence, inefficient management of transport system.

The aim and objective of research. The aim of the study is to develop a formalized approach of territorial differentiation by transport infrastructure level of development on the example of Ukrainian regions.

Presentation of the main material. The differentiation of transport infrastructure (TI) should be considered as a process of distribution of transport infrastructures on the basis of integrated quantitative assessments of their level of development.

The classic approach to transport infrastructure assessment is the analysis of regions provision with transport infrastructure, which is based on coefficients of Engel, Goltz, Uspensky, Vasilevsky [8]:

$$K_E = \frac{L}{\sqrt{S * H}}, \quad (1)$$

$$K_G = \frac{L}{\sqrt{S * N}}, \quad (2)$$

$$K_U = \frac{L}{\sqrt[3]{S * H * t}}, \quad (3)$$

$$K_V = \frac{L}{\sqrt[3]{S * H * Q}}, \quad (4)$$

where K_E – Engel coefficient;
K_G - Goltz coefficient;
K_U - Uspensky coefficient;
K_V - Vasilevsky coefficient;
L – the length of roads in the region;
S – area of region;
H – population;
N – number of settlements;
t - the total weight of freights transported to the territory;
Q - total weight of products produced on the territory.

However, this method has disadvantages, such as: a region with a large area loses to a country with a smaller area in advance; the geographical factor is not taken into account; etc. Therefore, during territorial analysis, these coefficients must be supplemented. It is recommended to take into account transport network density coefficients [8].

Transport network density coefficient is the ratio of total roads length in the region to the area of region (formula 5) and population (formula 6):

$$d_S = \frac{1000L}{S}, \quad (5)$$

$$d_H = \frac{1000L}{H}, \quad (6)$$

Density of roads in relation to: the area of region and population (formula 7), density of

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cargo transportation by road (formula 8), GBP (formula 9):

$$d_{S^{AT}}^{A} = \frac{S^{AT}}{\sqrt{S^R A^R}} \quad (7)$$

$$d_{S^{AT}}^{S^R A} = \frac{S^{AT}}{\sqrt{S^R * N_A^R}} \quad (8)$$

$$d_{S^{AT}}^{S^R V^R} = \frac{S^{AT}}{\sqrt{S^R V^R}} \quad (9)$$

where S^{AT} - density of highways;

S^R – area of region;

A^R – population;

N_A^R - range of transportation of goods by road;

V^R - GDP.

Then the formula of integral assessment of road density:

$$d_{S^{AT}} = \frac{S^{AT}}{\sqrt[4]{S^R A^R N_A^R V^R}}, \quad (10)$$

It is worth to be included another approach to transport infrastructure level assessment, which is based on traffic safety index in transport network [9].

Accident rate:

$$I = \frac{10^6 z}{365 * L * N}, \quad (11)$$

where z - number of accidents per year;

N - average daily traffic intensity in both directions;

L - the road length.

Using formulas (1-11) and statistical data [11-15], the coefficients of transport infrastructure level of development of Ukrainian regions were calculated:

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Table 1. Transport infrastructure level of development assessment

Criterion	Region								
	Donetsk region	Prydniprovsky region	Northeastern region	Central region	Northwestern region	Podilsky region	Black Sea region	Carpathian region	Capital region
K_E	0,0242	0,0348	0,0439	0,0446	0,0424	0,0498	0,0328	0,036	0,047
K_G	1,1831	1,4694	1,3309	1,4903	1,297	1,0768	1,2999	1,386	1,395
K_U	0,9045	1,174	1,6462	1,5807	1,6521	1,8136	1,134	1,146	1,495
K_V	1,1095	1,1228	1,4768	1,0877	0,8555	1,4537	1,4434	1,273	1,374
d_S	262203	317140	343750	305006	312 750	395051	234981	381084	309524
d_H	2225,5	3810,8	5618,5	6531,0	5734,8	6271,9	4587,8	3571,6	6987,2
$d_{S^{AT}}^{A}$	1,1	1,3	1,4	1,9	2,0	2,3	1,1	2,3	1,4
$d_{S^{AT}}^{S^R A}$	23,9	23,2	27,4	30,2	38,2	42,4	17,0	38,8	20,2
$d_{S^{AT}}^{S^R V^R}$	0,06	0,09	0,09	0,16	0,19	0,18	0,08	0,17	0,07
$d_{S^{AT}}$	0,35	0,49	0,56	0,85	0,99	0,98	0,43	0,80	0,45
I	0,03	0,09	0,09	0,06	0,05	0,08	0,15	0,12	0,11

