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Management of Reengineering of Business Processes of the Transport System Enterprises at Freight Transportation

Gestión de reingeniería en los procesos de negogio de empresas del sistema de transporte de carga

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Abstract

The study provides a comprehensive approach to reengineering business processes in transport system enterprises, which can help improve the efficiency and effectiveness of cargo transportation services. The purpose of this article is to consider the structural elements of management that provide reengineering of business processes of transport system enterprises in freight transportation. A comprehensive approach to the assessment of structural elements of management was developed. They form the functional flows of business process reengineering by transport system enterprises using simulation modeling and determine scenarios of quality freight, according to indicators that characterize the parameters of their effectiveness. The mathematical basis for the construction of a simulation model of scenarios for the reengineering of business processes of enterprises based on structural elements of management is substantiated. The model of the formation of the system of functional flows of management in the reengineering of business processes of enterprises is presented. The method of calculating indicators of the dynamic state of functional flows during the reengineering of business processes as structural elements of enterprise management are determined. The volume of rendering of cargo transportation services by the enterprises of the transport system of Ukraine is analyzed.

Keywords: management, business process reengineering, enterprises, transport system, freight transportation.

Resumen

El estudio provee un acercamiento a la reingeniería de procesos de negocio en empresas del sistema de transporte, a fin de ayudar a mejorar la eficiencia de servicios de transporte de carga, con el objetivo de considerar los elementos estructurales que proporciona la reingeniería de procesos de negocio de empresas en el transporte de mercancías. Para ello, presentamos una evaluación de los elementos estructurales del tema, en tanto forman los

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flujos funcionales de la reingeniería de procesos de negocio de las empreasas de transporte mediante modelos de simulación, determinando escenarios de calidad del transporte según indicadores que caracterizan los parámetros de su eficacia. Fundamentamos una base matemática para la construcción de un modelo de simulación de escenarios para la reingeniería de procesos de negocio basados en elementos estructurales de gestión. Además, presentamos el modelo de formación del sistema de flujos funcionales de gestión en el tema; determinamos el método para calcular los indicadores de los flujos funcionales durante la reingeniería de los procesos de negocio como elementos estructurales de la gestión empresarial, y finalmente, analizamos el volumen de prestación de servicios de transporte de carga en Ucrania.

Palabras clave: gestión, reingeniería de procesos de negocio, empresas, sistema de transporte, transporte de carga.

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Introduction

Modern changes in the functioning of enterprises are due to the need to adapt to the specific needs of a particular consumer, and the significant spread of computer and information technology. These features of modern management cause an objective need to rethink ways of building business processes and use fundamentally different approaches to the implementation of new programs and technologies, taking into account human resources. In this regard, the system of business process reengineering is of particular interest in solving the problem of creating efficient and cost-effective forms of business organization, as it opens wide opportunities for acquiring unique competencies and forming a sustainable management system.

With an unstable and uncertain external and internal environment, a dynamic consumer market necessitates increased competition and increased consumer demand for business services. Under these conditions, companies need to be more flexible, and move to clear and effective management processes with a systematic and high-quality structure of service delivery to meet customer requirements (Periokaitė and Dobrovolskienė, 2021). In addition, the implementation of business process reengineering by forming a special mechanism that would adapt the management of enterprises to radical changes in the formation of the cost and value of services provided for the transportation of products (goods), requires new tools to effectively ensure the economic parameters of their performance, focused on the stability of obtaining a positive effect. That is, with an emphasis on the transport and logistics sphere of activity and satisfaction of individual requests in the chain "supplier – consumer" reengineering of business processes in enterprises allows attracting and reproducing resources for logistics, recruitment, development of new and improvement of existing services, legal maintenance, warehousing, repackaging, storage, repair of rolling stock, forwarding, etc. (Krawczyk, 2022).

At the same time, the development and implementation of a set of measures for the redesign of certain key business processes in the current reengineering are aimed at standardizing service systems at the stage of increasing the performance of enterprises, which is characterized by a crisis. To ensure its minimization for increasing the level of profitability and financial strength the enterprises should be adapted to the new reengineering system in a set of measures that allow the identification of joint business processes in a holistic management system, in which control, monitoring, and evaluation of negative environmental factors to stabilize the competitiveness of entities have the key role.

Theoretical and methodical bases of formation and realization of management of business processes of the enterprises are considered in the research of many scientists, such as Dobson (2003), Irani *et al.* (2000), Kopp (2001), Lee *et al.* (2001), and Makin *et al.* (1997). Arora and Kumar (2000) in their study emphasized the importance of enterprise integration and how advances in information technology can make achieving integration feasible even in complex systems and proposed the use of Petrinets, tools for simulating complex systems, to optimize supply chains iteratively. Eto (2001) explored the concepts of public and private sector services through semantic and judicial case analyses, drawing from successful experiences of total quality management and business process reengineering, as well as classical ideas of human rights, citizens' sovereignty, and public services.

The study of the effectiveness of the reengineering system for redesigned business processes of enterprises by comparing the cost and production cost of services in economic projects was made by: Paik and Bagchi (2000), Remenyi and Heafield (1996), Sandberg (2001), Sohmen (1998), and Rajala *et al.* (1997) explored the use of simulation modeling and value analysis methodologies for managing business process variation, both retrospectively and prospectively, and provided worked-out examples to show how these techniques can be applied in traditional manufacturing process control and business process reengineering. Rory (1997) investigated the drivers and approaches to creating knowledge-based organizations from the perspective of practitioners responsible for implementing knowledge management as a business strategy. The author concluded that successful knowledge management implementation is mainly related to "soft" issues such as organizational culture and people, and most organizations try to use knowledge management tools and techniques effectively (Rory, 1997). Siew and S. Boon (1996) studied the management control issues that arise from business process reengineering and the evolution of management control functions in a reengineered organization. The study highlights the challenges that managers face in adjusting other organizational elements to facilitate the proper operations of such controls and emphasizes the importance of effective project management in implementing business process reengineering.

The study of the processes of transformation of economic systems, reorganization of business processes, and information bases of their modeling was made by: Dooley and Johnson (2001), Harris (1997), Kliem (2000), Koubarakis and Plexousakis (1999), McClennen and Ingersoll (1997), Paik and Bagchi (2000), and Corbitt *et al.* (2000) explored the use of Group Decision Support Software as an alternative to traditional business process redesign approaches. Hitt *et al.* (1998) provided an overview of the evolution of research in strategic management, from early single case studies to recent resource-based views of the firm using smaller sample studies. The study highlights the addition of environmental determinants and strategic choice as research foci, along with the use of larger, multi-industry firm samples. Hoskisson *et al.* (1999) highlighted the contributions of transaction costs economics and agency theory to strategic management and more recent theoretical frameworks, including the resource-based view of the firm, strategic leadership, strategic decision theory, and knowledge-based view of the firm. Linton and Walsh (2008) introduced the "research value-added" process developed and used at Sandia National Laboratories, which integrates technology description, the dual process model of innovation, and a product introduction model for idea generation and opportunity recognition. The study also presents the application of the model to potentially disruptive or sustaining technology developments from a research laboratory and highlights the generalizability of the research value-added process to both disruptive and sustaining technologies (Linton and Walsh, 2008).

However, scientific papers do not pay enough attention to the organization of management in the reengineering system, which would determine the dynamic features of the functionality of business processes with the construction of the most effective routes of their functional flows. The priority of our study is to develop a comprehensive approach to assessing the structural elements of management that form functional flows of business process reengineering by transport system enterprises and using simulation modeling to determine scenarios of quality freight with the indicators that characterize the parameters of their effectiveness.

