

# Creation of transport and logistics clusters on railway networks

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**Abstract.** The development of logistics terminals and their placement on the railway network, which involves their integration into transport and logistics clusters, will significantly reduce logistics costs, thanks to the optimal technology for the movement of goods, and also contributes to active import substitution and the level of growth in the competitiveness of goods and services. Clustering, which is being given great attention by the Government of the country today, will allow solving some issues of territorial balance of production concentration, increasing the share of high-tech industries, avoiding dependence on trade in resources, increasing the added value of goods, increasing economic growth rates. Modern Uzbekistan has huge transport potential and unique opportunities to meet the needs of the country in the movement of both goods and passengers in all directions by all possible modes of transport through the use of available transit resources. The article analyzes the sectoral structure of the industry of Uzbekistan, shows the existing clusters of the agricultural sector of the republic. The methods of assessing the level of cluster development in the context of the regions of Uzbekistan are described. Paired correlation analysis was used to determine the presence and type of relationship between the studied factors. As a result, the regions of Uzbekistan in terms of the placement of freight infrastructure on railways in order to create potential transport and logistic clusters were grouped depending on the indicators of socio-economic and infrastructural development.

## 1 Introduction

When studying the development of transport and logistics clusters, the effectiveness of planning, forecasting and management of cargo and container flows, special attention is paid in the works of scientists N.Y. Makhkamov, A.N. Rakhmangulov, O.A. Kopylova, O.D. Pokrovskaya, V.V. Baginova etc. [1-14].

World experience shows that the most successful economic systems base their success on factors that stimulate the spread of new technologies in production, management, promotion of services and goods, often with the complex and active use of the advantages of the cluster mechanism as a direction of innovative development. At the state level, they are used to support enterprises of system-forming industries, to form national innovation

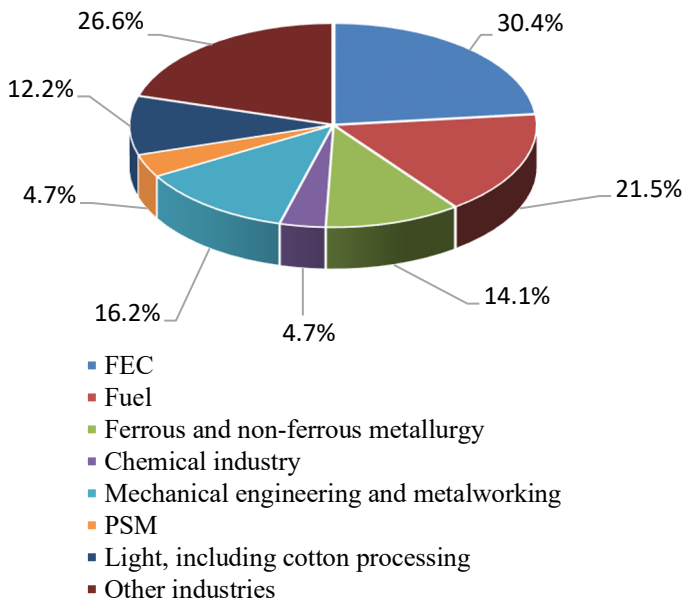
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systems, including forms of entrepreneurship in the field of railway transport [15].

From the point of view of railway transport support and placement of logistic hubs and cargo terminals, it can be noted that the main share of Uzbekistan's GDP (gross domestic product) is accounted for by industry and agriculture.

The strategy "New Uzbekistan" 2022-2026: macroeconomic stability [16] provides good forecasts for the future in 2023-2025 (6.5% will be the average annual GDP growth rate and 16-18% - the annual growth rate of lending to the economy). It is planned to increase the share of industry in GDP and achieve a 1.4-fold increase in production in its industries. According to the plan, large enterprises independently enter the financial markets and attract investments by confirming their credit rating at the international level [17]. The sectorial structure of Uzbekistan's industry for 2021 is shown in Fig.1.