The next step is the formation of an integrated assessment of transport infrastructure level of development for territorial differentiation. It is possible to use

the apparatus of decision-making theory in conditions of uncertainty in order to conduct this procedure. It is recommended to use Savage's criterion (C_S). In this case, by "alternatives" should be understood "certain regions" (table 1), the calculated coefficients (formulas 1-11) – as expert assessments.

$$r_{ij} = max_{1 \le i \le m} a_j - a_{ij} \quad (12)$$

$$\bar{F} = min_{1 \le i \le m} max_{1 \le j \le n} r_{ij} = min_{1 \le i \le m} max_{1 \le j \le n} (max_{1 \le i \le m} a_j - a_{ij}) \quad (13)$$

To conduct the assessment, it is necessary to develop a table (table 2) of relative values from table 1.

Table 2. Relative values of transport infrastructure level of development

Region	Assessment					
	K_E	K_G	K_U	K_V	d_{SAT}	I
Donetsk region	0,4859	0,7941	0,4983	0,5796	0,3535	0,2000
Prydniprovskyi region	0,6988	0,9873	0,6472	0,7603	0,4949	0,6000
Northeastern region	0,8815	0,8938	0,9074	0,8626	0,5657	0,6000
Central region	0,8956	1,0000	0,8716	0,9844	0,8586	0,6000
Northwestern region	0,8514	0,8705	0,9107	1,0000	1,0000	0,4000
Podilsk region	1,0000	0,7240	1,0000	0,9303	0,9899	0,3333
Black Sea region	0,6586	0,6964	0,6251	0,6811	0,4343	1,0000
Carpathian region	0,7410	0,7834	0,6318	0,8125	0,8081	0,8000
Capital region	0,9337	0,9873	0,8241	0,9770	0,4545	0,7333

According to formulas (12-13) a table of r_{ij} was formed (table 3):

Table 3. Table of r_{ij}

Region	Assessment					
	K_E	K_G	K_E	K_V	K_E	I
Donetsk region	0,5141	0,2059	0,5017	0,4204	0,6465	0,8000
Prydniprovskyi region	0,3012	0,0127	0,3528	0,2397	0,5051	0,4000
Northeastern region	0,1185	0,1062	0,0926	0,1374	0,4343	0,4000
Central region	0,1044	0,0000	0,1284	0,0156	0,1414	0,4000
Northwestern region	0,1486	0,1295	0,0893	0,0000	0,0000	0,6000
Podilsk region	0,0000	0,2760	0,0000	0,0697	0,0101	0,6667
Black Sea region	0,3414	0,3036	0,3749	0,3189	0,5657	0,0000
Carpathian region	0,2590	0,2166	0,3682	0,1875	0,1919	0,2000
Capital region	0,0663	0,0127	0,1759	0,0230	0,4455	0,2667

Then the territorial differentiation of regions (table 4):

Table 4. Territorial differentiation of Ukrainian regions

Place	Region	Integrated assessment (1 - C_S)
1	Carpathian region	0,6318
2	Central region	0,6000
3	Northeastern region	0,5657
4	Prydniprovskyi region	0,4949
5	Capital region	0,4545
6	Black Sea region	0,4343
7	Northwestern region	0,4000
8	Podilsk region	0,3333
9	Donetsk region	0,2000

According to the results, the Carpathian region is the most developed region of Ukraine, and the Donetsk region is the least developed.

Conclusions. The developed algorithm allows to estimate the level of transport infrastructure by integrated assessment. During the evaluation, it is possible to determine the factor with the greatest impact on the overall result by region. Improving the quantitative indicators that form the most influential qualitative assessment would lead to an increasement of the overall assessment. Thus, using the developed algorithm, it becomes possible to optimize the management of transport infrastructure development of a particular territory.

