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SUSTAINABLE DEVELOPMENT OF AGRARIAN INNOVATION-ORIENTED ENTERPRISES BY THE MEANS OF LOGISTICS MANAGEMENT

ABSTRACT

The article defines the key aspects of ensuring and diagnosing the sustainable development of agrarian innovation-oriented enterprises by means of logistics management. Attention is focused on the importance of improving logistics management, which plays an important role in ensuring the efficient movement of agricultural products from the producer to the consumer. It was determined that effective logistics management is able to ensure the sustainable development of agrarian innovation-oriented enterprises, which, due to the specificity of their activities, are particularly risky on the market. Diagnostics of the sustainable development of agrarian innovation-oriented enterprises by means of logistics management is proposed to be carried out by the method of transport linear programming. This method was tested on the example of the activity of four innovatively oriented agricultural enterprises: SE "DG Stepne" of Poltava district, PE "name Kalashnyk" of Poltava district, LLC "Agrofirma "Zorya-Agro" of Myrhorod district and LLC "Promin-privat" of Myrhorod district. The obtained results allow any enterprise using linear programming tools to model the strategy of sustainable development of agrarian innovation-oriented enterprises by means of logistics management.

Keywords: logistics management, agricultural enterprises, sustainable development, production costs, agricultural products, processing enterprises, innovative activity

JEL Classification: J43, O32, Q16

INTRODUCTION

Logistics management in the agricultural sector plays an important role in ensuring the efficient movement of agricultural products from the producer to the consumer. Logistics services allow you to optimize the processes of collection, storage, transportation and distribution of products, which in turn leads to a reduction in transformation and transaction costs and an increase in the efficiency of the entire supply chain. Effective logistics management is able to ensure the sustainable development of agrarian innovation-oriented enterprises, which, due to the specifics of their activities, are particularly risky. Such management should have a systematic approach and include the implementation of modern cargo monitoring and management technologies, the development of optimal delivery routes, the use of specialized vehicles and containers for product storage and transportation, as well as the improvement of the warehouse accounting and inventory management system. Improving the quality and efficiency of transportation of agricultural products helps to increase its competitiveness in the market by ensuring timely deliveries and maintaining the quality of products throughout the entire transportation path. This, in turn, will positively affect the financial results of agricultural enterprises, ensuring the sustainable development of the enterprise through obtaining sale income from the sale of products.

LITERATURE REVIEW

The article (Vyshnevskaya et al., 2015) analyzed key aspects of the operation of logistics systems of agricultural enterprises and determined the need to accumulate financial potential that would contribute to successful logistics. Logistics management is consid-

ered in depth in the work (Herelytsia, 2013), where the author defines the basic directions of managing the logistics activities of agricultural enterprises in conditions of crisis and an unstable external environment. Scientists (Zelenko, 2017; Kalchenko, 2006) defined the management of logistics activities of agricultural enterprises in sufficient detail and identified the main types of logistics and the logistics processes that take place in them.

The team of authors (Denysenko et al., 2010) thoroughly explained the basic principles of organization and design of logistics systems, including the means of mathematical and statistical modelling. In the work (Vasylchak et al., 2022), means of supporting the innovative development of enterprises are proposed, which are expedient to use in the process of logistics management and sustainable development strategy planning. The authors (Kalinichenko et al., 2004) offer non-standard approaches to solving the problem of optimal programming when solving problems of agricultural production.

The source (Kovalchuk, 2011) defines the theoretical essence of the logistics activity of agricultural enterprises and specifies the necessity of applying the logistics system. The authors (Zham et al., 2023) proposed non-standard methods and management diagnostic tools, which should also be used for logistics management. In the work (Zhyvko et al., 2022), mathematical modelling and forecasting of the development of individual sectors of the economy in unstable conditions, the implementation of which is necessary for the effective development of logistics systems and innovative entrepreneurship, is detailed. Scientists (Bosona and Gebresenbet, 2013) indicate an effective logistics management system in the supply of food products in agriculture. In a scientific article (Tsolakis et al., 2014), tools for managing the logistics supply chain and decision-making systems in the context of critical systematics are proposed.