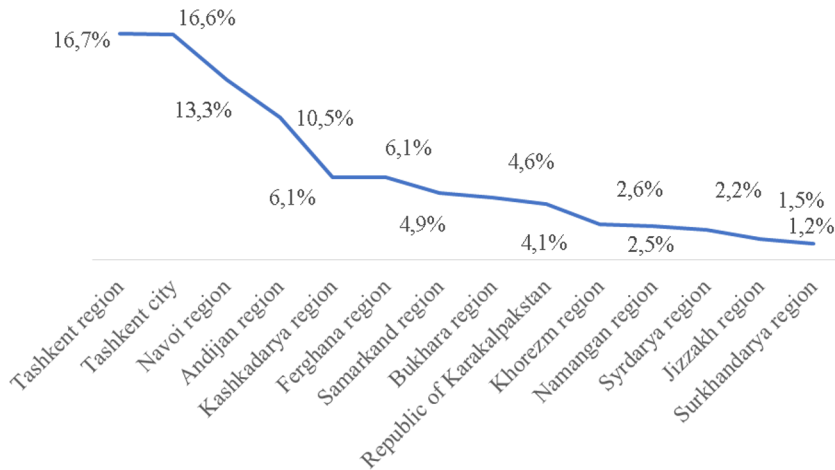


**Fig. 1.** Industry structure of Uzbekistan in 2021

In 2021, the largest share in the industrial complex of Uzbekistan, except for the fuel and energy complex of the fuel and energy complex (FEC) (30.4%), is occupied by the fuel industry (21.5%), mechanical engineering and metalworking (16.2%) and light industry (12.2%, including primary cotton processing - 8%). It should be noted that the share of industrial production in the country's GDP structure is growing, and this is supported in the plans for the next five years – in the interests of the state's economy, efforts are being made to move away from the raw material model and increase the share of processing.

Currently, more than 1.9 million people, or 14.1% of all employed in the country's economy, are employed in the industrial complex of Uzbekistan, and about 57 thousand industrial enterprises operate.

The dynamics in the regional structure of the country by the degree of industrial participation in GDP is shown in Fig. 2.



**Fig. 2.** The share of industrial production in the economy of the regions of Uzbekistan in 2021

More than 69% of the industrial part of Uzbekistan's GDP by its territorial concentration falls on 6 regions: Navoi (13.3%), Kashkadarya (6.1%), Ferghana (6.1%), Andijan (10.5%) and Tashkent regions (16.7%) and the city of Tashkent (16.6%). The lowest concentration is in Surkhandarya (1.2%), Jizzakh (1.5%) and Syrdarya (2.2%) regions [15, 16].

Historically, the country's industry was formed in a planning and administrative system with an emphasis on a special role in obtaining and manufacturing raw materials and minerals, manufacturing the necessary equipment for agricultural production, chemicals, fertilizers and building materials. This is how the Angren-Almalyk and Navoi-Zeravshan mining districts and industrial cities (Almalyk, Angren, Bekabad, Chirchik, Uchkuduk, Zarafshan, etc.) developed.

Clustering of the economy, which is currently being paid great attention by the Government of the country, will allow solving some issues of territorial balance of production concentration, increasing the share of high-tech industries, avoiding dependence on trade in resources, increasing the added value of goods, increasing economic growth.

The cluster system of production organization in Uzbekistan has been tested in the agricultural sector. Table 1 shows the number of active clusters by region.

The successful experience of clustering the economy in the field of agricultural production has led to the expansion of this process to other branches of industrial production. For example, by 2026, it is planned to create six chemical technology clusters in our country, the construction of facilities for some of which is already underway.

**Table 1.** The number of active clusters of Uzbekistan in the agricultural sector

Regions	Fruits and vegetables clusters		Cotton-growing and textile clusters		Grain clusters	
	Number	Area, ha	Number	Area, ha	Number	Area, ha
Republic of Karakalpakstan	12	6756	10	86291	18	25910
Andijan	14	11241	13	78991	18	76000
Bukhara	5	2738	10	97900	5	5763
Jizzakh	12	14968	6	78279	7	93500
Kashkadarya	8	3730	17	138578	18	135434

Continuation of table № 1

Regions	Fruits and vegetables clusters		Cotton-growing and textile clusters		Grain clusters	
	Number	Area, ha	Number	Area, ha	Number	Area, ha
Navoi	7	3313	2	31790	9	33977
Namangan	13	16304	7	67361	-	-
Samarkand	13	21848	9	75356	15	66965
Surkhandarya	13	6047	10	72370	8	90800
Syrdarya	6	2848	9	72557	16	84768
Tashkent	18	1330	6	72161	10	142050
Ferghana	19	11537	12	82080	26	95657
Khorezm	6	1578	11	82618	8	33200