References

1. Sadlovska I.P. Strategichne upravlinnya natsionalnoyu transportnoyu infrastrukturoyu Ukrainy [monografia]. Kyiv, 2011. 356 p.

2. Bakaev A.A., Pirozhkov I.I. Revenko S.I. Mezhdunarodnyie transportnyie koridoryi Ukrainyi: seti i modelirovanie. Kiev, 2003. 518 p.

3. Novikova O.F., Pokotilenko R.V. Ekonomichna bezpeka: kontseptualne viznachennya ta mehanizmy zabezpechennya [monografia]. Donetsk, 2006. 408 p.

4. Lozhachevska O.M. Upravlinnya funktsionuvannyam ta rozvitkom transportnogo kompleksu regionu [monografia]. Kyiv, 2002. 248 p.

5. Transportna Infrastruktura [Elektronniy resurs] // Vikipediya. Vilna entsiklopediya. – Rezhim dostupu: https://is.gd/sS18BU.

6. Usmanov Z.K. Integralnaya shema otsenki obespechennosti regionov avtomobilnyimi dorogami. Tashkent, 2014. 186-188 pp.

7. Freydman O.A. Otsenka potentsiala transportnoy sistemyi kak osnova formirovaniya transportno-logisticheskogo klastera. «Ekonomika», 2014, vol 3, pp 109-117.

8. Tohirov T. Otsenka sostoyaniya transportnoy infrastrukturyi regiona. Ekonomika i Upravlenie. Voprosyi upravleniya, Sankt-Peterburg, 2018, pp. 79-83.

9. Vedomstvennyie stroitelnyie normyi. Ukazaniya po obespecheniyu bezopasnosti dvizheniya na avtomobilnyih dorogah. Vsn 25-86 [Elektronniy resurs] – Rezhim dostupu do resursu : https://zakonbase.ru/content/part/399001 – Nazva z ekrana.

10. Transport Ukrainy [Elektronniy resurs] // Derzhavna sluzhba statistiki UkraYini. – KiYiv, 2020. – Rezhim dostupu do resursu: http://www.ukrstat.gov.ua/druk/publicat/kat_u/2020/zb/10/zb_trans_19.pdf.

11. Spisok regionov Ukrainyi po chislennosti naseleniya [Elektronniy resurs] // Vikipediya : Vilna Entsiklopediya – Rezhym dostupu do resursu: https://ru.wikipedia.org/wiki/Список_регионов_Украины_по_численности_населения.

12. Spisok regionov Ukrainyi po ploschadi [Elektronniy resurs] // Vikipediya : Vilna Entsiklopediya – Rezhim dostupu do resursu: https://ru.wikipedia.org/wiki/Список_регионов_Украины_по_площади – Nazva z ekrana.

13. NaselenI punkti UkraYini [Elektronniy resurs] // Vikipediya : Vilna Entsiklopediya – Rezhim dostupu do resursu: https://uk.wikipedia.org/wiki/ Населені_пункти_України – Nazva z ekrana.

14. DBN V.2.3-4-2015. AvtomobIlnI dorogi. Chastina I. Proektuvannya. Chastina II. [Na zamInu DBN V.2.3-4-2007; chinniy vId 01-04-2016]. Kyiv, 2015. 104 s.

15. Cilkina G.Yu. Teoriya prinyatiya resheniy i upravlenie riskami. Modeli konfliktov, neopredelennosti, riska. SPb, 2003. 72 p.

16. Yanchuk. M. B. i dr. Naukovo-metodichnI pIdhodi do upravlInnya transportnimi rizikami v multimodalnih vantazhnih perevezennyah. BIznes Inform, H., 2021, Vol 2, pp. 198–209.

