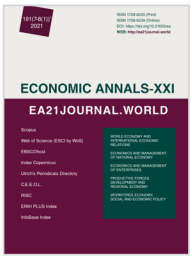

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Regional distribution networks: evaluation of the functioning and development efficiency

Abstract. The efficiency of the regional distribution network (DN) has the greatest impact on the timing, cost of goods delivery and quality of customer service. On the basis of the analysis the main social, economic and environmental indicators characterizing the activities of distribution networks were identified.
The authors evaluate the effectiveness of distribution networks of the regions of Kazakhstan on the basis of the selected indicators and develop recommendations for their improvement.
Research methods include correlation and regression analysis; factor analysis of data with reduction and allocation of the most important factors and the method of data analysis (DEA-analysis) to assess performance. Statistical data from 17 regions of Kazakhstan for 2000-2020 were used for the analysis.
The results regarding regional distribution network effectiveness show the uneven development of distribution systems in the regions of Kazakhstan - from high- to low-efficient, which is the reason for the growth of the return effect in the most prosperous regions and reduction of the return effect in the regions with inefficient distribution networks. The most important factors affecting the efficiency of DN are investments in infrastructure, goods turnover and cargo turnover, the value of inventory and retail space, the number of Internet and mobile app users, the length of roads, employment, the share of recycling and waste disposal.
It is concluded that the reason for such a high differentiation of the regional DN is associated with weak government support for the trade infrastructure environment, uneven efficiency of the distribution network in the regions and their unequal development. The regions have been ranked according to the level of efficiency of DN functioning. The results allow us to conduct differentiated policy on measures to support and stimulate the development and management of distribution networks in the regions, based on their level of efficiency. The practical implementation of the recommendations will reduce the gap in the level of development of regional DN.

Keywords: Distribution Network; Distribution System Efficiency; Trade; Logistics Infrastructure; Data Envelopment Analysis
JEL Classification: C43; D39; R11; R12
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Оцінка ефективності функціонування та розвитку регіональних товаропровідних мереж

Анотація. Ефективність функціонування товаропровідної мережі регіонів має найбільший вплив на терміни та вартості доставки товарів і якість обслуговування споживачів. На основі аналізу виявлено основні соціальні, економічні й екологічні показники, що характеризують діяльність товаророзподільчих мережі. Мета статті – оцінка ефективності функціонування товаропровідної мережі (ТПМ) регіонів Казахстану на основі виділених показників і розробка рекомендацій щодо їх поліпшення. Методи дослідження включають кореляційно-регресійний аналіз; факторний аналіз даних із скороченням та виділенням найважливіших факторів, а також метод аналізу даних (DEA аналіз) для оцінки ефективності. В аналізі були використані статистичні дані за 2000–2020 рр. щодо 17 регіонів Казахстану. Результати ефективності функціонування ТПМ свідчать про нерівномірний розвиток товаророзподільчих систем у регіонах країни – від високо-, до низькоефективних, і є причиною зростання ефекту віддачі в найбільш заможних регіонах або зниження ефекту віддачі в регіонах із неефективними товаророзподільчими мережами. Виделені найбільш важливі фактори, що впливають на ефективність ТПМ, а саме: інвестиції в інфраструктуру, товарооборот та вантажооборот, величина товарних запасів і торгових майданчиків, кількість користувачів Інтернету та мобільних додатків, протяжність автомобільних доріг, зайнятість, доля переробки та використання відходів.Зроблено висновок про те, що причина такої високої диференціації регіональної ТПМ пов'язана зі слабкою державною підтримкою торгової інфраструктурної складової середовища та нерівномірною ефективністю розподільної мережі, а також нерівномірністю їх розвитку.Нами проведено ранжування й класифікацію регіонів і великих міст у залежності від рівня ефективності функціонування ТПМ. Результати дозволяють проводити диференційовану політику щодо заходів підтримки та стимулювання розвитку й управління розподільними мережами регіонів, виходячи з їх рівня ефективності. Практична реалізація рекомендацій дозволить скоротити розрив у рівні розвитку ТПМ регіонів.

Ключові слова: товаропровідна мережа; ефективність розподільчої системи товарів; торгівля; логістична інфраструктура; метод аналізу даних DEA.

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Оценка эффективности функционирования и развития региональных товаропроводящих сетей

Анотация. Эффективность функционирования товаропроводящей сети регионов оказывает наибольшее влияние на сроки и стоимость доставки товаров и качество обслуживания потребителей. На основе анализа выявлены основные социальные, экономические и экологические показатели, характеризующие деятельность товаропроводящей сети (ТПС) регионов Казахстана.Цель статьи – оценка эффективности функционирования ТПС регионов Казахстана на основе выделенных показателей и разработка рекомендации по их улучшению. Методы исследования включают корреляционно-регрессионный анализ; факторный анализ данных с сокращением и выделением наиболее важных факторов и метод анализа данных (DEA анализ) для оценки эффективности. Для анализа были использованы статистические данные за 2000–2020гг. по 17 регионам Казахстана.