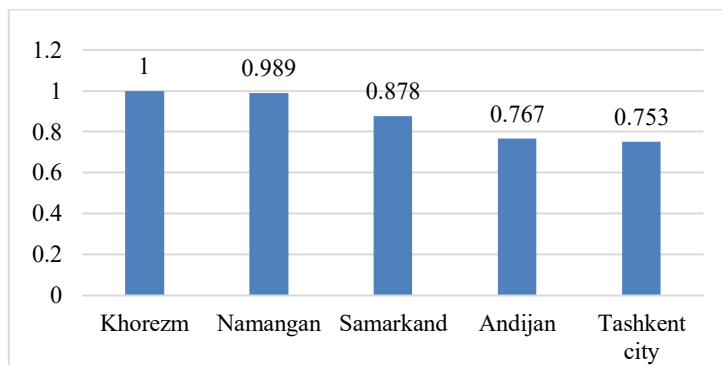
Due to this, by 2026 there will be significant growth rates from the manufacture of chemical products three times compared to this year, and in 2030 will amount to 7% of GDP. It should be noted that clustering plans also cover other areas (for example, now at the stage of creating medical clusters in seven regions of Uzbekistan, clustering penetrates into research, innovation, design areas), but the transport and infrastructure railway component is most important for large commodity production from the point of view of sales.

## 2 Materials and Methods

On Experts of the Institute of Forecasting and Macroeconomic Research (IPMI) conducted a study to assess the level of cluster development in the context of the regions of Uzbekistan. The rating evaluation method was used, within the framework of which the integrated cluster development index (IRC) was calculated taking into account five statistical indicators brought into a comparable form using the methods of relative differences, comparative estimates and groupings, and the “Pattern” method [17]:

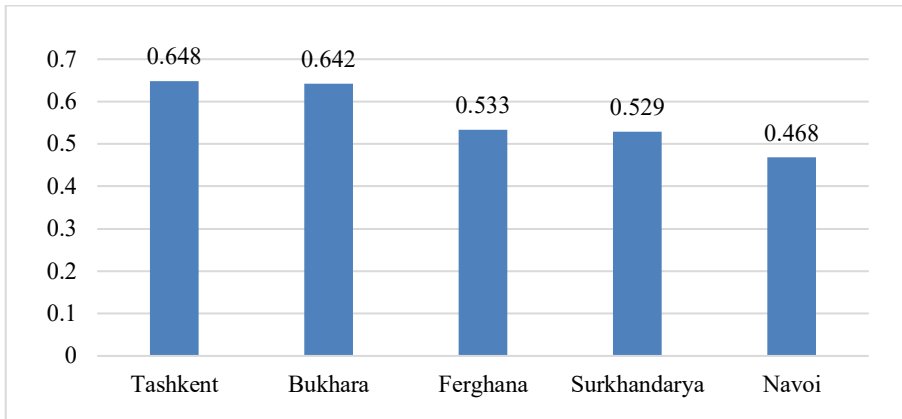
- role of clusters in the formation of GRP regions;
- volume of production per enterprise;
- labor productivity;
- capital productivity;
- share of exports in the total production of goods and services.

Figure 3-4 shows the results of grouping according to the cluster development index of the regions of Uzbekistan of 2021.



**Fig. 3.** Regions of Uzbekistan with a high level of cluster development in 2021

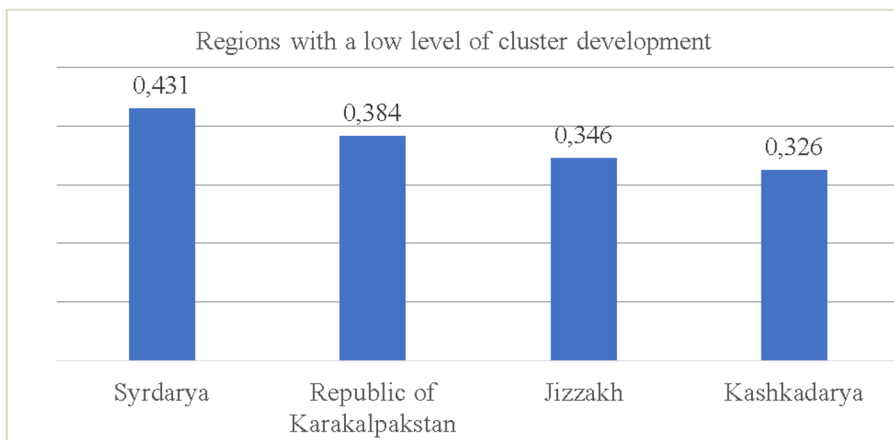
The largest cluster development index falls on the Khorezm, Namangan and Samarkand regions, and here we are talking about the development of agricultural clusters. The Andijan region and the city of Tashkent belong to the regions of large concentration of industrial production, but the clustering of this sector of the economy is at the planning stage. In the above-mentioned regions, more than 40 % of the volume of products produced in clusters has been produced, there is a high growth and development of production per enterprise (34.9-82.2 billion UZS), labor productivity (215.5-496.8 million UZS/person) and capital productivity (0.13-0.60 percent of units).