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CIRCULAR PROCUREMENT MANAGEMENT IN THE CIRCULAR ECONOMY SYSTEM

Davydenko Volodymyr, Harmash Oleh, Ovdiienko Oksana. «Circular procurement management in the circular economy system». *The article is devoted to the analysis of the possibilities of using the instruments of the circular economy. The article describes the theoretical and practical aspects of the circular economy. The article highlights the classical approaches to resource management in the system of a circular economy. Methods for managing the cyclicity of production and consumption are analyzed. Provides extensive explanations on how to manage production and consumption cycles. The main reasons that lead to the occurrence of resource losses are considered. The analysis of the basic tools and methods that can be applied in the implementation of the circular economy is carried out. The possibilities of obtaining benefits from the introduction of a circular economy are considered. The role of circular purchases in the system of circular economy is considered. The main directions of improvement in the circular procurement management system are determined. Critical aspects in the procurement management system have been identified. The analysis of the state of waste management in Ukraine has been carried out. The possibilities of using modern methods of circular procurement management have been analyzed. These are the classic circular procurement models. The main advantages of using circular procurement methods are proposed. Provided recommendations for further research in circular procurement management.*

Keywords*:* circular economy, circular procurement, waste management, resource management, production cycling management.

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Давіденко Володимир, Гармаш Олег, Овдієнко Оксана. «Управління циркулярними закупками, в системі циркулярної економіки». *Стаття присвячена аналізу можливостей використання інструментів циркулярної економіки. У статті викладені теоретичні і практичні аспекти циркулярної економіки. Висвітлено класичні підходи до управління ресурсами в системі циркулярної економіки. Проаналізовані методи управління циклічністю виробництва і споживання. Надані розширені пояснення щодо методів управління циклічністю виробництва і споживання. Розглянуто основні причини, які призводять до виникнення ресурсних втрат. Проведено аналіз базових інструментів та методів, які можуть бути застосовані при запровадженні циркулярної економіки. Розглянуто можливості отримання переваг від запровадження циркулярної економіки. Розглядається роль циркулярних закупок, в системі циркулярної економіки. Визначаються основні напрямки вдосконалення в системі управління циркулярними закупками. Були визначені критичні аспекти в системі управління закупками. Проведено аналіз стану управління відходами в Україні. Проаналізовано можливості використання сучасних методів управління циркулярними закупками. Зазначені класичні моделі циркулярних закупок. Запропоновані основні переваги від застосування методів циркулярних закупок. Надано рекомендаці подальших досліджень в області управління циркулярними закупками.*

Ключові слова: циркулярна економіка, циркулярні закупки, управління відходами, управління ресурсами, управління циклічністю виробництва..

Давиденко Владимир, Гармаш Олег, Овдиенко Оксана. «Управление циркулярными закупками, в системе циркулярной экономики». *Статья посвящена анализу возможностей использования инструментов циркулярной экономики. В статье изложены теоретические и практические аспекты циркулярной экономики. Освещены классические подходы к управлению ресурсами в системе циркулярной экономики. Проанализированы методы управления цикличностью производства и потребления. Предоставлены расширенные пояснения относительно методов управления цикличностью производства и потребления. Рассмотрены основные причины, которые приводят к возникновению ресурсных потерь. Проведен анализ базовых инструментов и методов, которые могут быть применены при внедрении циркулярной экономики. Рассмотрены возможности получения преимуществ от внедрения циркулярной экономики. Рассматривается роль циркулярных закупок, в системе циркулярной экономики. Определяются основные направления совершенствования в системе управления циркулярными закупками. Были определены критические аспекты в системе управления закупками. Проведен анализ состояния управления отходами в Украине. Проанализированы возможности использования современных методов управления циркулярными закупками. Указанные классические модели циркулярных закупок. Предложены основные преимущества от применения методов циркулярных закупок. Предоставленных рекомендаций дальнейших исследований в области управления циркулярными закупками.*

Ключевые слова: циркулярная экономика, циркулярные закупки, управление отходами, управление ресурсами, управление цикличностью производства.

Introduction. As economic development grows, more and more countries around the world are joining the debate about the circular or closed-cycle economies.

The relevance of an implementing the circular system of the economic processes management in the economy contributes to the use of resources as long as possible, obtaining maximum value from the goods consumption, and in the future, the restoration of goods and materials from which they were made.

To date, a lot of research have been devoted to the circular economy. An important area for investigating is the chance for obtaining additional profits by enterprises, which is possible due to the minimizing materials related costs and the raw materials recycling.

The circular economy is not limited to the task of the waste recycling at the end of the product life cycle, but also provides opportunities for innovation and social

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development in the economic relations system.