Materials and methods

The economic substantiation of expediency of the application of various variants of the organization of management of business processes requires carrying out the quantitative analysis which would prove the efficiency of their realization within the limits of reengineering (Telnov, 2004). At the same time, all major business processes of enterprises should be changed as a priority for the reorganization of the management organization, such as sales management (review and ordering), technical preparation of production, direct production, logistics system, service and warranty service. That is, these are the business processes that create a cost chain—in other words, the cost of transport services. Building an effective model of business process reengineering management allows changing the production system, and the able to respond flexibly to changes in the market environment.

The main business processes are carriers of value creation (form production cost) of the functional flow, which is necessary for services through the main flows of operations. At the same time, each of the business processes interacts both horizontally and vertically with the management top of the management structure in the system reengineering of transport enterprises (Kharlamov et al., 2014). In this case, such processes are almost equally stretched both horizontally and vertically. If the so-called "horizontalization" of the business process is a prototype of a clear organizational and technological structure, the "verticalization" is, above all, a significant slowdown in the process due to unnecessary control and approval procedures with the management of related departments of transport enterprises (Sergeeva, 2008).

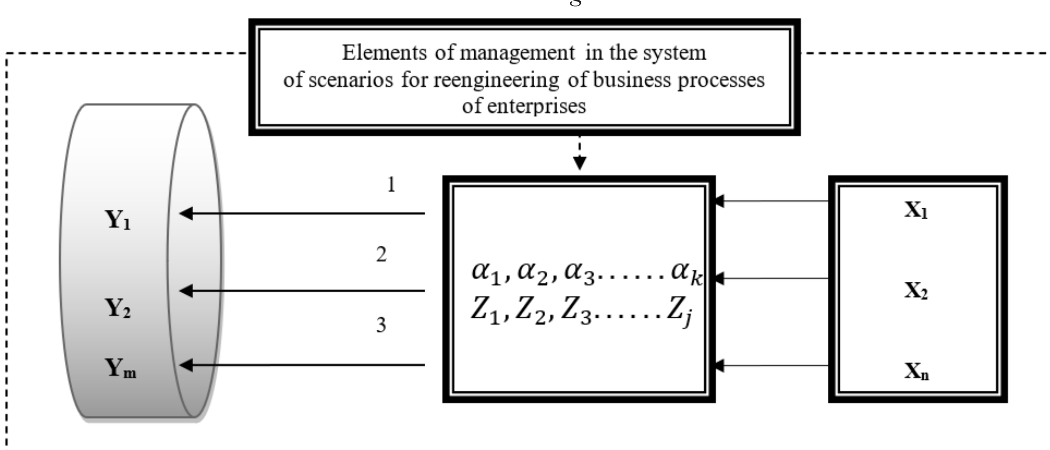
The study suggests a normative methodology for the economic evaluation of various methods of business process management. Prioritizing modifications to the important business activities that form a cost chain for transportation services is the most efficient way to restructure management. The paper suggests a functional method for analyzing management's structural components and functional flow routing. The model assesses the mobility of functional flows and the complexity of business process routes using a simulation-based methodology. The methodology, according to the authors, can be used to assess both sustaining and disruptive technology and services.

In the functional approach, the elements of management in a holistic system of reengineering of business processes of the enterprise for each structural component are assigned to some responsibilities, which form the criteria for the successful operation of service and service providers. At the same time, the horizontal connections between the elements of management are significantly weakened, but the vertical scheme of management is strengthened, which embodies the "management system of business process reengineering" and the "managed system of business process reengineering". To determine the boundaries of functional flows in the system of business process reengineering, the homogeneity of the specific structure of flows by their "input" and "output" from the system is used. If the output of functional flows for all interrelated operations is reduced to a single unit of management, such as an order, then their combination can create a business process that can be managed as a whole. The ideal situation is when one business process combines the whole chain of operations for one type of activity to create added value, which is quite possible with simple nomenclature services in the functional flow system (Bekbauov *et al*., 2017).

To determine the peculiarities of the business process, a comprehensive approach to assessing the structural elements of management based on business process reengineering is proposed. The system will be considered an organizational mechanism of action of management elements based on the reengineering of business processes of enterprises, which creates a holistic unity and has common operating conditions. The simplest simulation model of management elements in the system of reengineering of business processes of enterprises is as follows (Figure 1).

Figure 1. Simulation model of scenarios of business process reengineering of enterprises by structural elements of management

Figura 1. Modelo de simulación de escenarios de reingeniería de procesos de negocio de empresas por elementos estructurales de gestión



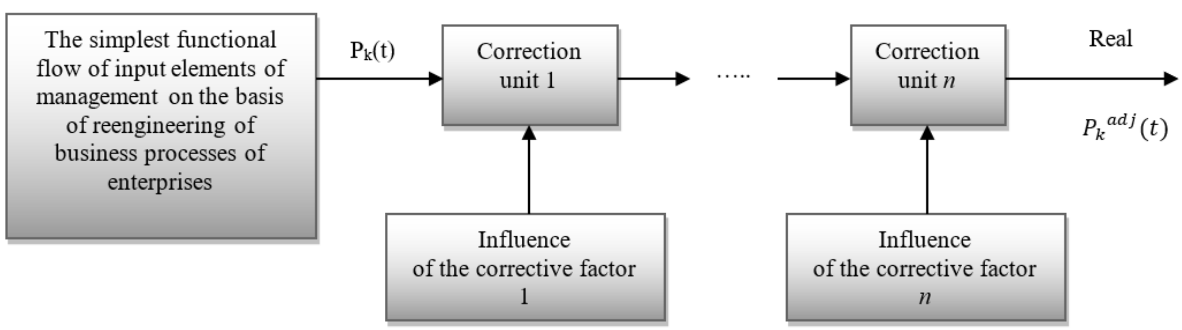
Source: own elaboration according to Kobelev (2003), Kulikov and Konev (2006), and Runova (2008).
Fuente: elaboración propia en base a Kobelev (2003), Kulikov y Konev (2006) y Runova (2008).

Elements X_1, X_2,... X_n are inputs to the management system of business process reengineering of enterprises, respectively elements Y_1, Y_2,... Y_m – outputs (output variables), Z_1, Z_2, Z_3... Z_j characterize the state of the management system based on business process reengineering of enterprises, and α_1, α_2, α_3... α_k– are its parameters. Inputs and outputs communicate with the external environment, i.e. with other business processes. The states of the management system based on the reengineering of business processes of enterprises record all the changes that occur due to the action of input signals (Runova, 2008; Ivanova, 2010). At the same time, the use of homogeneous functional flows based on business process reengineering is impractical, because the final modeling result creates erroneous conclusions about the quality of service delivery. If the functional flow of input elements of the business process is considered non-stationary and heterogeneous, the calculation will be more accurate, because such a flow needs to be transformed, taking into account the necessary factors such as seasonality, cyclicality, and others.

The model of formation of the functional flow system according to the input elements of management based on business process reengineering of enterprises are components of the blocks of correction of cyclical provision of services in the chain "supplier – consumer" (Figure 2).

Figure 2. Model of formation of the system of functional flows of management based on reengineering of business processes of enterprises

Figura 2. Modelo de formación del sistema de flujos funcionales de gestión basado en la reingeniería de los procesos de negocio empresarial



Source: own elaboration according to Kobelev (2003), Kulikov and Konev (2006), Runova (2008) and Ivanova (2010). Fuente: elaboración propia en base a Kobelev (2003), Kulikov y Konev (2006), Runova (2008) e Ivanova (2010).

The initial simplest functional flow of input elements $P_k(t)$ is the Poisson flow, in which the probability of an event is determined by the following dependence (formula (1)) (Kobelev, 2003):

$$P_k(t) = \frac{(\lambda t)^k}{k} \times e^{-\lambda t} \quad (1)$$

basis of the natural logarithm; λt– the average number of orders for services for the time interval t; k– the actual number of orders for services for a time interval t.