Результаты оценкиэффективности функционирования ТПС свидетельствуют о неравномерном развитии товарораспределительных систем в регионах Казахстана – от высоко- до низкоэффективных,что является причиной роста эффекта отдачи в наиболее благополучных регионах или снижения эффекта отдачи в регионах с неэффективными товарораспределительными сетями.Нами выделены наиболее важные факторы, влияющие на эффективность ТПС: инвестиции в инфраструктуру, товарооборот и грузооборот, величина товарных запасов и торговых площадей, количество пользователей Интернета и мобильных приложений, протяженность автомобильных дорог, занятость, доля переработки и утилизации отходов. Сделан вывод о том, что причина столь высокой дифференциации региональной ТПС связана со слабой государственной поддержкой торговой инфраструктурной среды и неравномерной эффективностью распределительной сети, а такжеее развития.
Проведены ранжирование и классификация регионов и крупных городов в зависимости от уровня эффективности функционирования ТПС. Результаты позволяют проводить дифференцированную политику по мерам поддержки и стимулирования развития и управления распределительных сетей регионов, исходя из их уровня эффективности. Практическая реализация рекомендаций позволит сократить разрыв в уровне развития ТПС регионов.
Ключевые слова: товаропроводящая сеть; эффективность распределительнойсистемы товаров; торговля; логистическая инфраструктура; метод анализа данных DEA.

1. Introduction

The uneven development of the distribution network in different parts of the country leads to higher costs, lower efficiency of goods delivery and lower quality of service. The main reason for the uneven development of the distribution system is the low density and uneven location of trade, transport and logistics infrastructure across the country (Raimbekov et al., 2016).

In the western regions of Kazakhstan, where oil and gas are mostly produced, and in the northern regions, where agro-industrial products are produced, the volume of cargo turnover is much higher than in the central-eastern regions and the southern region. Simultaneously, if we look at the structure of retail trade by regions, we can see the opposite picture. The highest rates of retail turnover are in the south, including Almaty and the central-eastern region. The lowest indicators are in the northern and western regions. Commodity turnover unevenly develops, the difference between the highest indicator and the lowest is from 3 to 17 times (Agency for Strategic Planning of the Republic of Kazakhstan, 2020).

This indicates the existing problems in the functioning and effectiveness of the use of these infrastructures.

Due to the significant differentiation of the Republic of Kazakhstan economy by regions, the priority of these tasks in the regional projection is not the same. Therefore, it is important and relevant to monitor the main indicators of the development of distribution network efficiency in the regions, their comparative analysis and the choice of methods for generalizing evaluation for their optimal planning and support.

The current work assesses the effectiveness of the functioning and the corresponding typology of regional distribution systems of distribution network of Kazakhstan in terms of differentiated support for developing logistics infrastructure in the regions of Kazakhstan.

The difference in our study is also that we considered social, economic and environmental factors.

2. Brief Literature Review

The efficiency of the goods distribution system is important in the logistics system because it is this aspect that leads to significant losses: downtime of trade and transport infrastructure waiting for service, broken delivery dates, unsecured cargo and so on, and, as a consequence, to increased costs.

There are many methods and models for assessing the integral efficiency of various entities (enterprise, industry, region). Methods for assessing the development potential of the distribution infrastructure are investigated in (Vilko et al., 2011; Kugan, 2019). The method of Data Envelopment Analysis (DEA) (Charnes, W. W., 1994), which is used in various areas becomes a promising tool for analyzing the performance of various entities by a wide set of input and output indicators of their activities.

This also applies to the regional distribution network. Despite the existence of individual studies to assess the effectiveness of regional logistics distribution systems, they are poorly understood. Vaz, C. B., Camanho, A. S. (2012) investigates the efficiency of retail chains using the DEA method.

The method for analyzing the efficiency of the process of distribution of goods and services using various modifications of the DEA-analysis method and various input and output parameters is used in the works of Farsi et al. (2007); Tovar et al. (2011); Lau, Kwok (2013); Dano, F. (2014), Tang et al. (2015); Sun Qi, Liu Shifeng (2018); Izadikhah, M. (2019); Brzezinski et al. (2020). The studies explain the performance and effects of different areas: trade (Vaz et al., 2012), energy (Farsi, F., 2007), industry (Liu, Li, 2012); agriculture (Paul, Nehring, 2005); logistics service providers (Cagliano et al., 2017); e-retail suppliers (Shi Yong et al., 2017); electricity suppliers (Farsi et al. 2007); trade network efficiency (Brzezinski et al., 2020); and others. The proposed models combine operational indicators, quality indicators, and quantitative indicators (energy, warehousing, and transportation).

Andrejic et al. (2013) proposed the DEA model to measure the performance of commodity distribution centers (DCs). The modified DEA model using a series of evaluation indices is constructed to evaluate the performance of logistics services (Tang et al., 2015) and e-commerce logistics distribution center (Sun et al., 2017), performance evaluation and ranking of two-stage supply chains (supplier-producer) (Ang et al., 2019). The models have the advantages of handling uncertain or inaccurate input data. However, because of the large number of indicators describing DC performance, the main problem is the choice of indicators. Also, the model of Ang et al. (2019) is complex in terms of resources used and time and requires a large number of indicators.

Dixit et al. (2020) evaluated the efficiency of drug warehouses using DEA. The inputs are the volume and cost performance of the warehouse; the outputs are drug quantity, inventory turnover rate, and time efficiency. Based on the results, efficient and inefficient drug warehouses were identified and recommendations for improvement were given.

Cagliano et al. (2017) identified the main factors affecting the efficiency and productivity of logistics service providers (LSP) using regression analysis. Raimbekov et al. (2018) highlighted the main key factors of logistics infrastructure in Kazakhstan and assessed their impact on the economy using regression analysis. However, regression models do not allow determining the efficiency of the regions under study.