The circular economy is considered as an economic model in which both the results and the processes of the resourcing and the production are planned and organized in a way to maximize a human well-being and the efficiency of an ecosystems [1].

The business' transition to a circular model should take place by organizing interaction in resource provision on a cascading basis, in which waste from one production is a raw material for another, thus reducing the amount of the generated waste, its reusing and recycling. This approach provides the considerable economic benefits, even despite the need for significant investments in the information interaction, as well as the creating of the efficient and high-quality waste management systems [2].

One of the circular economy tools is the circular procurement. The necessity to use special technologies for minimizing the use of new material and energy resources and to increase the utilization of secondary raw materials has begun to appear already at the product creation stage. Due to this approach a closed-cycle supply chain could be created, which would provide additional income.

Analysis of recent research and publications. The urgency of an exploring the circular approaches implementation is due to the limited global resources and the increasing of its consumption.

Research and development in the circular economy field focus mainly on some topical issues of logistics, production and processing technologies and provided in the works of W. Stahel, R. Lifset, G. Pauli and others [3-8].

Local researchers and scientists in the circular economy field mainly refer to the analysis of foreign experience.

The purpose and objectives of the paper. The purpose of this article is to consider the approaches for the introduction and management of the enterprise's circular processes as a component in the circular economy system.

Main materials and results. Circular economy can be considered as a concept based on the flow-process understanding of the nature of production, distribution, trade and consumption of goods in the socio-economic system and, accordingly, the turnover of resources and energy within this system [9].

The circular economy model involves the implementation of new approaches and methods, based on "smart" resource savings and goods reuse. This procedure assumes that companies should completely reconsider the management strategy of both the production and sales flows.

The introduction of this model was provoked by an increase in waste volumes worldwide. This trend increases environmental pollution and resource consumption.

The situation with waste in Ukraine is becoming dangerous. Almost 53 million m3 of household waste was generated in 2019 (excluding data from Autonomous Republic of Crimea and the city of Sevastopol), that corresponds to the more than 10 million tons of garbage, which are disposed of in 6,000 landfills with a total area of almost 9,000 hectares [10].

There is a need to introduce and maintain methods of circular economy in our country, considering the information from the State Statistics Service of Ukraine (Table 1) [11].

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Table 1. Household and similar waste management

	2011	2012	2013	2014*	2015*	2016*	2017*	2018*	2019*
Collected HSW, thsd.t	10356,5	13878,0	14501,0	10748,0	11491,8	11562,6	11271,2	11857,2	11792,7
Removed HSW, thsd.t	7030,0	9362,7	9504,4	5893,8	6233,0	6089,5	6469,0	7171,2	7099,0

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incl. to specially equipped dump	4321,5	5175,1	5178,5	3397,9	4194,3	4208,1	4417,5	4885,8	5043,6
Incinerated HSW for energy recovery, thsd.t	154,0	149,9	147,6	149,0	254,3	257,3	244,4	205,5	198,5
Incinerated HSW without energy recovery, thsd.t	98,5	78,6	2,9	3,8	2,1	2,0	1,2	1,0	1,0
Utilized HSW, thsd.t	74,5	57,4	9,4	3,8	4,0	6,5	16,5	16,7	0,1
incl. composted	…	…	3,7	0,0	0,4	0,0	8,2	7,9	0,0
Wastes per capita									
Collected HSW, kg	226,6	304,3	318,7	250,0	268,5	271,0	265,3	280,5	280,6
Removed HSW, kg	153,8	205,3	208,9	137,1	145,6	142,7	152,3	169,7	168,9
incl. to specially equipped dump	94,6	113,5	113,8	79,0	98,0	98,6	104,0	115,6	120,0
Incinerated HSW for energy recovery, kg	3,4	3,3	3,2	3,5	5,9	6,0	5,8	4,9	4,7
Incinerated HSW without energy recovery, kg	2,2	1,7	0,1	0,1	0,05	0,05	0,03	0,02	0,02
Utilized HSW, kg	1,6	1,3	0,2	0,1	0,1	0,2	0,4	0,4	0,00

** Data exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and a part of temporarily occupied territories in the Donetsk and Luhansk regions.*

The disappointing results shown in the table 1 indicate an increase in waste volumes each year. However, recycling or reuse remains at a low level (Table 2) [11].