**Fig. 4.** Regions of Uzbekistan with an average level of cluster development in 2021

In the category of regions of Uzbekistan with an average level of cluster development, the Tashkent region can be noted as industrial. The remaining areas with an average level of development are fruit and vegetable, grain and cotton-textile clusters.

From the point of view of freight infrastructure on the railway network of Uzbekistan, special attention is paid to regions with a relatively low level of clusters, for which appropriate programs are planned to develop the existing production and economic potential. The regions of Uzbekistan with a relatively low level of cluster development in 2021 are shown in Fig. 5.



**Fig. 5.** Regions of Uzbekistan with a relatively low level of cluster development in 2021

Kashkadarya region has a high industrial and production potential and has the potential for clustering. Syrdarya region has a low level of industrial production. The remaining regions, shown in Fig. 5, have the potential for clustering and the development of manufacturing industries.

In order to support the viability of clusters, it is necessary to take into account the factors necessary for the construction of an integral value chain, the level of preparation of products for production, taking into account the ratio of the shares of primary, secondary and tertiary processing.

From the point of view of the efficiency of logistics support of Uzbekistan from the point of view of foreign partners and operating operators, according to criteria such as the quality of transport infrastructure and logistic services, the efficiency of customs and border services, the organization of international transportation, the efficiency of cargo tracking and others, the indicators have improved significantly in recent years, however, the country is noticeably inferior to Russia and Kazakhstan.

As for export-import freight rail transportation in terms of logistics, it is necessary to note the construction of nine modern customs terminals that are adjacent to the territory bordering customs posts, including the circumstances of a mixed partnership between the state and private owners. These are terminals “St. Najimov”, “Gishtkuprik”, “Oibek” and “Yallama” in the Tashkent region, “Alat” in the Bukhara region, “Madaniyat” and “Dustlik” in the Andijan region, “Uzbekistan” in the Ferghana region and “Daut-ata” in the Republic of Karakalpakstan).

In Uzbekistan, in addition to the logistic facilities studied in, there are also such logistic facilities as:

- multimodal logistic center UP “Logistics Center PAP” (Namangan region);
- logistic terminal of LLC “Termez Cargo Center” (Surkhandarya region).

The Jizzakh region, having at the moment a low level of clustering of industrial production, is simultaneously included in plans for the development of logistic infrastructure and for the opening of new and expansion of existing production facilities.

Jizzakh lies on the way from the capital of Uzbekistan to Samarkand, Bukhara and the Ferghana Valley, which makes it possible to implement four projects to create large logistic centers that will contribute to the further development of the region’s economy. The region has 17 mineral deposits, large reserves of mineral resources that are being developed by less than 65%, agriculture is well developed, projects are being implemented to open high-tech industries (the total amount of investments amounted to 21956 billion UZS), the development of industrial production (for a total investment of 14.1 billion UZS). A large trade and logistic terminal will be built in the Syrdarya region, whose activities should also include transport support, including by rail [16].

In the Samarkand region, the construction of one of the largest logistic centers in Central Asia is being completed with the main specification - storage and refinement of garden products, including for export [17].

### 3 Results and Discussion

Based on the above information, in *Table 2*, an expert forecast of the regions of Uzbekistan was made, taking into account the development of clusters in large cargo terminals. The preliminary expert assessment was carried out by the author on a three-point scale, where:

- 1 - low level;
- 2 - medium level (there are plans for development, or additional transport support is required);
- 3 - high level (there are already large logistics centers).

When assessing in *table 2*, the geographical extent of the regions and the insufficient level

of ensuring the needs of existing industry clusters for additional cargo capacities were not taken into account.

**Table 2.** Forecasting the availability of cargo facilities in the regions of Uzbekistan

Regions	The level of cluster development	The level of availability of cargo terminals
Tashkent region	2	3
Tashkent city	3	3
Navoi region	2	3
Andijan region	3	2
Kashkadarya region	1	1
Ferghana region	2	2
Samarkand region	3	2
Bukhara region	2	2
Republic of Karakalpakstan	1	2
Khorezm region	3	1
Namangan region	3	3
Syrdarya region	1	2
Jizzakh region	1	2
Surkhandarya region	2	3

According to preliminary estimates, taking into account the above assumptions, we can talk about the need for transport infrastructure development in such regions as Khorezm and Kashkadarya regions and the implementation of the planned logistic plans, including the placement of cargo facilities on the railway network in such areas as Andijan, Ferghana, Samarkand, Bukhara, Syrdarya and Jizzakh, as well as in the Republic of Karakalpakstan. The issue of transport support of production and trade logistics in the Khorezm region is particularly acute.