The correction factor blocks should affect the value of the parameters λ and k so that the adjusted probability $P_k^{adj}(t)$ has the formula (2):

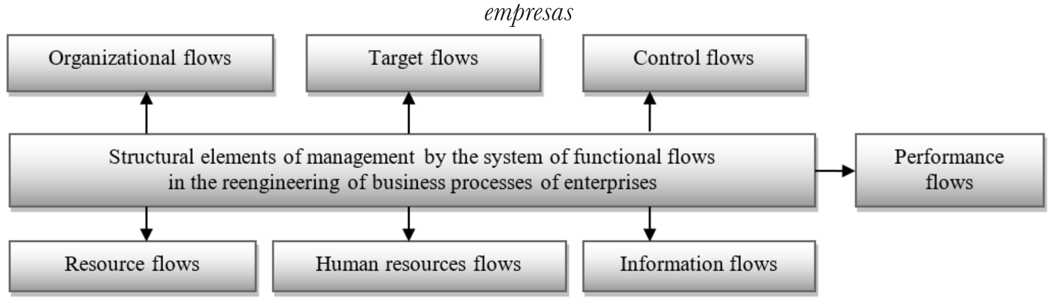
$$P_k^{adj}(t) = Y[P_k(t), \gamma_1 \ldots \gamma_n] \quad (2)$$

where, λ – the magnitude of the impact of the corrective factor on the actual functional flow of input elements of the business process, their number varies from 1 to n.

It should be noted that the interval of the input functional flow should take into account the period during which any changes in the signals from the numerous transport services take place. The input elements of other main business processes of enterprises can also be simulated: electronic documents for business service processes, logistics for business processes to ensure the safety and security of goods, consumer products, logistics business processes, and more. Business modeling divides functional flows based on the reengineering of business processes of enterprises by structural elements of management (Figure 3).

Figure 3. Business modeling of functional flows based on reengineering of business processes of enterprises

Figura 3. Modelado de negocios de flujos funcionales basado en la reingeniería de proesos de negocio en las empresas



Source: own elaboration according to Kobelev (2003), Kulikov and Konev (2006), Runova (2008) and Ivanova (2010). Fuente: elaboración propia en base a Kobelev (2003), Kulikov y Konev (2006), Runova (2008) e Ivanova (2010).

The speed of the functional flow, as well as input flow, can be expressed in terms of the number of signals (functions) per time unit, i.e. the number of performed (passed by flow) reengineering functions in the business process per time unit. We should note that each function of business process reengineering should be performed in the specified order of priority of their sequential location, so as not to interrupt the functional flow. In its simplest form, the speed of the functional flow is determined by the formula (3) (Ivanova, 2010).

$$S_{ff} = \frac{n_{pf}}{T} \quad (3)$$

where, n_{pf} – the number of consecutive functions in the business process; T – regulatory time interval, i.e. one that is determined by the regulations and provides the full implementation of business process reengineering functions during this interval.

Note that the maximum speed is the speed of functional flow, in which the number of consecutively performed reengineering functions per interval T is equal to the total number of functions in the total set of business processes. Note that the successful and timely implementation of the sequence of reengineering functions in business processes depends on the routing of functional flows, i.e. the routes (trajectory) of their movement, provided by the established management organization for the provision of services by enterprises. Routing of functional management flows based on enterprise reengineering indicates the total number of components of the business process, including connections and directions between them. It is clear that if the number of these elements and connections increases, the complexity of the route of functional flows will increase too (Ivashchenko *et al.*, 2004; Naumov and Khairulin, 2009). At the same time, there is a need to quantify the potential value of functional flows in order to form clear criteria for ranking business process routes according to the level of complexity and determine the impact of route complexity and speed of function flows (Stepanchuk *et al.*, 2017).

It is proposed to determine the complexity (potential value) of the route on the following indicators: the number of subjects of responsibility (functional barriers) in the business process; the total number of functions that make up the functional flow of the business process; the number of untimely functions, i.e. those that inhibit the speed of the total functional flow; the number of movements of objects (products, auxiliary materials, documents) within the business process. To determine the complexity of the functional flow route, it is proposed to introduce an intermediate coefficient of delay of the function (K_df), calculated by the formula (4) (Ivashchenko et al., 2004; Skorokhod et al., 1994; Naumov and Khairulin, 2009):

$$K_{df} = \frac{n}{N}, \qquad (4)$$

where, n – the number of untimely functions in one business process, i.e. those that are not performed within the time specified by the regulations; N – the total number of functions in the business process.

The number of movements of objects from one entity to another, combined with the number of entities involved in the process, provide information on the possible delay in the length of the business process cycle. Therefore, it is proposed to calculate an intermediate coefficient that shows the relative characteristics of the frequency of movement (K_sm) of business process objects in the subjects of responsibility (formula (5)) (Ivashchenko et al., 2004; Naumov and Khairulin, 2009; Stepanchuk *et al.*, 2016):

$$K_{sm} = \frac{L}{W}, \qquad (5)$$

where L – the total number of movements of objects in all subjects of responsibility; W – the number of subjects of responsibility.

Therefore, the integrated coefficient of complexity of the functional flow route according to the structural elements of management on the basis of reengineering of business processes of enterprises is as follows formula (6) (Ivashchenko *et al.*, 2004; Naumov and Khairulin, 2009):

$$K_{crff} = K_{df} \times K_{sm}, \quad (6)$$

Reconciliation of input and output functional flows can be carried out both schematically (business process diagrams developed during the movement of flows) and in the form of tables (special tabular forms), which determine the criteria basis of indicators of dynamic state of functional flows in management system based on reengineering of business processes of enterprises (Table 1).

Table 1. Indicators of the dynamic state of functional flows during the reengineering of business processes as structural elements of enterprise management
Tabla 1. Indicadores del estado dinámico de los flujos funcionales durante la reingeniería de proceso de negocio como elementos estructurales de la gestión empresarial

Name of the indicator, the principle of calculation	**Criteria base of indicators**
Functional flow rate (S_{ff})	$S_{ff} \rightarrow max$ Note. The maximum can be considered the speed of the functional flow, in which the number of consecutive functions for a certain time interval is equal to the total number of functions in the business process.
Complexity of the functional flow route (K_{crff})	$1.7 \leq K_{crff} \leq 2.1$ – unsatisfactory complex route of functional flow. $1.4 \leq K_{crff} \leq 1.69$ – route of medium complexity of functional flow. $1 \leq K_{crff} \leq 1.39$ – satisfactory functional flow route.

Source: own elaboration according to Ivashchenko *et al*. (2004), Naumov and Khairulin (2009) and Kamennova *et al*. (2002). Fuente: elaboración propia en base a Ivashchenko *et al*. (2004), Naumov y Khairulin (2009) y Kamennova *et al*. (2002).

Thus, the functioning of the main service business processes of enterprises in assessing the elements of management in the reengineering system is possible through a simulation model taking into account all factors that inhibit the cyclical nature of logistics and logistics services for moving goods and products. At the same time, the introduction of business process reengineering allows calculating the local movement of objects, interconnecting the fragmentary management functions to improve the effect of successive changes in the elements of the reengineering system, which does not lose its integrity. All changes in the structural elements of management should be comprehensive, taking into account the general parameters of the business process reengineering system.