Table 2. Waste generation and management

thsd.t	Volume of generated waste	Volume of recycled waste	Volume of incinerated waste	Volume of waste disposed of in specially designated places and facilities	Total volume of waste accumulated during operation, in specially designated places and facilities
2014	355 000,4	109 280,1	944,7	203 698,0	12 205 388,8
2015	312 267,6	92 463,7	1 134,7	152 295,0	12 505 915,8
2016	295 870,1	84 630,3	1 106,1	157 379,3	12 393 923,1
2017	366 054	100 056,3	1 064,3	169 801,6	12 442 168,6
2018	352 333,9	103 658,1	1 028,6	169 523,8	12 972 428,5
2019	441 516,5	108 024,1	1 059,0	238 997,2	15 398 649,4

** Data exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and a part of temporarily occupied territories in the Donetsk and Luhansk regions.*

The frequency of the procurement can be reduced by the extension of the products' life cycle. At the same time, the costs of waste removal and disposal are reduced, as the volume of waste is diminished. And according to this governance at macro level faced the situation when the need to introduce the model of circular economy and its toolkit is obvious.

The development of the circular economy can be traced in relevance with the areas of expansion of the tool "R", as the basis of the business model of methods of cyclical production and consumption management (Fig. 1).

One of the principles is to use the product or function which is needed instead of owning it. This format involves the establishment of relations between enterprises and consumers, the active use of instruments of lease and loan, i.e. the transition to a form of service, in contrast to the existing principle of "purchase and sale".