The study (Gryshchenko et al., 2021) proposed a combination of models and methods of forecasting in the education market, which is advisable to use in the logistics management system. Scientists (Ahumada and Villalobos, 2011) proposed an interesting system for planning the collection and distribution of perishable agricultural products. Important aspects in the field of logistics management were conducted by (Ciliberti et al., 2008), who specified the tools of social responsibility in the example of the work of logistics in Italian companies.

Scientific developments (Bochtis et al., 2014) that systematize system management methods in agriculture that are appropriate to use in logistics deserve attention. Scientists (Bumblauskas et al., 2020) raise the urgent issue of using blockchain in the food logistics system. In a scientific study (Ovcharenko et al., 2022), a system of calculating the functioning of clusters and their logistical support in the conditions of environmentalization, which agriculture needs, is proposed.

An important question is defined in the work (Tzounis et al., 2017), which groups a system of digitized things in agriculture, the use of which will be appropriate in logistics systems. The issue of distribution in agriculture and product promotion is detailed in scientific works (Eastwood et al., 2017; Coley et al., 2009).

The authors (Saurabh and Dey, 2021) proposed an interesting issue of using blockchain technologies in agro-food. Scientists noted the need to improve the quality of livestock production and improve its movement (Kyrlyuk et al., 2021).

Scientists (Matos and Silvestre, 2013) proposed the management of the formation of sustainable business relations in the energy sector, the use of which is appropriate in logistics management.

The works (Kurian et al., 2013; Khodakivska et al., 2022) propose tools for improving the efficiency of enterprises in the process of innovative activities and logistical relationships. In the scientific work (El Bilali and Allahyari, 2018), the tools for the formation of sustainable agriculture in conditions of uncertainty and crisis were specified.

Scientists (Zhai et al., 2020) detailed the key problems of the decision-making system in agriculture in the context of digitalization and emphasized the need to deepen the sustainable development of agribusinesses.

Paying respect to the listed authors, we note that the issues of sustainable development of agrarian innovation-oriented enterprises by means of logistics management in their scientific works were studied fragmentarily, and the analytical data are outdated, which makes it impossible to form promising proposals for improving the quality of logistics management, taking into account the bifurcations and crises in which it is now agro-food sector.

AIMS AND OBJECTIVES

The purpose of the article is to diagnose and model the development of agricultural innovation-oriented enterprises with the tools of logistics management, which will provide an opportunity to ensure the sustainable development of agricultural enterprises.

To solve the set goal, we solved the following tasks:

- the methodology of sustainable development of agrarian innovation-oriented enterprises by means of logistics management is specified;
- guidelines for modelling the sustainable development of innovatively oriented enterprises by means of logistics management are detailed;
- the specified methodology and modelling were tested on the example of the operation of four agricultural enterprises in the Poltava region;
- forecasting of the sustainable development of agrarian innovation-oriented enterprises by means of logistics management is proposed.

METHODS

We offer diagnostics of the sustainable development of agrarian innovation-oriented enterprises by means of logistics management by means of transport linear programming. Specified programming is a mathematical optimization method that is used to solve transportation problems, such as the optimal distribution of shipments from sources to receivers with minimum costs or maximization of profit. In agriculture, the specified method can be used to solve various tasks related to the transportation of agricultural products, raw materials, equipment, etc. Transportation linear programming can help determine optimal routes for delivering products from agricultural fields to warehouses or markets, reducing transportation costs and delivery times. This method is useful for the efficient distribution of resources, such as vehicles or workers, between different agricultural objects (for example, between fields, warehouses, farms, etc.). It allows you to find such a distribution of transportation that minimizes the total costs of transporting agricultural products, including the costs of fuel, vehicle maintenance, etc. Thus, transport linear programming in agriculture can be a powerful tool for optimizing transport processes, increasing efficiency and reducing costs.