The review of the available works on assessing the effectiveness of the distribution network of goods and services allows us to state the insufficient development of methodological aspects of the study of the effectiveness of regional goods distribution activity, in particular:

1) methods for assessing the effectiveness of the regional distribution network from the perspective of a broad approach in regional, interregional and national levels of economy are not presented;
2) there is a limited object area of performance research - the predominance of the study of economic efficiency of micro-units - enterprises, industry.

The advantage of the DEA-analysis method is the calculation of a single aggregate performance indicator for each region without the use of weighting coefficients for the variables used in the analysis, as well as the ability to assess the effectiveness of the CDN of the region considering multiple types of resources and the volume of gross regional product or gross output, etc.

3. Purpose

The purpose of the study is to evaluate the effectiveness of distribution networks of the regions of Kazakhstan on the basis of the selected indicators and develop recommendations for their improvement.

4. Methodology and Data

Our research methodology consists of two parts: factor analysis and DEA analysis.

1) The purpose of factor analysis of data using the principal component method is to reduce and classify factors and to isolate the most important factors (Rummel, 1970).The entire factor analysis (FA) process consists of several stages:
   a) basic stages of factor analysis;
   b) calculation of the correlation matrix;
   c) factor extraction;
   d) factor selection and rotation;
   e) factor interpretation;
   f) calculation of factor values;
   g) model quality assessment.

2) The purpose of DEA data analysis is to evaluate the performance of the distribution system. The classical DEA approach (Charnes et al., 1994) is based on a linear programming method to find the optimal solution among a set of admissible ones.

Efficiency in DEA-analysis is defined as the ratio of the weighted sum of outputs (useful results of activity, for example, the gross value added of an industry) to the weighted sum of its inputs (consumed resources), which allows to classify objects as efficient only when they produce the largest outputs for the smallest inputs.

We have chosen the DEA method as a tool for evaluating the performance of the CDN distribution network. Often the DEA calculation is checked through the Malmquist index, which will also be presented next.

The model itself in DEA analysis is described as follows:

$$\sum_{j=1}^{s} \mu_j y_{jo} \to \max \tag{1}$$

at

$$\sum_{i=1}^{r} t_i x_i = 1; \quad \mu_j; t_i \geq 0. \tag{2}$$

where:
x_i - input indicators;
y_i - output indicators;
t_i - output weights;
μ_j - input and output indicators, respectively;
i - the number of units that are compared;
r - the number of input factors;
s - the number of output parameters.

To assess the dynamics of technological efficiency, an aggregate index such as the Malmquist index proposed by Malmquist (1953):

$$M_k = \left[\frac{\theta^k_{t+1}(x_{t+1}, y_{t+1})}{\theta^k_{t+1}(x_t, y_t)} \cdot \frac{\theta^k_t(x_{t+1}, y_{t+1})}{\theta^k_t(x_t, y_t)} \right]^{\frac{1}{2}}, \tag{3}$$

where:
M_k - the index of realization of the Malmquist - potential for the object;
k and $\theta^k_i(x_j, y_j)$ - the value of the technological efficiency of the object k, characterized by the vectors of costs and output of the moment j with respect to the technological set at the time i.

If an object j improves its performance, its Malmquist index will be greater than unity $(M_j > 1)$. Conversely, a Malmquist index value less than unity can be interpreted as a decrease in object performance (Fare, 1995).

For the FA, we used data from the Bureau of Statistics of the Republic of Kazakhstan for the period from 2000 to 2020.

At the first stage of our study, based on the purpose of the research, to characterize the object of research, we selected the following indicators from various literature sources (Table 1). The calculation of the correlation matrix for the variables involved in the analysis allowed us to exclude dependent (correlating) parameters, to select the most significant 16 factors (see Table 1).

The SPSS program was used for factor analysis. The software package EMS (Efficiency Measurement System) was used to calculate the DEA method.

Table 1:
Variables after exclusion of correlated parameters

N	Scores	Designation	Unit of measure	Full name of Variables
1	Indicators of economic activity (value indicators)	Y1	thousand tg	GRP per capita
		Y2	%	Share of GVA in GDP
		X1	%	Volume of sales of products and services in GDP
		X2	%	Share of commodity turnover in GDP%
		X3	billion tenge	Inventories in the retail network
		X4	%	Share of investment in trade, transport and warehousing, and communications in GDP
2	Economic indicators characterizing the scale of CDN (quantitative)	X5	billion tkm	Cargo turnover of all modes of transport
		X6	unit	Length of public roads
		X7	thousand units	Availability of motor vehicles
		X8	unit	Number of commodity exchanges
		X9	unit	Number of markets
		X10	sq.m.	Total selling and storage area
		X11	unit	The number of trading places in the markets
		X12	%	Share of Internet users in the total population
3	Environmental indicators	X13	%	Share of recycling and disposal of municipal waste
4	Social indicators	X14	man	Employment in the distribution of goods

Source: Compiled by the authors based on data from the Bureau of National Statistics of the Republic of Kazakhstan (2021)

5. Results

5.1. Results of factor analysis

In the first stage of our study, the significance of the indicators was assessed and insignificant factors were excluded (Table 2 presents the results of the assessment of significant correlation indicators at the 0.01 level).