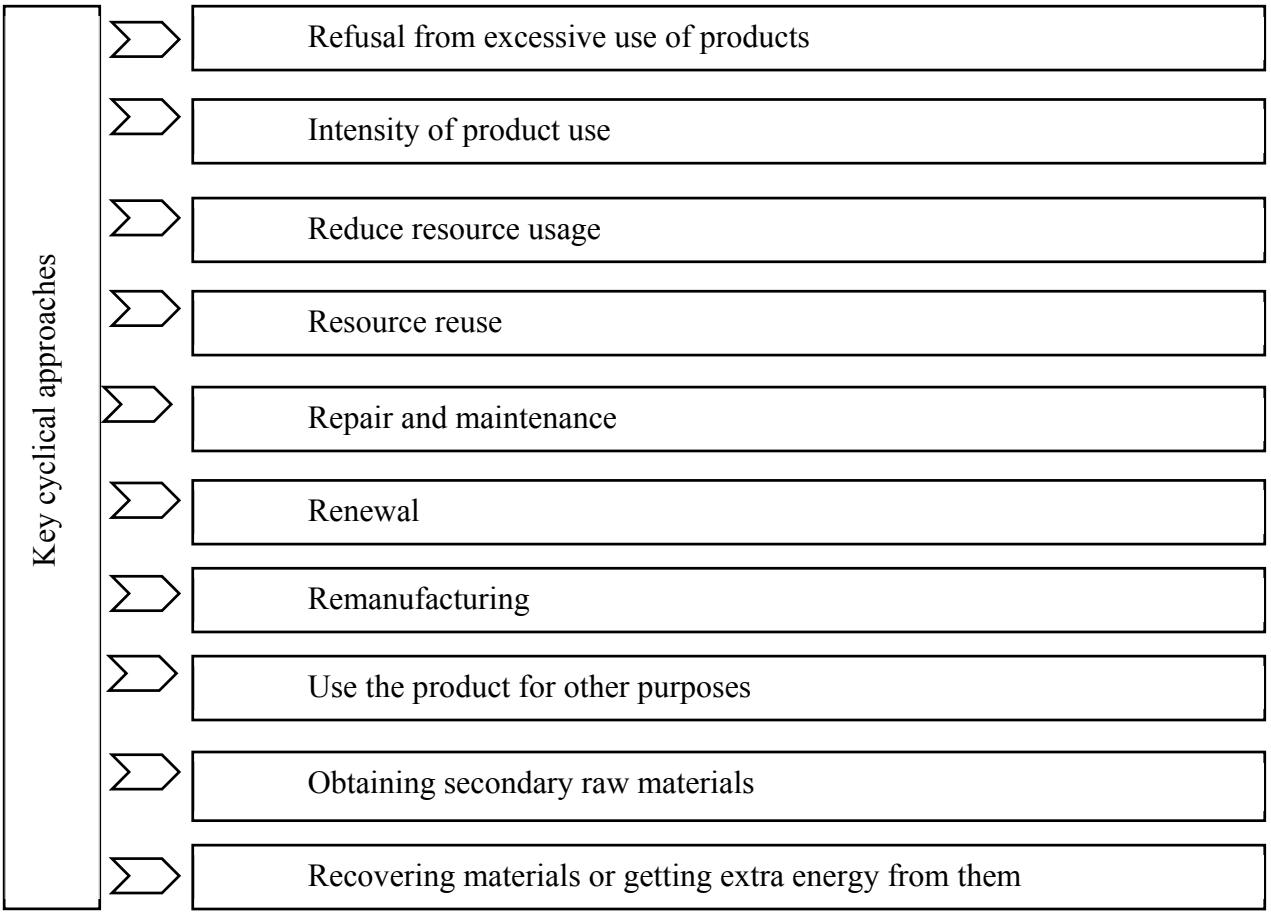

Figure1 – Methods of managing the cyclical nature of production and consumption
(Built by the authors based on [8])

The process of product sharing determines the possibilities of efficient use of tangible and intangible resources, in order to save costs. In addition, for some products, manufacturers are actively implementing the principle of sharing parts and components. As an example, a charger with a universal connector, or batteries.

Reuse of the product for initial or other purposes involves the search for alternative solutions to simplify service, and possibly provide the product with multifunctional properties.

Another approach is to maintain and repair the product to extend its life cycle. A special role is played by the possibility of easy

widening of the product potential, in case of obsolescence of its functional properties.

Progressive is the processing of used products to create new raw materials or goods. The development of such a cyclical process will not only create new types of commodities, but also generate additional jobs.

Along with the challenges of creating favourable conditions for the circular economy introduction there is the problem of lack of proper attention to other tools that acting as service elements of the gradual formation of new economic approaches. Namely, circular procurement.

The purpose of the circular procurement sustainability ensuring is to create long-term economic values for all stakeholders involved in the sale of goods and services on the market.

The circular procurement model launching could provide an opportunity to create "zero waste" conditions and the involvement of a significant part of the industry in this process, which would lead to the formation of a circular economy as a whole.

Circular procurement is a part of sustainable procurement, which is based on such principles of sustainability as recovery and cyclical use of resources.

Circular procurement can be defined as the process of purchasing of the goods, works and services by customers that helps to minimize energy and material losses in supply chains and also to avoid negative impacts on the ecosystem of the environment [12, 13]. This process involves the purchase of competitively priced goods, which increase the life cycle of products, their preservation and reuse.

Any manufactured products must be designed for durability, maintainability and recycling. After its main consumption purpose, the product must be reusable, have the ability to disassemble components, materials and raw materials that can be reused in new production.

The main approaches to circular procurement are not only reducing the costs on raw materials and diminishing waste volumes, but also establishing the conditions for closed production cycles and products.

There are different views on circular procurement in the scientific community, but today focus is put on three main models [12].

First model is based on the following processes. The supplier undertakes to buy from the customer the products previously provided to them. It could be realised after the expiration of the warranty period at a certain, agreed price. This approach creates the preconditions for products careful treatment by the customer and eliminates the need to address issues related to disposal.

Second model contain requirements according to which the customer sells the product after using to a third parties for further partial or full use. It is possible that in this model a third party will give the product other properties or create a new product.

Third model assumes that ownership remains with the manufacturer or supplier. In this case, the customer buys the service, not the product itself, or simply rents it. In this model the supplier will be fully responsible for maintenance and repair. The supplier and the customer are directly interested in this form of cooperation, namely, to minimize tangible and intangible costs within the agreements.