RESULTS

Logistics management plays a critical role in the formation and implementation of the sustainable development strategy of an innovatively oriented agricultural enterprise. It is important to improve the process of optimizing the management of product flows from the supplier to the final consumer, taking into account a systematic approach to the management of various links of this process in order to achieve the strategic, tactical and operational goals of the enterprise. The main goal of logistics management is to implement promising and adaptive logistics strategies with optimal use of resources, which allows to ensure the sustainable development of the enterprise and response to the changing needs of the market. This includes quick fulfilment of orders, exact compliance with delivery dates and adaptation of the enterprise to the requirements of consumers. Transport modelling will help in the best ways to ensure the sustainable development of agricultural enterprises in the conditions of an unstable external environment, the toolkit of which is shown in the source (<https://financial.lnu.edu.ua/wp-content/uploads/2019/09/ME-lektsiia-6.pdf>). Which was raised by us as a reference point for mathematical programming. Agriculture has its own unique requirements for logistics management due to the seasonality of products, the peculiarities of cultivation and transportation, as well as competitiveness and quality requirements. Deficiencies in the transport infrastructure can significantly limit the ability to deliver agricultural products in a timely and efficient manner. In the agricultural sector, cargo transportation and unloading services are important steps in the logistics process, as they affect overall costs and production efficiency. Accordingly, optimization of these processes can help reduce transaction and transformation costs for transportation and unloading of products, which is an important factor in reducing the cost of agricultural products. The use of modern technologies in transportation, such as automated systems for monitoring and regulating traffic flows, can contribute to more efficient use of petroleum products and reduce transportation costs. In addition, infrastructure development and the modernization of vehicles can contribute to the sustainability of the agricultural sector in general. Therefore, logistics management in agriculture requires a comprehensive approach and attention to detail to ensure efficient movement of products from field to market and reduce overall production costs. For the practical study, research, analysis, modelling and forecasting of the sustainable development of agricultural innovation-oriented enterprises by means of logistics management, we will use the statistical data of four agricultural enterprises of the Poltava region: SE "DG Stepne" of the Poltava region, PE "Kalashnyk" of the Poltava region, LLC "Agrofirma" Zorya-Agro" of Myrhorod district and "Promin-privat" LLC of Myrhorod district, each of which has three warehouses for winter wheat storage. The initial information for the study of logistics management in the studied enterprises is taken from the annual balance sheet form No. 1, form No. 50 of the current year and the primary documents of the divisions, in particular

the accounting of goods and transport invoices, documents of receipt, disposal and accounting of products in the warehouse of the enterprise, orders and consumer contracts. Initial information on the distances from the warehouses of the studied agricultural enterprises to the processing plants in kilometres is presented in Table 1.

Table 1. Initial information on the distances from the warehouses of the researched innovatively oriented agricultural enterprises to processing plants. (Source: reporting documentation of the researched enterprises)

SE "DG Stepne" of Poltava district			
Suppliers	Processing enterprises		
	"Ukrainian Grain" LLC, Poltava	"Burat" LLC, Poltava	TM "Dykanske" Dykansky district
Composition No. 1	26	28	60
Composition No. 2	28	24	58
Composition No. 3	25	26	56
PP "named after Kalashnyk" of Poltava district			
Suppliers	Processing enterprises		
	LLC "Agrofirma "Zherelo"	"Agrofirma "Vorskla" LLC	TM "Dykanske" Dykansky district
Composition No. 1	15	14	60
Composition No. 2	10	8	58
Composition No. 3	20	18	56
LLC "Agrofirma "Zorya-Agro" of Myrhorod district			
Suppliers	Processing enterprises		
	"Hermes Trading" LLC	"Zernova Grupa" LLC	"Interstarch Ukraine" LLC
Composition No. 1	62	70	52
Composition No. 2	60	72	54
Composition No. 3	61	73	58
"Promin-privat" LLC of Myrhorod district			
Suppliers	Processing enterprises		
	"Clean Krynytsia" LLC	LLC "NVP Poltavaska Pal-yanitsa"	PJSC "State Food and Grain Corporation of Ukraine"
Composition No. 1	26	15	42
Composition No. 2	25	13	46
Composition No. 3	24	17	48

It was proposed, as mentioned earlier, that four agricultural enterprises of the Poltava region, on whose territory there are warehouses for the storage of winter wheat - they are suppliers of uniform cargo. Three consumers are selected for each agrarian enterprise supplier, who have the greatest demand for this cargo and contractual conditions during a certain period. Stocks of cargo, i.e., winter wheat, in tons in the warehouses of agricultural enterprises for the last studied period are as follows (Table 2).