The second step was to decide on the optimal number of factors using the principal component method.

Table 3 shows the eigenvalues obtained from the factor analysis analyzed for 16 variables for the years 2000-2020. The factor analysis of the correlation matrix selected the groups of factors in which the variables have variance and eigenvalues greater than one. Two groups of factors were selected. As you can see from Table 3, the total percentage of variance explained by the first factors is 80.946 and with the second factors -88.96%, which is high.

The eigenvalues of the factors in the first group of factors amounted to 12.951, the percentage variability of which was 80.9%, i.e. the influence of the variables in this group of factors is large. Then, the value of the second group of factors fell sharply to 1.282, and its variability was 8.04%. That is, the variables in these two groups of factors accounted for 88.96% of 100% and they had to have an overall estimated effect, while the influence of other groups of factors was low or unchanged (Table 3). In what follows, we will use the influence of these two groups of factors on the efficiency of the distribution system.

The test of internal consistency of the characteristics under study using Cronbach's alpha test (G. Chelsea, 2015) showed high reliability of the indicators with the coefficient - 0.813 (Table 3). The Kaiser-Meyer-Olkin (KMO) criterion, equal to 0.788, shows high sample adequacy (Darton, 1980).

At the next stage, the calculation and analysis of factor loadings were conducted. Note that the original matrix of factor loadings did not allow us to identify a clear factor structure, so the Varimax rotation method was applied for a clearer interpretation of the solution. The correlation between a factor and a variable was considered a strong if the modulus of the factor loading took a value greater than 0.70. The results of the calculations are presented in Table 4.

Analysis of the data in Table 4 shows that the first, i.e. general, factor includes 12 variables with positive values of the correlation coefficient.

The first group of factors is associated with the scale of production of logistics infrastructure. Generally, the factor weight was 80.946%.The second group of factors characterizes the economic activity of the distribution network. Generally, the factor weight was 8.0%.

Thus, two important groups of factors were identified, namely:

Factors F1 (factors of production scale): The turnover of all types of transport; Length of public roads; Availability of vehicles; Number of Internet users per 100 people; Total retail space, sq.m.; Employment in the distribution of goods; Share of recycling and disposal of municipal waste.

Table 2:
Results of the correlation matrix of indicators of distribution network of Kazakhstan for the period 2000-2020

	У1	У2	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
У1	1	.862**	-.603**	.716**	.987**	-.860**	.965**	.666**	.879**	.485*	-.525**	.835**	.812**	.835**	.972**	.981**
У2	.862**	1	-.684**	.638**	.869**	-.811**	.845**	.480*	.724**	.537**	-.510**	.688**	.659**	.617**	.879**	.865**
X1	-.603**	-.684**	1	-0.145	-.585**	.694**	-.589**	-.441*	-.537**	-.506**	0.217	-.533**	-.564**	-.457*	-.682**	-.668**
X2	.716**	.638**	-0.145	1	.740**	-.475*	.742**	.429*	.628**	.617**	-.372*	.613**	.510**	.625**	.692**	.651**
X3	.987**	.869**	-.585**	.740**	1	-.858**	.930**	.575**	.816**	.487*	-.533**	.782**	.736**	.767**	.945**	.954**
X4	-.860**	-.811**	.694**	-.475*	-.858**	1	-.831**	-.520**	-.731**	-.380*	.449*	-.673**	-.681**	-.665**	-.837**	-.868**
X5	.965**	.845**	-.589**	.742**	.930**	-.831**	1	.788**	.949**	.534**	-.501*	.887**	.888**	.911**	.973**	.978**
X6	.666**	.480*	-.441*	.429*	.575**	-.520**	.788**	1	.913**	0.244	-0.301	.863**	.935**	.919**	.717**	.749**
X7	.879**	.724**	-.537**	.628**	.816**	-.731**	.949**	.913**	1	.380*	-.536**	.882**	.942**	.983**	.922**	.931**
X8	.485*	.537**	-.506**	.617**	.487*	-.380*	.534**	0.244	.380*	1	0.011	.415*	0.355	0.352	.554**	.472*
X9	-.525**	-.510**	0.217	-.372*	-.533**	.449*	-.501*	-0.301	-.536**	0.011	1	-0.170	-0.321	-.517**	-.576**	-.562**
X10	.835**	.688**	-.533**	.613**	.782**	-.673**	.887**	.863**	.882**	.415*	-0.170	1	.926**	.852**	.826**	.847**
X11	.812**	.659**	-.564**	.510**	.736**	-.681**	.888**	.935**	.942**	0.355	-0.321	.926**	1	.922**	.843**	.861**
X12	.835**	.617**	-.457*	.625**	.767**	-.665**	.911**	.919**	.983**	0.352	-.517**	.852**	.922**	1	.877**	.881**
X13	.972**	.879**	-.682**	.692**	.945**	-.837**	.973**	.717**	.922**	.554**	-.576**	.826**	.843**	.877**	1	.987**
X14	.981**	.865**	-.668**	.651**	.954**	-.868**	.978**	.749**	.931**	.472*	-.562**	.847**	.861**	.881**	.987**	1

Notes:
*. - The correlation is significant at the 0.05 level (bilateral).
**. - The correlation is significant at the 0.01 level (bilateral).
c. - List value N=2.