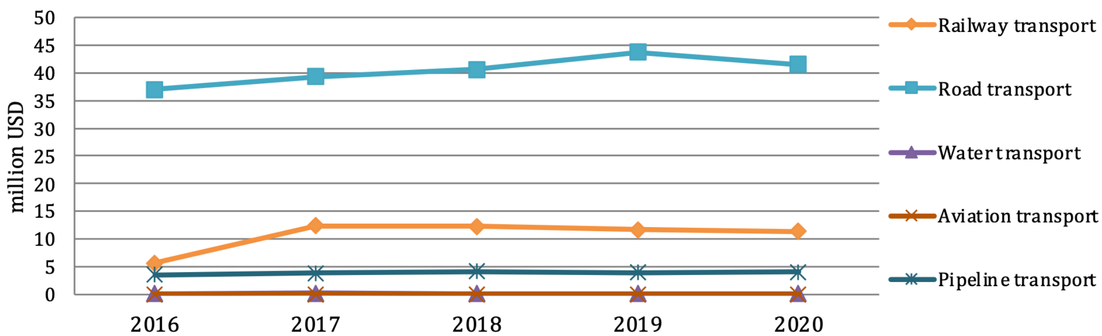
Results and discussion

Today, the Ukrainian transport system needs to reformat all major processes and restructuring in order to achieve sustainable economic growth, in particular through the introduction of information management, logistics, and transport services, as well as expanding the range of consumers in Ukrainian and foreign markets. This requires increasing the efficiency of transport enterprises and the market value of integrated transport and logistics services. Safe and high-quality transport services affect the efficiency of the functioning and development of production, business, and social sphere. Transport enterprises provide economic growth; increase the competitiveness of the state economy and quality of life. At the same time, process-oriented management of transport enterprises as a new organizational form of management based on business process reengineering is due to analytical studies of transport enterprises in order to change customer service and provide quality services.

Thus, in 2016-2020, the volume of sales of services by enterprises of the transport system tends to increase (Figure 4). The volume of services provided by land modes of transport (road and rail) and pipeline during this period has increased 2.0 times. In 2020, water transport enterprises received profits from the transportation of goods by 34.26 million USD more than in 2016 and 31.79 million USD more than in 2018.

Figure 4. The volume of services provided for the transportation of goods by enterprises of the transport system of Ukraine for 2016-2020, million USD

Figura 4. Volumen de servicios prestados para el transporte de mercancías por empresas del sistema de transporte

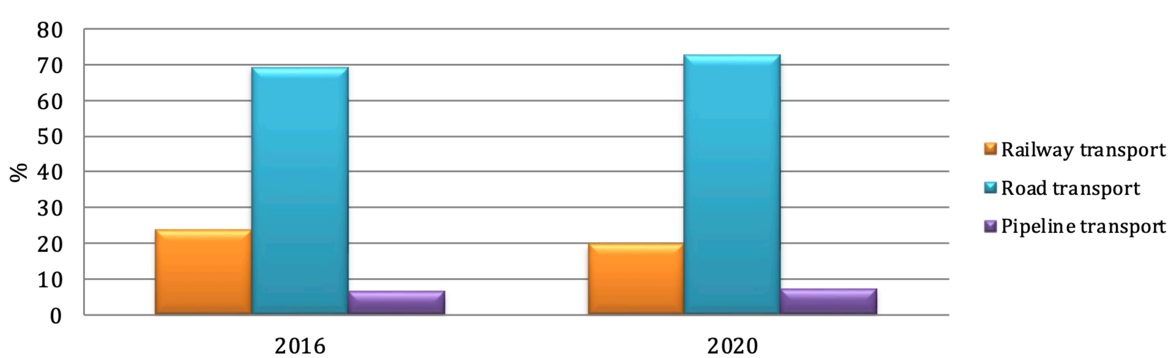


Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

In 2020, the volume of cargo transportation by road compared to 2016 increased by 12.3% and pipeline by 16.5%. The number of rail transportation decreased during the study period by 10.6% (Figure 5). In general, there is a general tendency to reduce transportation in Ukraine.

Figure 5. Structure of provided services for cargo transportation of enterprises of railway, automobile and pipeline transport system of Ukraine for 2016-2020, million USD

Figura 5. Estructura de los servicios prestados para el transporte de carga de las empresas del sistema de transporte ferroviario, automovilístico y por tuberías de Ucrania, en millones de dólares

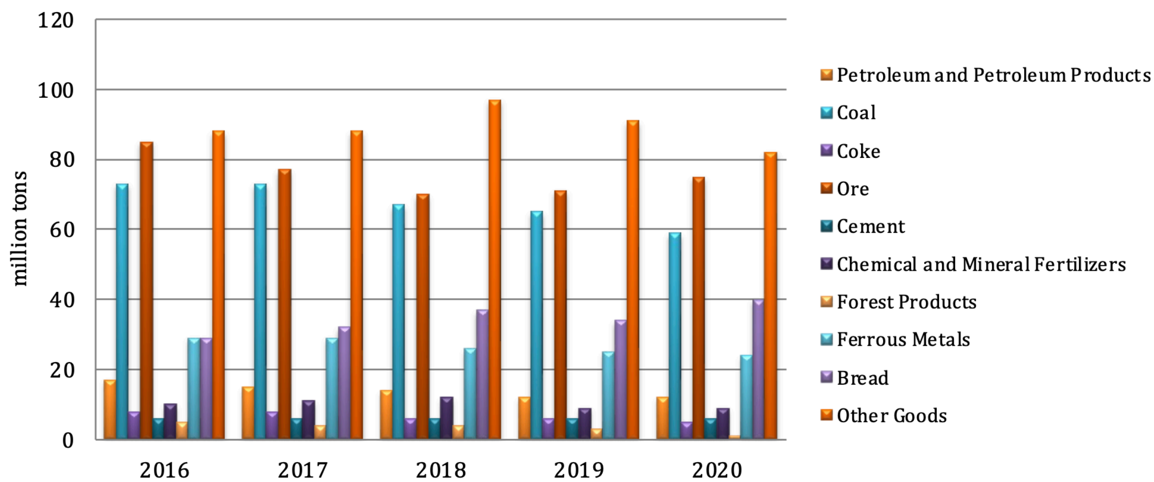


Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

Transportation of goods, which was carried out by railway transport enterprises, in contrast to transportation by road transport enterprises, according to the nomenclature of goods and products decreases every year (Figure 6). In 2020, the following types of cargo occupied the largest share: ore (24%), coal (19%), bread (13%) and ferrous metals (8%). The share of other cargoes is less 5%.

Figure 6. Volume of cargo transportation by rail according to the nomenclature of goods in 2016-2020, million tons

Figura 6. Volumen de transporte de carga por ferrocarril según nomenclatura de mercancías entre 2016-2020, en millones de toneladas

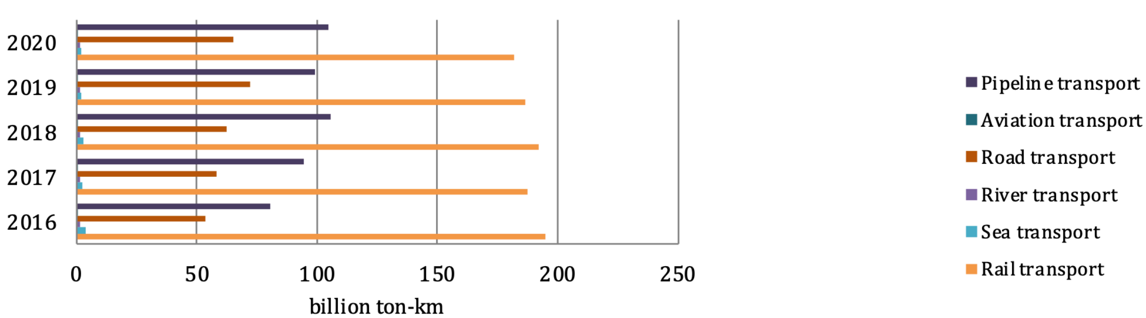


Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

In 2020, the freight turnover of transport enterprises increased by 6.1% compared to 2015. However, in 2019-2020 this figure decreased by 1.8% (Figure 7).