In general, assessing the issues of clustering of regions of potential placement of cargo facilities on the railway network of Uzbekistan, the following points can be noted:

- weak scientific justification for the purposeful projected development of railway transport and the lack of a root master plan for the development of transport and cargo infrastructure as a whole;
- the insufficiency of a centralized plan and the weakness of scientific justification of the directions of the rise of industrial and manufacturing industries with a focus on the export of products with high added value in order to increase the country's GDP in the future;
- large logistic facilities in the regions were often built and are being built proactively with the expectation that this will trigger the development of production of industries with products with higher added value without scientifically based consideration of global demand for these products, or production developed locally without multilateral consideration of its logistic needs, infrastructure and investment opportunities in the field of rail transportation;
- some cargo facilities are overloaded, and some, on the contrary, do not use most of the design capacity, which is unprofitable for both railway operators, the state, manufacturers and end users;
- during the construction and development of cargo facilities, it is necessary to have an idea of the types of transportation, taking into account their further transportation by other

modes of transport (air, sea and road), as well as how much products mainly supplied by regions need special transport containers (barrels, containers, etc.), which, in turn, affects the type and equipment of a freight facility on the railway network;

- with further clustering of regions by types of economic and industrial activities involving the use of railway infrastructure, it is preferable to choose the railway stations that are the most geographically approximate and suitable for these purposes as the location of storage and distribution centers and container sites.

When solving the problem of optimal placement of cargo facilities on the railway network in order to provide logistic capacities to existing and emerging industrial processing clusters, it is necessary to find such a location of distribution centers or sites relative to their suppliers and consumers, in which a certain objective function of total logistic costs reaches its minimum value with a comprehensive account of all significant influencing factors. Mathematically, this problem serves the purpose of multi-criteria optimization in the presence of a system of constraints.

Initially, the problem of the optimal location of a cargo facility with the possibility of loading and warehousing should take into account such basic factors as the distances between the warehouse and suppliers and consumers, the volume of goods transported, transport tariffs and the time of delivery of goods from suppliers to and from the warehouse to consumers, and be solved by determining the coordinates  $(x, y)$  of the cargo facility so that logistic costs, equal to the sum of the products of the distances from the suppliers to the cargo object and from the cargo object to the destination having coordinates  $(x_i, y_i)$ , the volumes of transported goods  $Q_i$  (demand or offer) were minimal, as shown by formula 1:

$$P = \sum_{i=1}^n Q_i d_i \rightarrow \min \quad (1)$$

where is:  $d_i$  - the distance from the  $i$  cargo object to the supplier or to the destination ( $i = 1, 2, \dots$ ).

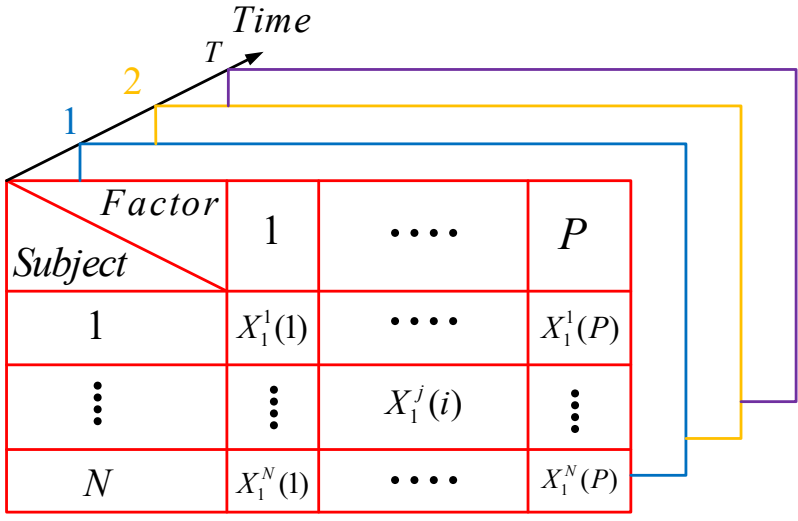
To determine the level of dependence between the factors influencing the placement of logistic centers, the values of dependent (endogenous) variables are estimated  $y_1, y_2, \dots, y_m$  depending on the values of independent (exogenous) variables  $x_1, x_2, \dots, x_k$  taking into account the influence of non-measurable random components  $\varepsilon_1, \varepsilon_2, \dots, \varepsilon_m$  (the influence of factors not included in the model and random errors in the measurement of indicators).

Exogenous or independent variables of the statistical model include: climate zone, availability of roads and railways, availability of transport corridors in the region, population.

The remaining variables are defined as dependent (endogenous).