Source: Calculated by the authors based on quantitative data from the Bureau of National Statistics of the Republic of Kazakhstan (2021)

Table 3:
Eigenvalues of factor analysis

Factors	1	2	3	4	5	. . .	. . .	15	16
Eigenvalue	**12.951**	**1.282**	0.769	0.401	0.205			0.001	0.000
% variance	80.946	8.014	4.808	2.505	1.283			0.002	0.000
Cumulative %	80.946	**88.961**	93.769	96.274	97.558			100.0	100.0
Cronbach's Alpha coefficient	0.908	0.813	0.521	0.241	0.213			0.102	0.065

Source: Calculated based on data from the Bureau of National Statistics of the Republic of Kazakhstan (2021)

Table 4:
Rotated component matrix after Varimax rotation

Variables	Group of factors 1	Group of factors 1
GRP per capita	0.127	**0.961**
Cargo turnover of all modes of transport	**0.753**	0.050
Length of public roads	**0.955**	0.103
Availability of motor vehicles, thousand units	**0.924**	0.330
Number of Internet users per 100 people	**0.914**	0.340
Total sales area, sq.m.	**0.810**	0.228
Employment in the distribution of goods	**0.744**	0.245
Share of recycling and disposal of municipal waste	**0.701**	0.695
Share of GVA in GDP	0.332	**0.801**
Inventories in the retail network	0.278	**0.770**
Share of trade turnover in GDP	0.134	**0.740**
Share of investment in trade, transport and warehousing, communications	-0.241	**-0.752**

Source: Calculated based on data from the Bureau of National Statistics of the Republic of Kazakhstan (2021)

Factors F2 (factors of economic activity): GRP per capita; Share of GVA in GDP; Commodity stocks in the retail network; Share of commodity turnover in GDP; Share of investment in trade, transport and warehousing, communication.

After determining the two main groups of factors, we analyzed the relationship between these groups of factors and GRP (Table 5). GRP per capita is taken as the dependent variable, and the other variables remain independent variables. The calculations showed that the unit change in F1 and F2 increases GDP per capita by 443.125 and 135.110 units.

5.2. Analysis of CDN effectiveness using the DEA method

At the third stage was assessed the effectiveness of CDN using the DEA method.

The values of factors F1 and F2 from Table 4 were used to evaluate the effectiveness of CDN.

The input parameters used were Cargo turnover of all modes of transport, bln.tkm (X1); Share of commodity turnover in GDP (X2); Commodity stocks in retail network, bln.tkm (X3); Share of investment in trade, transport and storage, communications, % (X4); Length of roads, km (X6); Availability of motor vehicles, unit (X7); Total commercial and storage area, sq.m (X10); Share of Internet users in the total population (X12); Share of recycling and disposal of municipal waste, % (X13); Employment in trade and delivery of goods, people (X14).

The output parameters are GRP per capita, thousand tenge. (Y1); GVA share in GDP (Y2).

Table 6 shows the values of input and output data from the regions of Kazakhstan.

Table 5:
Regression analysis after factor analysis

Variable GRP	*GRP = β0 + β1 F1 + β2 F2*			
Variable		***std error***	***t-stat***	***prob***
F1	443.125	43.337	11.609	0.000
F2	135.110	43.365	10.225	0.000
β0	490.977	42.292	3.116	0.005
R-sq	0.929	*mean dependent var*		21.3236
Adj R-sq	0.914	*s.d. dependent var*		4.8091
S. E. of reg.	135.2321	*akaike info criterion*		11.0525
F-Stat	56.8825	*Durbin-Watson stat.*		2.6356
Prob F-stat	0.0005			

Source: Calculated by the authorsusing the SPSS program based on data from the Bureau of National Statistics the Republic of Kazakhstan (2021)

Table 6:
Statistics of the «input» and «output» variables of the DEA model for assessing the comparative effectiveness of CDNs

	Factors - F1							Factors - F2				
	X5	**X6**	**X7**	**X10**	**X12**	**X13**	**X14**	**X2**	**X3**	**X4**	**Y1**	**Y2**
Observation	21	21	21	21	21	21	21	21	21	21	21	21
Minimum	39.5	250.0	6831.0	157.9	63.0	8.6	5.7	14.7	13.2	16.9	1008.1	0.6
Maximum	825.6	11961	56505	1617.7	89.4	20.4	37.0	103.5	132.5	274.8	14584.4	1.4
Average	209.6	5715.3	27163	745.0	74.7	12.2	14.2	45.4	39.2	75.0	4085.6	0.9
Standard deviation	210.4	3456.5	12688	465.9	6.7	3.0	7.5	22.5	35.3	71.3	3239.6	0.2

Source: Calculated based on data from the Bureau of National Statistics of the Republic of Kazakhstan (2021)

Analysis of the results obtained by the DEA method

The ranking of the regions of Kazakhstan in terms of the quality of logistics development conditions and performance evaluation showed the following (Table 7).

The efficiency of CDN functioning in large regions (Almaty, Nur-Sultan, Mangistau region) is in the best conditions for developing trade logistics, which can be seen from the efficiency index equal to 100, or close to it. Zhambyl, Kyzylorda and Turkestan regions (15th-17th places) have the worst conditions in terms of efficiency, where efficiency is within 63%-69%. The remaining regions have intermediate values in terms of efficiency: Group 2 within 90%-95%, Group 3 within 81%-87%, Group 4 within 70%-80% and Group 5 within 60%-69% (Figure 1).