Table 2. Stocks of winter wheat in the warehouses of innovatively oriented agricultural enterprises, tons. (Source: reporting documentation of the studied enterprises)

Warehouse "No"	Agricultural enterprise			
	SE «DG Stepne» of Poltava district	PP «named after Kalashnyk» of Poltava district	LLC «Agrofirma «Zorya-Agro» of Myrhorod district	«Promin-privat» LLC of Myrhorod district
Composition No. 1	600.00	900.00	1200.00	1050.00
Composition No. 2	549.70	840.00	1080.00	1080.00
Composition No. 3	565.00	994.40	1132.00	890.00
In total	1714.70	2734.40	3412.00	3020.00

Consumers need this cargo, that is, winter wheat, in the last period according to the data presented in Table 3.

Table 3. Consumer demand for winter wheat, 2022. (Source: reporting documentation of the studied enterprises)

Provider	Processing enterprises			
	«Ukrainian Grain» LLC, Poltava	«Burat» LLC, Poltava	TM «Dykanske» Dykansky district	In total
SE «DG Stepne» of Poltava district	700.00	450.00	564.70	1714.70
Provider	Processing enterprises			
	LLC «Agrofirma «Zherelo»	«Agrofirma «Vorskla» LLC	TM «Dykanske» Dykansky district	In total
PP «named after Kalashnyk» of Poltava district	810.00	790.00	1134.40	2734.40
Provider	Processing enterprises			
	«Hermes Trading» LLC	«Zernova Grupa» LLC	«Interstarch Ukraine» LLC	In total
LLC «Agrofirma «Zorya-Agro» of Myrhorod district	1100.00	1090.00	1222.00	3412.00
Provider	Processing enterprises			
	"Clean Krynytsia" LLC	LLC «NVP Poltavaska Palyanitsa»	PJSC "State Food and Grain Corporation of Ukraine"	In total
«Promin-privat» LLC of Myrhorod district	850.00	1090.00	1080.00	3020.00

We proceed from the fact that the sustainable development of agrarian innovation-oriented enterprises by means of logistics management in this case consists in creating an optimal plan for the transportation of cargo, i.e., winter wheat. With the fact that all the volumes of transport work carried out in ton-kilometres were with minimal transaction costs. Given the chosen research method, namely transport linear programming, we will determine the need for a distribution class of the problem, taking into account openness or closedness. In the open transport problem, the volumes of goods transported from the supplier to the consumer are not limited. This means that any amount of cargo can be transported between any pair of sources and sinks. The main goal is to find the optimal transportation method that minimizes the total transportation costs. In a closed transport problem, the volumes of transported goods are limited by certain quantities or capacities of vehicles. For example, a limit can be set on the number of goods that can be transported by each mode of transport (eg, wagons, cars, ships), or on the total number of goods that can be transported between pairs of sources and receivers. Both types of transportation problems can be solved using linear programming optimization methods, such as the simplex method, the boundary point method, or the iterative method. These methods help to find the optimal distribution of loads and minimize the total transport costs while respecting the restrictions regarding the volumes of loads and the capacity of vehicles. We consider logistic modelling from a mathematical and statistical point of view, i.e., we will assume the unknown volumes of transportation between each warehouse of the studied agricultural enterprise and each processing enterprise: $x_{11}, x_{12}, x_{13}, x_{21}, x_{22}, x_{23}, x_{31}, x_{32}, x_{33}$ (the first index for unknowns – warehouse number, second index – number of the processing enterprise). The target function of these calculations is the minimized amount of transport work in ton-kilometers. The target function of optimization of transport operations during the transportation of winter wheat of the studied agricultural enterprises for the next period is presented in Table 4.

Table 4. Models of the objective functions of the optimization of transport operations during the transportation of winter wheat of the studied agricultural enterprises, 2025.