Thus, statistically describing and allowing to estimate the change in time and space of the system of factors for the placement of logistic centers, the data array consists of  $P$  factors for  $N$  regions of Uzbekistan for  $T$  time intervals [17], as shown in Fig.6.





**Fig. 6.** Graphical representation of the data structure under consideration

Preliminary analysis has shown that the logistic centers available in Uzbekistan are located in regions with high values for the development of trade and industry, population and favorable geographical location in relation to land transport corridors.

The evaluation of the system of factors for the placement of logistic centers was carried out on the basis of a spatial and temporal sample (17 indicators for 13 regions (Tashkent city was excluded from the sample due to sufficient availability of logistic centers), the study period 2010-2022), based on data from the State Committee of the Republic of Uzbekistan on Statistics.

The indicators are included in a statistical model with various regression coefficients, the values of which depend on the region belonging to a particular cluster.

The dependence model of the *i*-th factor has the form:

$$Y_i(X) = f(Y, X_1, X_2, \dots, X_p, r_1, r_2, r_3, r_4) + \varepsilon_i, \quad (2)$$

where is:  $\varepsilon_i$  - random component.

The form of the dependence  $X$  of the *i*-th indicator ( $Y_i$ ) on has the form:

$$Y_i(X) = \beta_0 + \sum \alpha_k * r_k + \sum \beta_j * X_j + \varepsilon_j, \quad (3)$$

where is:  $X_j$  - the value of the variable *j* that has the strongest influence on the *i* indicator;  $\beta_0$  and  $\beta_j$  - unknown coefficients of the regression equation;  $\alpha_k$  - unreal variable, where is the *k* cluster number;  $r_k$  - regression coefficient for a unreal variable.

Multiple regression analysis is used to estimate the parameters of the regression equation, since the number of variables on which the indicator *j* depends is more than one.

To group multidimensional objects and represent the results of individual observations by points of a suitable geometric space, followed by the allocation of groups as clusters,

cluster analysis is performed using various software packages (for example, Statistic). Objects belonging to a certain cluster have similar properties.

Similarity with other objects is defined as the corresponding distance between objects in space is called, that is, the value  $d_{ab}$  satisfying the axioms:

$$\begin{aligned} A1. & d_{ab} > 0, \quad d_{ab} = 0, \\ A2. & d_{ab} = d_{ba}, \\ A3. & d_{ab} + d_{bc} \geq d_{ac}. \end{aligned} \quad (4)$$

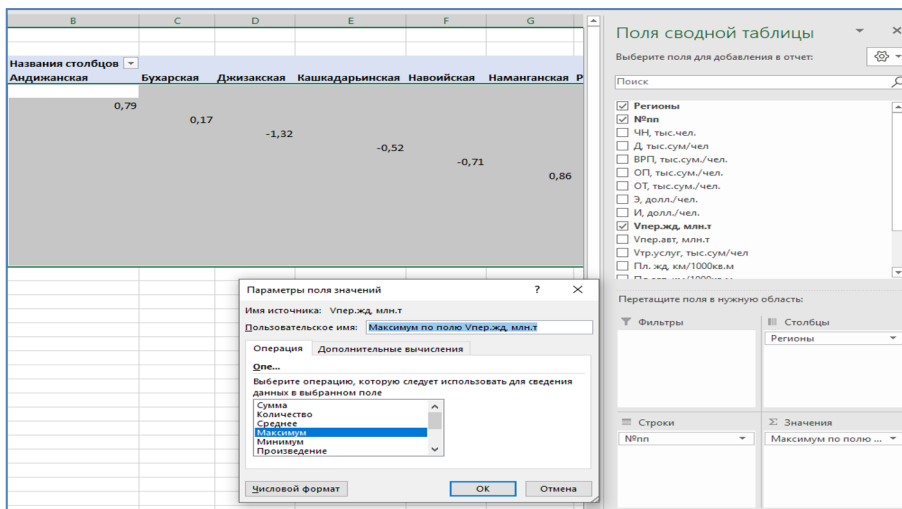
As a measure of distance, it is advisable to use the geometric distance between two points in a multidimensional space, that is, the Euclidean distance:

$$d_{ab} = \sqrt{\sum_{i=1}^K (X_{ia} - X_{ib})^2}, \quad (5)$$

where is:  $X_{ia}, X_{ib}$  - values of the  $i$ -th feature of the  $a$ -th ( $b$ -th) object ( $i = 1, 2, \dots, k, a, b = 1, 2, \dots, n$ ).

Cluster analysis was carried out using the Excel program. All indicators are normalized by the ratio of the difference between the initial and arithmetic mean values of the indicators to the standard deviation (in the created model, this tab is called "Cluster Analysis"). The results of the calculations are presented in Table 3.