Analysis of data from the Bureau of Statistics of Kazakhstan and our calculations of CDN efficiency showed the following results:

Group 1 regions: Excellent conditions for logistics development: developed infrastructure (31%) with a large wholesale trade turnover (29%) and active freight traffic (28%) with a high level of investment in transport (30%). These regions are transshipment points with high storage volumes due to their favorable geographical location, as well as the main centers of extractive industries and consolidation centers;

Group 2 regions: The most favorable conditions for developing logistics: geographical location and developed transport networks are favorable for freight transport (27%), infrastructure is underdeveloped (16%) with an active turnover of wholesale trade (32%), the average rate of investment in transport (24%);

Group 3 regions: Average conditions for developing logistics: good transport accessibility, so the transportation of goods by road takes the first place of all groups (29%), actively developing infrastructure - fixed assets account for 25%, investments account for 19%;

Table 7:
Assessment of distribution network efficiency in the regions of Kazakhstan

Region/City	Rating	Efficiency of scale of production				Performance				The Malmquist Index	
		2018	2019	2020	Average	2018	2019	2020	Average	2019/2018	2020/2019
1 group of regions											
Almaty	1	100	100	100	100	100	100	100	100	1.00	1.01
Nur-Sultan	2	100	97.9	100	99.3	95.3	96.7	100.0	97.3	0.99	1.01
Mangistau	3	100	100	98.5	99.5	94.6	97.3	97.6	96.5	1.01	1.00
Medium		**100**	**99.3**	**99.5**	99.6	**96.6**	**98.0**	**99.2**	**97.9**	**1.00**	**1.01**
Group 2 regions											
Aktobe	4	95.6	94.3	100.0	96.6	91.3	90.8	92.3	91.5	0.95	1.01
Pavlodar	5	93.6	93.3	94.9	93.9	92.1	92.3	92.3	92.2	0.96	1.00
Almaty	6	94.9	93.5	94.8	94.4	88.2	89.1	88.3	88.5	0.99	0.98
West Kazakhstan	7	92.1	91.2	92.1	91.8	87.3	88.3	89.4	88.3	0.98	0.97
Medium		**94.1**	**93.1**	**95.5**	94.2	**89.7**	**90.1**	**90.6**	**90.1**	**0.97**	**0.99**
Group 3 regions											
Akmola	8	86.5	87.2	88.9	87.5	82.3	83.5	84.8	83.5	0.93	0.92
East Kazakhstan	9	87.3	87.6	88.2	87.7	83.2	84.3	83.0	83.5	0.99	0.98
Shymkent	10	86.3	85.2	87.8	86.4	81.3	82.3	83.1	82.2	0.96	0.95
Karaganda	11	87.3	85.3	85.3	86.0	80.3	82.3	84.3	82.3	0.99	0.98
North Kazakhstan	12	84	84.2	85.2	84.3	80.8	80.3	81.2	80.8	0.93	0.96
Medium		**86.2**	**85.9**	**87.1**	86.4	**81.6**	**82.5**	**83.3**	**82.5**	**0.96**	**0.96**
Group 4 regions											
Kostanay	13	76.2	77.1	79.2	77.5	69.4	72.8	75.6	72.6	0.95	0.95
Atyrau	14	74.2	76.5	78.5	76.4	68.1	71.4	70.5	70.0	0.91	0.89
Medium		**75.2**	**76.8**	**78.9**	77.0	**68.8**	**72.1**	**73.1**	**71.3**	**0.93**	**0.92**
Group 5 regions											
Zhambyl	15	71.2	69.2	67.8	69.4	67.8	65.2	65.2	66.1	0.88	0.87
Kyzylorda	16	72.3	67.2	66.5	68.7	62.7	61.3	62.3	62.1	0.88	0.86
Turkestan	17	70.3	68.2	64.3	67.6	60.9	61.8	59.4	60.7	0.85	0.84
Medium		**71.3**	**68.2**	**66.2**	68.6	**63.8**	**62.8**	**62.3**	**63.0**	**0.87**	**0.86**

Source: Calculated by the authors on the basis of quantitative data from the Bureau of National Statistics of the Republic of Kazakhstan