Figure 7. Volume of services sold by transport enterprises of Ukraine in 2016-2020, billion ton-km

Figura 7. Volumen de servicios vendidos por las empresas de transporte ucranianas entre 2016-2020, miles de millones ton-km

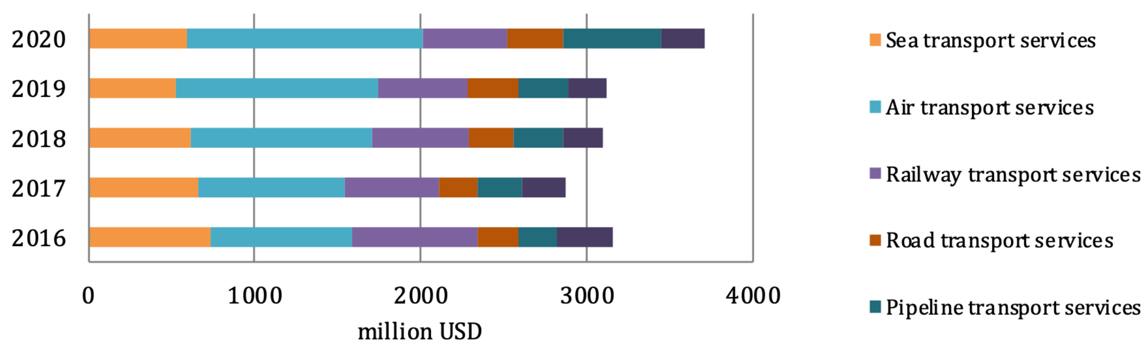


Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

Reductions in transportation volume affected the value of rail and maritime freight turnover, which decreased in 2016-2020 by 6.8% and 53.9% respectively. River transport is characterized by the stability of the analyzed indicator. The growth rate of road transport turnover during the study period increased by 22%, aviation – by 50%, pipeline – by 30%. In 2020, the turnover of transport enterprises amounted to 355 billion ton-km (98.3% of the volume in 2019). The largest reduction in freight turnover was experienced by pipeline transport (-43.7%), sea transport (-15.4%) and road transport (-13.5%). Exports of transport services in 2016-2020 increased by 73.1% (Figure 8). This increase is mainly due to the growth of exports of pipeline transport by 2.5 times, aviation by 66.3% and road (by 36%). Exports by rail were significantly reduced compared to a decrease 33.2%. In the structure of exports of transport services, the largest share is occupied by pipeline (64.8%) and air transport (15.6%). The share of sea transport is 6.5%, rail – 5.5% and road – 3.7%.

Figure 8. Exports of services of enterprises of the transport system of Ukraine for 2016-2020, million USD

Figura 8. Exportaciones de servicios de empresas del sistema de transporte ucraniano ente 2016-2020, en millones de dólares

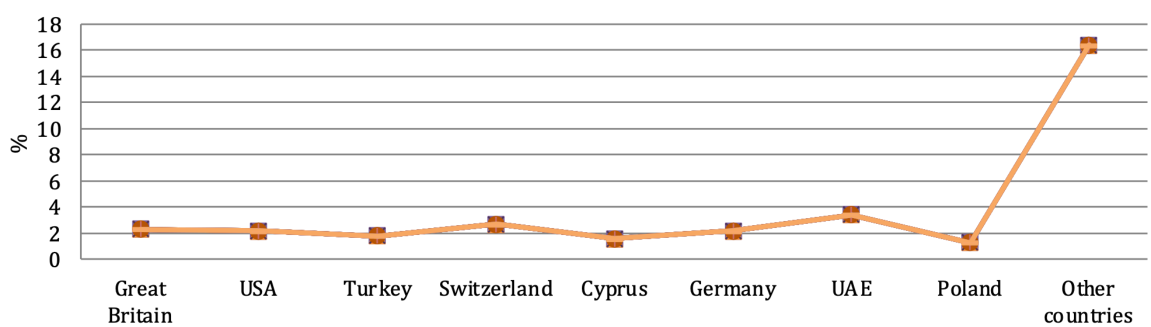


Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

Export of transport services of Ukraine with the countries of the world for 2020 is presented in Figure 9.

Figure 9. Estructure of exports of services of enterprises of the transport system of Ukraine with the countries of the world for 2020, in percentage

Figura 9. Estructura de las exportaciones de servicios de las empresas del sistema de transporte ucraniano con países alrededor del mundo en 2020, en porcentaje

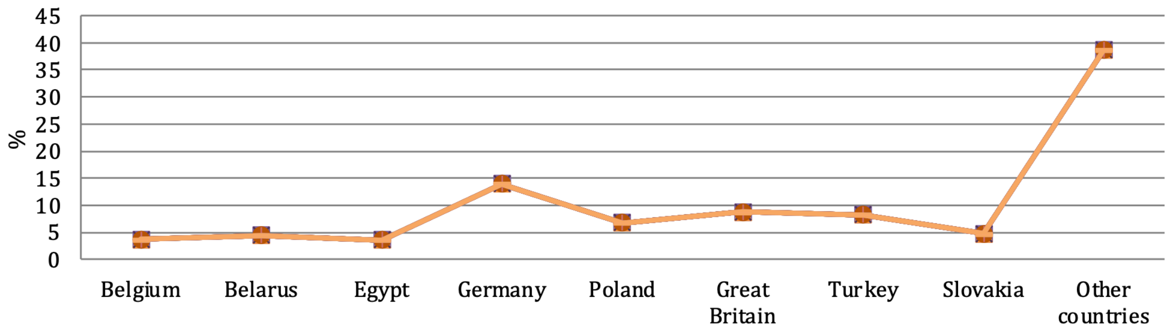


Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

Thus, the share of exports of UAE services is 3.4% (310.15 million USD), Switzerland – 2.7% (247.05 million USD), Great Britain – 2.3% (206.43 million USD), USA (197.01 million USD) and Germany (196.55 million USD) by 2.2%, the share of other countries does not reach 1%. Imports of transport services in 2016-2020 increased by 35.2% (Figure 10).

Figure 10. Structure of imports of services of enterprises of the transport system of Ukraine with the countries of the world for 2020, in percent

Figura 9. Estructura de las importaciones de servicios de las empresas del sistema de transporte ucraniano con países alrededor del mundo en 2020, en porcentaje



Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

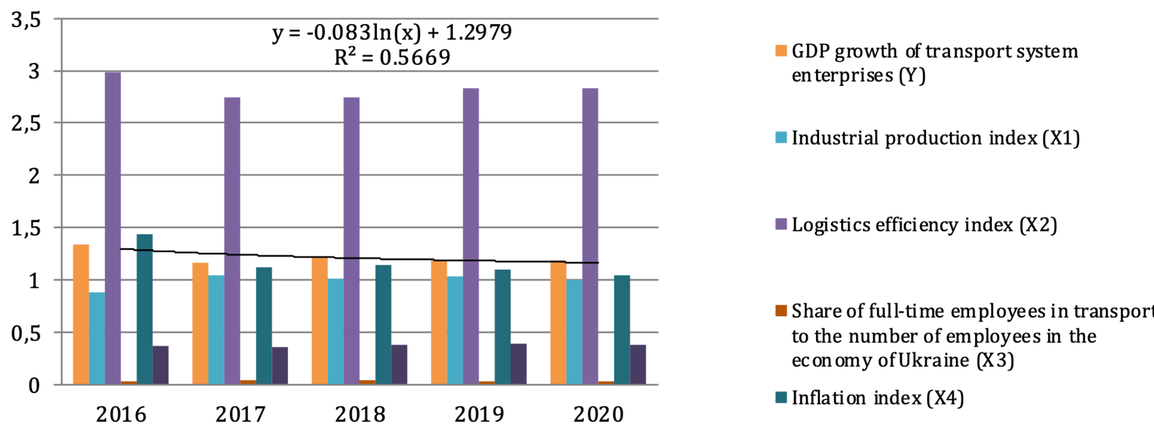
The growth of imports is characteristic of half of the modes of transport, except river (-11.5%), rail (-8.5%) and pipeline (-39.2%). The largest share in imports is occupied by air transport (48.6%), sea transport (17.6%) and rail transport (16.8%). The leaders of the countries among the imports of transport services are Germany (216.34 million USD), its share is 13.9%, Great Britain (137.69 million USD) – 8.8%, Turkey (127.26 million USD) – 8.2%, Poland (106.32 million USD) – 6.8%, Slovakia (74.02 million USD) – 4.8%, Belarus (68.87 million USD) – 4.4% and Belgium (57.44 million USD) – 3.7%. A significant number of countries that fall into the group of "other countries" have a share of imports less 3%.