Next, the resulting data is highlighted and, using the Insert-Pivot Table algorithm, opened in a new sheet (in the created model, this tab is called "Smallest Distances"). Here the parameter "regions" is transferred to columns, the parameter "region number" (number of series) is transferred to rows according to the selected value "Volume of freight rail traffic" ( $V_{nep.}$ , million tons) with the setting of the parameters of the fields of the value "Maximum by field".



**Fig. 7.** Setting parameters for determining the shortest distance to the cluster center in the cluster analysis of the regions of Uzbekistan

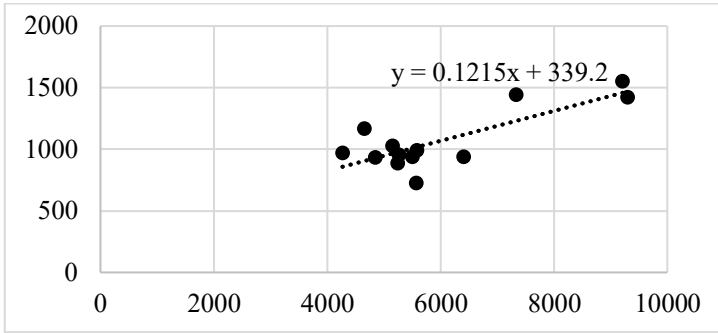
**Table 3.** Standardized data for clustering

Regions	Population size, thousand people.	Per capita income of the population, thousand UZS/person	Volume of gross regional product, thousand UZS/person	The volume of industrial production, thousand UZS/person	Trading volume, thousand UZS/person	Volume of export products, USD/person	Volume of imported products, USD/person
Republic of Karakalpakstan	-0.518	-0.433	-0.407	-0.289	-1.079	0.449	-0.713
Andijan	0.723	-2.063	-0.404	-0.151	-0.322	0.277	-0.093
Bukhara	-0.495	0.956	0.082	-0.179	0.803	-0.370	-0.538
Jizzakh	-1.021	-0.038	-0.185	-0.423	0.231	-0.235	-0.620
Kashkadarya	0.868	-0.238	-0.451	-0.452	-0.728	-0.933	-0.992
Navoi	-1.411	2.315	3.106	3.125	2.016	-0.142	0.747
Namangan	0.409	-0.447	-0.539	-0.481	-0.482	-0.350	-0.516
Samarkand	1.469	-0.114	-0.414	-0.444	-0.467	-0.663	0.011
Surkhandarya	0.225	-0.327	-0.602	-0.617	-0.283	-0.890	-0.835
Syrdarya	-1.560	-0.157	-0.062	-0.146	-0.840	0.911	1.929
Tashkent	0.515	0.630	0.748	0.786	1.959	2.829	2.108
Ferghana	1.343	-0.533	-0.509	-0.363	-0.538	-0.263	-0.343
Khorezm	-0.547	0.448	-0.365	-0.366	-0.270	-0.619	-0.145

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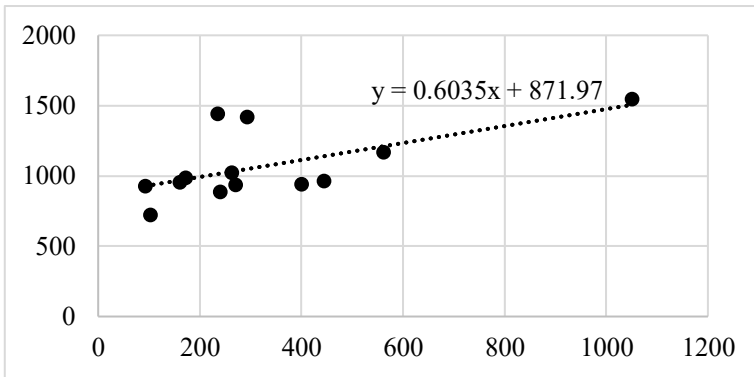
Regions	Volume of freight rail traffic, million tons	Volume of auto traffic, million tons	Volume of transport services, thousand UZS/person	Density of railway tracks, km/1000 sq.m	Density of auto tracks, km/1000 sq.m	Availability of transport corridors in the region. ball	Climate zone, ball
Republic of Karakalpakstan	-1.127	-1.013	-0.423	-1.198	-1.202	0.526	-1.215
Andijan	0.795	1.540	-0.531	0.601	1.726	0.526	1.418
Bukhara	0.168	-0.198	1.494	-0.762	-0.786	-1.754	-1.215
Jizzakh	-1.318	-1.095	-0.550	-0.813	-0.666	0.526	0.101
Kashkadarya	-0.516	-0.307	-0.570	0.019	-0.699	0.526	0.101
Navoi	-0.706	-0.959	1.404	-1.180	-1.149	-1.754	0.101
Namangan	0.861	0.399	-0.741	-0.525	0.918	0.526	1.418
Samarkand	1.352	0.453	-0.468	0.509	-0.018	-1.754	0.101
Surkhandarya	-0.400	-0.606	-1.397	-0.226	-0.615	0.526	-1.215
Syrdarya	-0.892	-1.231	0.387	1.963	0.163	0.526	0.101
Tashkent	0.198	1.648	1.921	1.695	0.031	0.526	0.101
Ferghana	-0.380	1.159	-0.186	0.317	1.789	0.526	1.418
Khorezm	1.964	0.209	-0.338	-0.400	0.509	0.526	-1.215