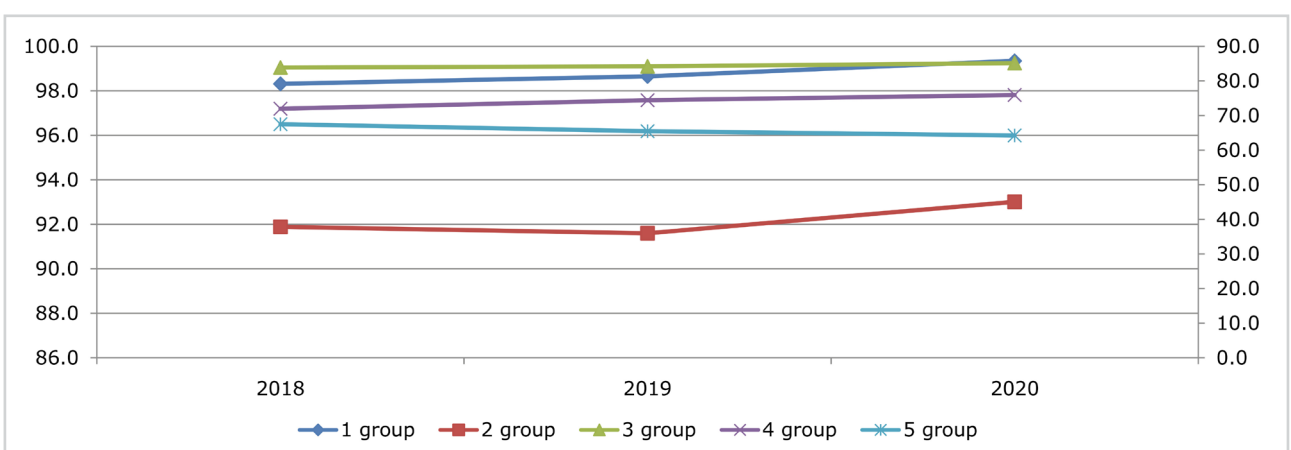

Figure 1:
Dynamics of change in the efficiency of functioning of the regional CDN in the Republic of Kazakhstan
Source: Data from the authors' study

Group 4 regions: Close to average conditions for logistics development: geographically located near economically developed neighboring regions, existing infrastructure is developing (17%), but not enough use of wholesale trade (10%) and transportation of goods (15%), investments account for 16%;

Group 5 regions: Underdeveloped conditions for the formation of logistics: the infrastructure is underdeveloped (11%) due to underloading of the regions with cargo (7%) and wholesale trade (8%), the production potential is average, investments -11%.

Table 7 shows that three regions out of seventeen were efficient; each of them corresponds to a high level of gross value added. In the second and third groups of regions, there is a slight increase in the absolute indicator of efficiency in both scale and economic indicators of efficiency compared to previous years.

In three regions (group 5), there is a decrease in the absolute efficiency indicator relative to the previous year.

The Malmquist index indicates the efficiency of the use and redistribution of funds between regions. Here, twelve regions have an index less than one, which indicates a decrease in the efficiency of resource use, the remaining five regions have an index equal to or greater than one. Based on these data, we can judge the effectiveness of regions and cities.

The contribution weights of the criteria to the system performance indicator and their reliability are shown in Table 8. The average weight of the evaluation indicators of the participating regions (μ) and the average weight of the reliability coefficient $(\mu(\Theta = 1))$ were calculated based on the current state of the distribution network.

Table 8 shows that the largest increases occurred in the number of Internet users and Merchandise inventory in the retail network.

The largest shares are Investment in Transportation (0.28), Share of Turnover in GDP (0.10), Area of Distribution Networks (0.11), Cargo Turnover (0.08), Merchandise Inventory (0.12), Number of Internet Users (0.10). Less influential is Length of Roads (0.04), Employment (0.05), Share of Processing and Recycling (0.08).

Thus, investments primarily influenced by logistics performance (gross value added of transport and trade) in transport and warehousing, the volume of goods turnover and freight transportation, the area of distribution systems and commodity stocks.

The low average weight of industry employment and length of roads means that for most of the logistics area, human resources and road use are negligible, so their weight value will be low.

It is also possible to determine the percentage contribution of each region to the overall «inefficiency».

Based on the DEA-analysis, we conclude that we must pay more attention to investment in fixed assets and their use, the use of employees, the volume of transportation, inventory and space to increase the economic efficiency of the CDN.

The Malmquist index, which characterizes the efficiency of the use of resources, is positive in 5 regions, for the same period GVA in these regions was growing. In 12 regions, the index is less than one, which indicates a decrease in the efficiency of resource use in these regions.

The results of the work can be applied in determining the priorities of regional policy for developing logistics and trade infrastructure. In particular, in regions with low CDN efficiency, it is necessary to conduct additional research on the feasibility of public investment in this sector.

Table 8:
Average weight of input criteria evaluation indicators

Criteria	2018 (medium)		2019 (medium)		2020 (medium)		Average for 3 years	
	μ	$\mu(\Theta = 1)$	μ	$\mu(\Theta = 1)$	μ	$\mu(\Theta = 1)$	μ	$\mu(\Theta = 1)$
Share of trade turnover in GDP	0.09	0.21	0.11	0.24	0.10	0.23	0.10	0.41
Inventories in the retail network	0.09	0.29	0.13	0.35	0.14	0.32	0.12	0.39
Share of investment in GDP	0.30	0.83	0.29	0.78	0.26	0.83	0.28	0.81
Cargo turnover	0.08	0.21	0.08	0.17	0.07	0.23	0.08	0.35
Length of roads	0.06	0.18	0.04	0.32	0.03	0.38	0.04	0.35
Availability of motor vehicles	0.04	0.41	0.03	0.33	0.03	0.39	0.03	0.38
Retail and warehouse space	0.11	0.62	0.11	0.61	0.10	0.67	0.11	0.28
Share of Internet users	0.09	0.21	0.08	0.19	0.13	0.18	0.10	0.19
Share of recycling and disposal of municipal waste	0.08	0.16	0.07	0.13	0.09	0.17	0.08	0.15
Employment	0.06	0.15	0.06	0.11	0.05	0.13	0.06	0.13
Total:	1.00		1.00		1.00		1.00	

Source: Calculated by the authors

6. Discussion

DEA-analysis allowed us to devise the main conclusions in the context of this research study.

We have established indicators for assessing the performance of the regional CDN. Many indicators are used in previous studies before us (Dano, 2014, Izadikhah et al., 2019, Brzezinsk, 2020), but we additionally investigated social, environmental and economic factors.