Ukraine's transport system largely depends on the external environment. So the indicators that have the greatest impact on the efficiency of reengineering the business processes of transport enterprises are identified: the index of industrial products; logistics efficiency index (relative to the LPI of leading countries); the share of the average number of full-time employees employed in transport to the number of employees in the national economy; inflation index; innovation index. The result of the growth of the gross domestic product of Ukraine according to the production method, which is formed by the areas of activity "Transport, warehousing, postal and courier activities", was chosen as the resulting indicator. Most of the GDP in this area is formed by transport enterprises and warehousing, postal and courier activities are related activities. Figure 11 shows the data for calculating the regression model of dependence. Building a regression model involves solving a system of six equations with six unknowns, which has the following form:

$$\begin{cases} 6.091 = a_0 \times 5.000 + a_1 \times 4.953 + a_2 \times 3.366 + a_3 \times 0.1760 + a_4 \times 5.833 + a_5 \times 1.857 \\ 6.016 = a_0 \times 4.953 + a_1 \times 4.924 + a_2 \times 3.327 + a_3 \times 0.174 + a_4 \times 5.742 + a_5 \times 1.840 \\ 4.108 = a_0 \times 3.366 + a_1 \times 3.327 + a_2 \times 2.270 + a_3 \times 0.118 + a_4 \times 3.942 + a_5 \times 1.250 \\ 0.214 = a_0 \times 0.176 + a_1 \times 0.174 + a_2 \times 0.118 + a_3 \times 0.006 + a_4 \times 0.204 + a_5 \times 0.065 \\ 7.147 = a_0 \times 5.833 + a_1 \times 5.742 + a_2 \times 3.942 + a_3 \times 0.204 + a_4 \times 6.899 + a_5 \times 2.164 \\ 2.262 = a_0 \times 1.857 + a_1 \times 1.840 + a_2 \times 1.250 + a_3 \times 0.065 + a_4 \times 2.164 + a_5 \times 0.690 \end{cases}, \quad (7)$$

Figure 11. Regression model of the impact of external factors on the GDP of enterprises of the transport system of Ukraine under the conditions of reengineering of business processes in 2016-2020

Figura 11. Modelo de regresión del impacto de factores externos en el PIB de las empresas del sistema de transporte ucraniano, en las condiciones de reingeriería de los procesos comerciales entre 2016-2020



Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

As a result of solving this system of equations, the regression equation is obtained:

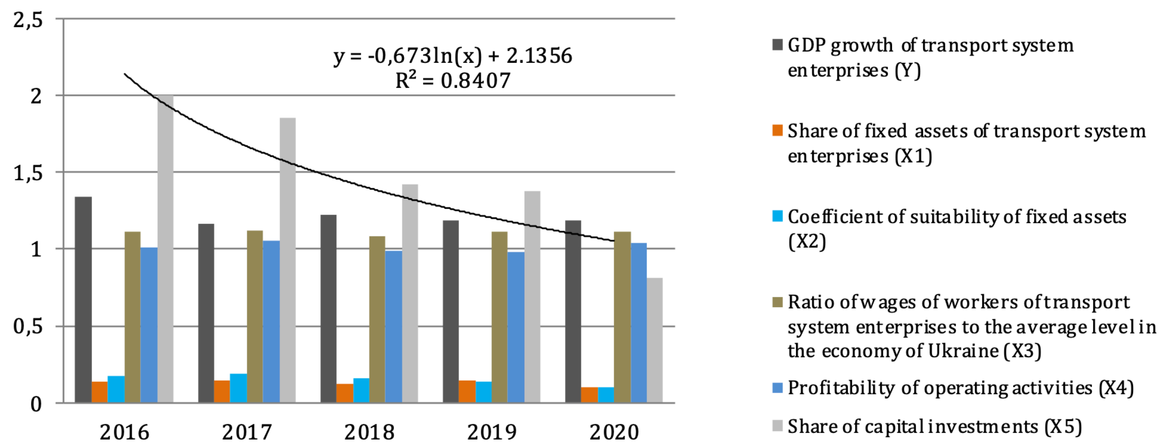
$$Y_{ex} = 1.703 + 1.818x_1 + 0.216x_2 - 0.257x_3 - 0.271x_4 + 0.639x_5, \quad (8)$$

For this model, the coefficient of determination is equal to 0.637, i.e. it confirms the reliability of calculations and can be used to analyze the impact of environmental factors on the effectiveness of business process reengineering in the transport system. Thus, the index of industrial production has the greatest impact on the growth of the gross output of enterprises in the transport system. This corresponds to the peculiarities of their operational activities, the products of which are services for the transportation of products of major sectors of the economy of Ukraine. The second place is occupied by the index of innovation because it is the innovation that is the driving force of the development of enterprises in any industry. The influence of other factors (logistics efficiency, average number of employees, and inflation) is almost the same. It should be noted that the impact of the average number of full-time employees and the inflation index is reversed, i.e. with the growth of these factors, the gross output of enterprises in the transport system will decrease.

We consider the impact of internal environmental factors on the efficiency of reengineering the business processes of transport system enterprises using five indicators, namely: the share of fixed assets of transport system enterprises in total value; coefficient of the suitability of fixed assets; the ratio of the average wage of workers in the transport system to the average level in the economy of Ukraine; profitability of operating activities of transport system enterprises; the share of capital investment of transport system enterprises in the total volume of the set of activities. As a result, the GDP growth of transport system enterprises, calculated according to the production method, is also used. The data for calculating the regression model of the dependence are shown in Figure 12.

Figure 12. Regression model of the impact of internal factors on the GDP of enterprises of the transport system of Ukraine under the conditions of reengineering of business processes in 2016-2020

Figura 12. Modelo de regresión del impacto de los factores internos en el PIB de las empresas del sistema de transporte ucraniano, en las condiciones de reingeniería de los procesos entre 2016-2020



Source: own elaboration according to UKRSTAT, 2016-2020.
Fuente: elaboración propia en base a UKRSTAT, 2016-2020.