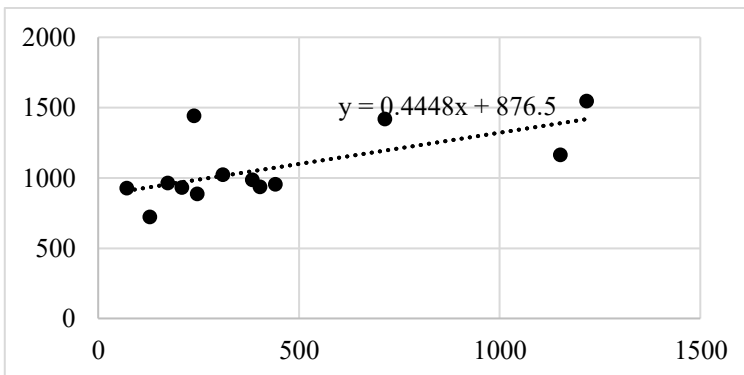
**Fig. 9.** Dependence of the volume of transport services per capita on the volume of retail turnover per capita

The dependence of the volume of transport services per capita on the volume of retail turnover per capita is strong direct (correlation coefficient – 0.795605). The higher the retail turnover, the greater the volume of transport services.



**Fig. 9.** Dependence of the volume of transport services per capita on the volume of exports per capita

The dependence of the volume of transport services per capita on the volume of exports per capita is moderately positive (correlation coefficient – 0.61924), there is a direct influence of foreign trade on the volume of transportation.



**Fig. 10.** Dependence of the volume of transport services per capita on the volume of imports per capita

The dependence of the volume of transport services per capita on the volume of imports per capita is moderately positive (correlation coefficient – 0.662933), imports directly affect the volume of traffic.

Also, in the course of the study, it was found that the volume of cargo transportation by road is determined by the cost of fixed assets per capita, the number of people employed in the economy, the volume of trade, the average per capita income of the population, the availability of transport corridors and the density of highways. At the same time, the subject belongs to the second, third and fourth cluster (Namangan region) reduce the value of this indicator. This is due to the good value, in comparison with road transport, of the length of railway tracks, along which transportation is more profitable.

## 4 Conclusions

A preliminary assessment of the regions of the Republic of Uzbekistan showed the need for transport infrastructure development in such regions as Khorezm and Kashkadarya regions and the implementation of the planned logistic plans, including the placement of cargo facilities on the railway network in such areas as Andijan, Ferghana, Samarkand, Bukhara, Syrdarya and Jizzakh, as well as in the Republic of Karakalpakstan. The issue of transport support of production and trade logistics in the Khorezm region is particularly acute.

According to the results of the cluster analysis of the regions where it is possible to place cargo facilities, the territory of Uzbekistan is divided into four clusters in accordance with the stages of their social, economic and infrastructural development, while the volume of transport work and the characteristics of geographical location were also taken into account. The regions of Uzbekistan were grouped into clusters depending on such indicators as population size, per capita income of the population, GRP volume, industrial production volume, volume of export products, density of railways, density of highways, belonging to the climatic zone. Of the selected clusters, the first cluster is assigned to the Khorezm region, the second to the Samarkand region, the fourth to Namangan, and the remaining regions belong to the third cluster.

Thus, the dependence of rail transport volumes on the density of highways and railway coverage, imports, the cost of fixed assets per capita, the volume of road transport, retail trade volumes and the availability of transport corridors is statistically confirmed. At the same time, the indicator increases due to belonging to the first cluster (Khorezm region) and decreases due to belonging to the third cluster (Karakalpakstan, Andijan, Bukhara, Jizzakh, Kashkadarya, Navoi, Surkhandarya, Syrdarya, Tashkent, Ferghana regions).

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