Any model of cyclic purchases usage allows to reduce customers' financial expenses. On the contrary, none of these models can guarantee a closed product cycle, as it is necessary to take into account market conditions and existing actors. These models are only a guide for modelling relationships in procurement.

Along with the application of these models, there is a need to use circular tools and environmental requirements for the efficient use of resources and at the same time, to meet the needs of all participants in the supply chain.

In the process of circular procurement, it is important to figure out clear requirements concerning the proper use of the materials,

the maintenance of the product in suitable state and conditions, as well as further action with the product after its expiration date.

Based on the analysis of the studied area, the use of circular procurement allows to achieve significant economic and social benefits:

– significant savings, by reducing the volume of purchases of new products and raw materials;

– reduction of waste volumes due to their transformation into new raw materials;

– reducing the use of imported raw materials;

– the possibility of using the saved resources in the development of lean production.

Conclusions. The lack of the necessary capacity for waste disposal in Ukraine, as well as the significant advantages of using circular procurement in the field of resource, labour and energy savings, determine the feasibility of reorienting efforts to support these approaches. This should be facilitated by the interaction of business and government, which will simultaneously reduce the pressure on the environment, cut back resource consumption and create additional jobs.

The national economy should promote the formation of innovative solutions to ensure a harmonious social basis for sustainable development. Restructuring of the national economic system according to the principles of the circular economy can help to solve global and domestic problems with waste management by reducing production and distribution chains and increase their efficiency in terms of resource use.

References

1. Murray A. The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context / A. Murray, K. Skene, K. Haynes // Journal of Business Ethics. – 2015. DOI: doi:10.1007/s10551-015-2693-2

2. The Ellen MacArthur Foundation. Towards a Circular Economy - Economic and Business Rationale for an Accelerated Transition // The Ellen MacArthur Foundation: Greener Management International, 2012. – 97 p. DOI: https://doi.org/2012-04-03

3. Stahel W.R., Reday-Mulvey G. Jobs for Tomorrow: The Potential for Substituting Manpower for Energy. New York, Vantage Press, 1981, 116 p.

4. Van der Straaten J., Van den Bergh J.C. Towards Sustainable Development: Concepts, Methods, and Policy. California, Island Press, 1994, 299 p.

5. Stahel W.R. The Product-Life Factor in Orr S.G. An Inquiry into the Nature of Sustainable Societies, the Role of the Private Sector. The Mitchell Prizes, 1984, 232 p.

6. Lifset R., Anex R. The Indirect Effects of Industrial Ecology. Journal of Industrial Ecology, 2009, vol. 13, iss. 3, pp. 347–349. URL: https://doi.org/10.1111/j.1530-9290.2009.00135

7. Pauli G.A. The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs. Paradigm Publications, 2010, 308 p.

8. Fedulin A., Chernaya I., Orlova E., Avtsinova G., Simonyan, T. (2020). Formation of approaches to environmental policy under conditions of digital economy. Journal of Environmental Management and Tourism, vol. 11, no. 3, pp. 549–554. DOI: 10.14505//jemt.v11.3(43).06.

9. Valko D.B. Natsyonalnye Ynteresy Pryorytety Y Bezopasnost, 2018, V. 14, #8, pages. 1415–1429 [in Russian] URL: http://fin-izdat.ru/journal/national/

10. Stan sfery povodzhennia z pobutovymy vidkhodamy v Ukraini za 2019 rik. Ministry for Communities and territories development of Ukraine [in Ukrainian] URL: https://www.minregion.gov.ua/napryamki-diyalnosti/zhkh/terretory/stan-sfery-povodzhennya-z-pobutovymy-vi/

11. State Statistic Service of Ukraine. Household and similar waste management. URL: http://www.ukrstat.gov.ua/

12. EU Green Public Procurement criteria for Furniture. Commission Staff Working Document. 2018. URL: http:// ec.europa.eu/environment/gpp/pdf/toolkit/furniture_gpp.pd

13. Marchuk Volodymyr, Harmash Oleh, Ovdiienko Oksana. (2020). World Trends in Warehouse Logistics. Electronic Scientifical and Practical Journal "Intellectualization of Logistics and Supply Chain Management", (2), 32–50. http://doi.org/10.46783/smart-scm/2020-2-3

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