Building a regression model involves solving a system of six equations with six unknowns, which has the following form:

$$\begin{cases} 6.091 = a_0 \times 5.000 + a_1 \times 4.953 + a_2 \times 3.366 + a_3 \times 0.1760 + a_4 \times 5.833 + a_5 \times 1.857 \\ 0.791 = a_0 \times 0.649 + a_1 \times 0.086 + a_2 \times 0.100 + a_3 \times 0.720 + a_4 \times 0.659 + a_5 \times 0.997 \\ 0.925 = a_0 \times 0.757 + a_1 \times 0.100 + a_2 \times 0.120 + a_3 \times 0.838 + a_4 \times 0.768 + a_5 \times 1.189 \\ 6.747 = a_0 \times 5.540 + a_1 \times 0.720 + a_2 \times 0.838 + a_3 \times 6.138 + a_4 \times 5.626 + a_5 \times 8.264 \\ 6.182 = a_0 \times 5.077 + a_1 \times 0.659 + a_2 \times 0.768 + a_3 \times 5.626 + a_4 \times 5.159 + a_5 \times 7.571 \\ 9.153 = a_0 \times 7.458 + a_1 \times 0.997 + a_2 \times 1.189 + a_3 \times 8.264 + a_4 \times 7.571 + a_5 \times 11.993 \end{cases} \quad (9)$$

As a result of solving this system of equations, the regression equation is obtained:

$$Y_{ix} = 10.570 + 2.460x_1 + 1.909x_2 - 1.292x_3 + 1.830x_4 + 2.694x_5, \quad (10)$$

For this model, the coefficient of determination is equal to 0.696, which confirms the reliability of the calculations and can be used to analyze the impact of internal environmental factors on the effectiveness of business process reengineering in the transport system. Thus, capital investments have the greatest impact on the GDP of transport system enterprises. Second in terms of impact on performance are fixed assets, which determine the real and potential opportunities in the future to transport goods to their destination and consumer requirements. The coefficient of the suitability of fixed assets and profitability of operating activities also have a significant impact. The level of wages of workers in the transport system has the opposite effect on the formation of GDP due to the growth of its rate, which exceeds the rate of productivity growth.

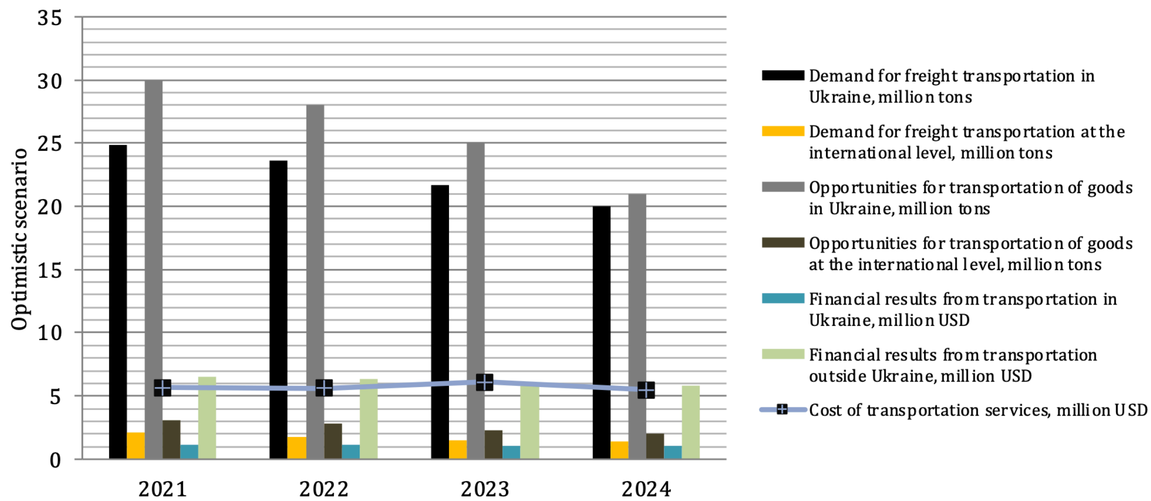
Simulation modeling of structural elements of management based on reengineering of business processes was used, which allowed for simulation of the parameters of logistics operations on average per one enterprise of the transport system in conditions of uncertainty of the internal and external environment. The mathematical basis of the models is nonlinear differential equations that determine probabilistic management scenarios for functional flows, both at the design stage and at the stage of reengineering business processes to meet consumer needs for freight transportation of their goods and products within Ukrainian and foreign markets. The construction of key functional flow management scenarios for one enterprise of the transport system is based on the key parameters of uncertainty regarding the demand for transportation, business process reengineering strategies and transport infrastructure. They form a fixed framework for all scenarios (optimistic, predictable, and adaptive).

The optimistic scenario is based on the assumption that the management of one enterprise of the transport system of Ukraine uses the current reengineering of business processes. Implementation of this strategy involves the development and systematic implementation of an approved program to reduce the crisis in demand for transportation, which is accompanied by intensified competition in the transport market, underestimation of environmental hazards (critical financial deterioration and bankruptcy, constant decline in profitability, accompanied by rising costs unrelated to the process of transport production). The projected scenario is based on the assumption that the management of the transport system due to the external and internal environment leads to a crisis that can be avoided by introducing precautions for business process reengineering, namely: maintaining a short-term linear-functional type of enterprise management and acceleration information flows functions (Nastisin *et al.*, 2022). The result of this scenario is a temporary increase in the profitability of transport enterprises.

The adaptive scenario is based on the assumption that reengineering operations of transport system enterprises are based on adaptation to changes in the transport market (creation and development of a cluster of business processes with partner enterprises), in the short and long term. This will allow maintaining the level of effective operation of enterprises by deepening ties between partners; obtaining a synergetic effect from joint business processes through a balanced redistribution of freight and passenger flows between enterprises in the cluster; improving the quality of transport services; to effectively use the combined potential of network partners; to improve the indicators of transport safety and the efficiency of management functions through the division of labor, specialization, involvement of specialized organizations. The results of the implementation of the considered scenarios on average per enterprise of the transport system of Ukraine are shown in Figure 13, 14, and 15.

Figure 13. Implementation of the optimistic scenario of functional flows management based on business process reengineering on average per enterprise of the transport system of Ukraine for 2021-2024

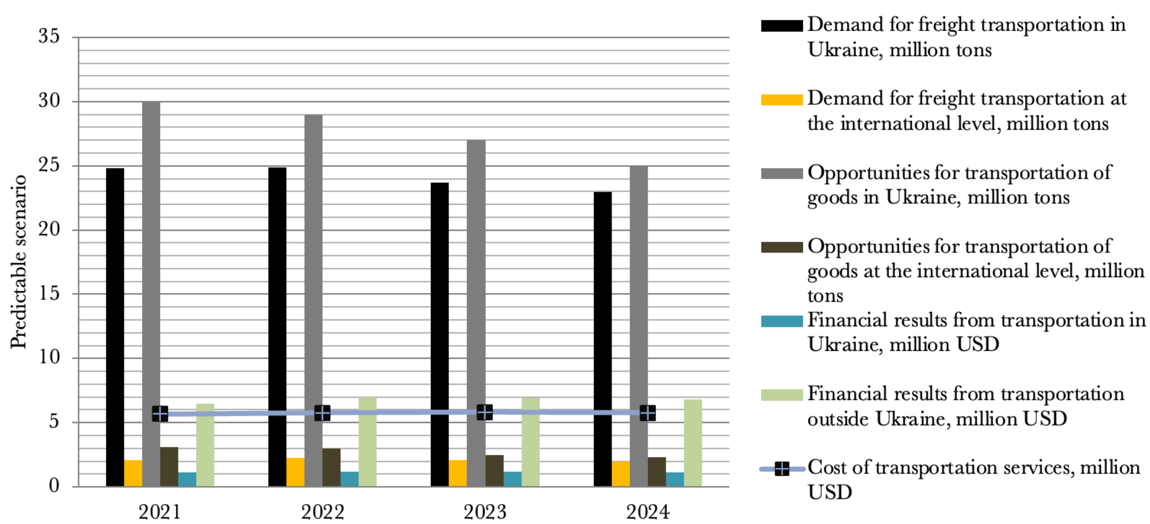
Figura 13. Implementación del escenario optimista de gestión de flujos funcionales basado en la reingeniería de procesos comerciales en promedio por empresa del sistema de transporte ucraniano entre 2021-2024



Source: own elaboration. Fuente: elaboración propia.