The research allowed us to obtain a single performance indicator that considers many different input and output parameters of distribution networks in the regions.

We confirmed the positive relationship between the macroeconomic indicator (GVA share in GDP) and the study groups of factors (F1 and F2) (Figure 1).

This fact confirms the truth from economic theory that economies of scale work up to a certain period, then, with the subsequent returns go down or remain unchanged. Here, to increase the

efficiency of the distribution network, we should increase investment and use innovative technologies (blockchain, digitalization, intelligent systems, etc.).

We have established a correlation between the indicators of the regional distribution network and their efficiency of operation. In 2020, two of the 17 regions became effective (in 2019 one region was technically effective, in 2018 - two regions). Among them are Almaty, Nur-Sultan, and Mangistau region. Three regions had a decrease in efficiency (Zhambyl, Kyzylorda and Turkestan regions). In other regions there was a slight increase in performance.

The Malmquist index, confirms the presence of higher rates of technical development of regions with a high level of development of macroeconomic indicators compared to the regions-outsiders (Table 7).

The index of efficiency of the scale of production was higher than the efficiency of activity in all regions. It is consistent with research that the effect of returns to scale is greater than the effect of returns on economic activity (Paul, 2005, Liu, 2012, Andrejic, 2013).

Large regional CDN (group 1 and 2) have a high level of development of distribution systems compared to other regions of Kazakhstan and, accordingly, have a high positive return on scale. This statement is consistent with many studies on the overall positive increasing returns of large entities (banks, enterprises, distribution center stores (Tang et al., 2005, Vaz,2012).

We also found that there was an increase in the efficiency of scale factors in the regions with a higher level of development (Group 1 and 2), while in the inefficient regions (Group 4 and 5) there was a decrease (Table 7).

The efficiency difference between Group 1 and Group 5 regions is 25% (1.1 and 0.88), and the growth rate of factor productivity between the best and worst groups of regions increased from 14.9% to 27.9% between 2017 and 2020, indicating even greater unevenness in distribution network development.

We confirmed that the greatest influence on the efficiency of CDN has investments, areas, inventories (by their specific weight), which is consistent with the research of the authors Andrejic (2013), Raimbekov et al. (2018), Brzezinski (2020). Simultaneously, we identified other factors: the greatest influence of the share of the population using the Internet, mobile applications, which indicates their importance in the development of distribution networks.

The main empirical results are as follows.

1. Estimates of the level of technological efficiency of national economies are consistent with the conclusion on the ranking of regions by the degree of infrastructure development presented in earlier studies (Raimbekov, 2016 and 2018).

The regions with the developed and developing CDNs show greater dynamism in the technological development of the first and second groups of regions compared to the rest of the regions. Thus, for the first group of regions, the growth rate of the benchmark the Malmquist index for the period 2017-2020 was 1.0%, while the second group was 2.1%, while the fourth and fifth groups of regions decreased by 1.07 and 1.15%, respectively.

2. The analysis of CDN of the regions of the Republic of Kazakhstan, which comprehensively considers the efficiency of the use resources, has revealed different positions of the regions from highly efficient to low-efficient. Large cities and regions of Kazakhstan are positioned as highly efficient. A common negative feature of CDN in the regional economy was noted - low economic indicators compared with the scale of production. The CDN of two regions (group 1 and 2) is distinguished by high efficiency of the scale of production and efficiency of economic activity.

The results allow us to speak about the possibility of using the DEA method along with the modification of the data under study, both in the primary economic analysis in the preliminary preparation of projects for developing regional distribution networks, and in the process of current monitoring of the dynamics of their performance, considering trade, transport and logistics indicators.

The results of the analysis can be used in planning the development of regional CDN.

7. Conclusion

Formed and proposed a system of indicators necessary for an objective assessment of the effectiveness of the regional commodity distribution system.

Assessment of the effectiveness of CDN development in the regions of Kazakhstan by the method of DEA-analysis allowed the classification and ranking of regions in terms of economic efficiency and scale of activity.

The most important factors influencing the efficiency of the CDN are highlighted. For a country with a huge territory with sparsely populated regions with low density and, accordingly, uneven development and low density of the infrastructure of the commodity distribution network, the important factors are investments in infrastructure, goods turnover and cargo turnover, the value of inventory and retail space, the number of Internet and mobile app users, the length of roads, employment, the share of recycling and waste disposal.

Recommendations for assessing the effectiveness allow to identify the distribution of regions, reflecting the prospects of development of logistics infrastructure of the commodity supply chain, which allows to propose a differentiated state policy for developing CDN with the participation of business and in the future - development of indicative plans, improve planning and management tasks of supply chains in the CDN.

Regions should first improve large-scale indicators to improve the quality of service, then to increase the indicators of economic activity by the experience of developed countries. This also applies primarily to regions with medium and low CDN efficiency with the provision of preferential investment, incentives for producers and trade through the provision of subsidies or tax reductions, etc.

In this regard, we wanted to outline the following areas of problem solving

- uneven development and placement of transport, logistics, trade and distribution network in major regions and cities require planning and regulation of them at the state level in Kazakhstan, rather than at the regional level, which will require differentiation in the distribution of investment in infrastructure development;
- increasing the efficiency of CDN requires an integrated approach to the provision of quality logistics services, optimization and management of goods movement processes by increasing the number of logistics trade distribution centers, their optimal location by service areas, the use of digital technologies.

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