Figure 14. Implementation of the predictable scenario of functional flows management based on business process reengineering on average per enterprise of the transport system of Ukraine for 2021-2024

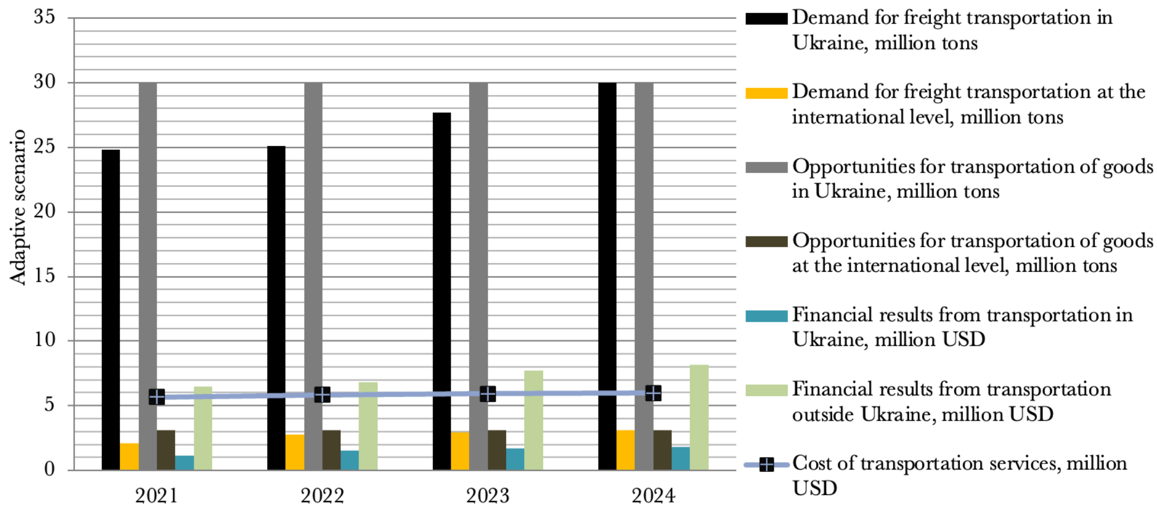
Figura 14. Implementación del escenario predecible de gestión de flujos funcionales basado en la reingeniería de procesos comerciales en promedio por empresa del sistema de transporte ucraniano entre 2021-2024



Source: own elaboration. Fuente: elaboración propia.

Figure 15. Implementation of the adaptive scenario of functional flows management based on business process reengineering on average per enterprise of the transport system of Ukraine for 2021-2024

Figura 14. Implementación del escenario adaptativo de gestión de flujos funcionales basado en la reingeniería de procesos comerciales en promedio por empresa del sistema de transporte ucraniano entre 2021-2024



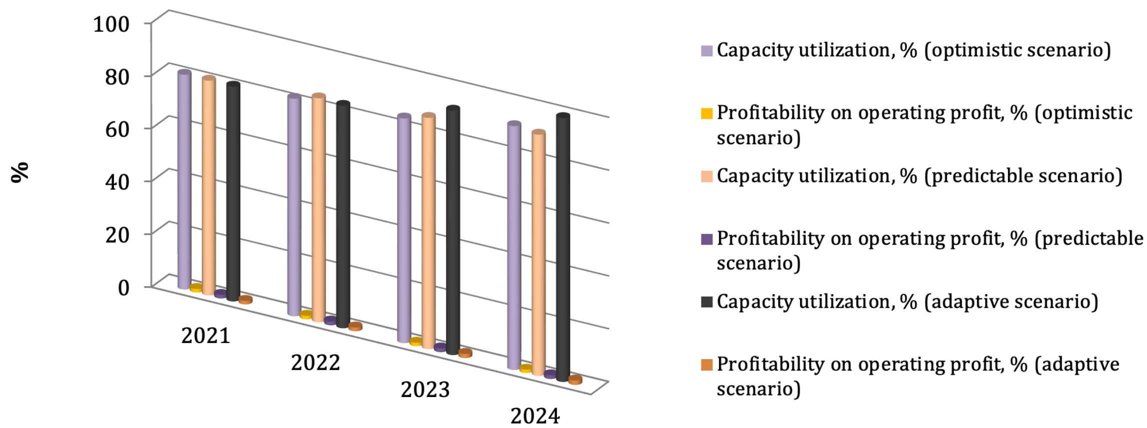
Source: own elaboration. Fuente: elaboración propia.

Thus, the implementation of the optimistic scenario (current reengineering of business processes) will be a constant decrease in financial results from freight transport on average per transport enterprise. Of particular danger are the rates of reduction of financial results (-10%), which will exceed the rate of reduction of the cost of services (-4.5%). During the implementation of the envisaged scenario (preventive reengineering of business processes), there will be a decrease in demand for transportation. However, the decline will be slower, as management will provide anti-crisis measures, including those related to expanding the customer base. As a result of this trend, the financial results from the transportation of goods will begin to decrease gradually (the total decrease for 2021-2024 will be 2.8%) while the cost of transportation services will not change.

With the implementation of the adaptive scenario (adaptive reengineering of business processes), the demand for transportation will not decrease. The result will be an increase in financial results from transportation (growth will be +30.6%), with an increase in the cost of services provided by only 5.6%. The efficiency of implementation of management scenarios for production functional flows of reengineering of business processes on average per transport enterprise of Ukraine is presented in Figure 16.

Figure 16. Effectiveness of the implementation of management scenarios for production functional flows of reengineering of business processes on average per enterprise of the transport system of Ukraine for 2021-2024

Figura 16. Efectividad de la implementación de escenarios de gestión de flujos funcionales de producción de reingeniería de procesos comerciales, en promedio, por empresa del sistema de transporte ucraniano, entre 2021-



Source: own elaboration. Fuente: elaboración propia.

Thus, the effectiveness of the study shows that transport enterprises should develop and implement management of adaptive reengineering, which involves the creation of joint business processes with related companies, both industrial and transport. This will allow the introduction of a logistics platform to group businesses into clusters that share business processes to ensure their attractiveness in volatile and uncertain economic conditions.

Conclusions

The management of transport system enterprises depends on the size of the industrial sector. It encourages the formation of an integrated form of logistics as an effective reengineering tool that combines the movement of material and service flows aimed at maximizing profits by all participants in the transport and distribution process by optimizing their logistics costs in space and time. At the same time, the coordination of the functions of technological, technical, and economic flows should be combined in the interaction between all functional units of reengineering and ensure the integration of participants in the transportation process into a single system. Such a system is able to provide quality logistics service to internal or external consumers while minimizing common logistics costs, requires coordination of interests between system contractors and the creation of the necessary organizational prerequisites to manage the reengineering process. The integration of interests, resource opportunities and business processes of different enterprises of the transport system into a cooperating organization should be carried out on the basis of territorial, regional, product, functional, and demographic unity.

Realization of opportunities for reengineering business processes should provide a reduction of specific transport expenses in the final price of the goods. At the same time, the need to form structural elements of management to justify the compliance of transport services with the requirements of commercial speed, quality, and reliability of freight transport, require significant changes at the reengineering stage, which creates economic interdependence between all transport market participants. Coherence of activities between all participants in the process of creation, production, marketing, and customer service based on the logistics platform allows for ensuring a high level of development of transport system enterprises and directly affects the investment attractiveness of the state. In particular, the decision to enter a new market by large companies should be based on the ability of the warehousing potential of a certain area to provide potential opportunities for quality transport services, and the presence of large transport companies.

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