Agricultural enterprise	Target function of optimization of transport works when transporting winter wheat
SE «DG Stepne» of Poltava district	$Z_{min} = 26x_{11} + 28x_{12} + 60x_{13} + 28x_{21} + 24x_{22} + 58x_{23} + 25x_{31} + 26x_{32} + 56x_{33}$
PP «named after Kalashnyk» of Poltava district	$Z_{min} = 15x_{11} + 14x_{12} + 60x_{13} + 10x_{21} + 8x_{22} + 58x_{23} + 20x_{31} + 18x_{32} + 56x_{33}$
LLC «Agrofirma «Zorya-Agro» of Myrhorod district	$Z_{min} = 62x_{11} + 70x_{12} + 52x_{13} + 60x_{21} + 72x_{22} + 54x_{23} + 61x_{31} + 73x_{32} + 58x_{33}$
«Promin-privat» LLC of Myrhorod district	$Z_{min} = 26x_{11} + 15x_{12} + 42x_{13} + 25x_{21} + 13x_{22} + 46x_{23} + 24x_{31} + 17x_{32} + 48x_{33}$

Next, we model the possibilities of suppliers - the studied agricultural enterprises regarding the volumes of product deliveries, i.e., winter wheat, and restrictions that model the needs of consumers (Table 5).

Table 5. Modelling of opportunities and needs of agricultural enterprises and consumers, 2025.

Agricultural enterprise	Modelling of restrictions on the possibility of suppliers (agricultural enterprise stocks), tons	Modelling restrictions on consumer needs, tons
SE «DG Stepne» of Poltava district	$\begin{cases} x_{11} + x_{12} + x_{13} = 600 \\ x_{21} + x_{22} + x_{23} = 549,70 \\ x_{31} + x_{32} + x_{33} = 565 \end{cases}$	$\begin{cases} x_{11} + x_{21} + x_{31} = 700 \\ x_{12} + x_{22} + x_{32} = 450 \\ x_{13} + x_{23} + x_{33} = 564,70 \end{cases}$
PP «named after Kalashnyk» of Poltava district	$\begin{cases} x_{11} + x_{12} + x_{13} = 900 \\ x_{21} + x_{22} + x_{23} = 840 \\ x_{31} + x_{32} + x_{33} = 994,40 \end{cases}$	$\begin{cases} x_{11} + x_{21} + x_{31} = 810 \\ x_{12} + x_{22} + x_{32} = 790 \\ x_{13} + x_{23} + x_{33} = 1134,40 \end{cases}$
LLC «Agrofirma «Zorya-Agro» of Myrhorod district	$\begin{cases} x_{11} + x_{12} + x_{13} = 1200 \\ x_{21} + x_{22} + x_{23} = 1080 \\ x_{31} + x_{32} + x_{33} = 1132 \end{cases}$	$\begin{cases} x_{11} + x_{21} + x_{31} = 1100 \\ x_{12} + x_{22} + x_{32} = 1090 \\ x_{13} + x_{23} + x_{33} = 1222 \end{cases}$
«Promin-privat» LLC of Myrhorod district	$\begin{cases} x_{11} + x_{12} + x_{13} = 1050 \\ x_{21} + x_{22} + x_{23} = 1080 \\ x_{31} + x_{32} + x_{33} = 890 \end{cases}$	$\begin{cases} x_{11} + x_{21} + x_{31} = 850 \\ x_{12} + x_{22} + x_{32} = 1090 \\ x_{13} + x_{23} + x_{33} = 1080 \end{cases}$

The next stage of the study of logistics management in agricultural enterprises is the mathematical processing of constraints and the objective function. Technically, they can be processed in two ways manually and using Microsoft Excel spreadsheets and the Solver tool. So, as a result of the calculations, the following cargo transportation plan will be optimal, that is, winter wheat in tons (Table 6).

Table 6. Results of optimization of transport operations during the transportation of winter wheat by agricultural enterprises to processing enterprises, 2025.

SE «DG Stepne» of Poltava district			
Suppliers	Processing enterprises		
	"Ukrainian Grain" LLC, Poltava	«Burat» LLC, Poltava	TM «Dykanske» Dykansky district
Composition No. 1	600.00		
Composition No. 2		450.00	99.70
Composition No. 3	100.00		465.00
The volume of transport works, t-km			60722.60
PP «named after Kalashnyk» of Poltava district			
Suppliers	Processing enterprises		
	LLC «Agrofirma «Zherelo»	«Agrofirma «Vorskla» LLC	TM «Dykanske» Dykansky district
Composition No. 1	760.00		140.00
Composition No. 2	50.00	790.00	
Composition No. 3			994.40
The volume of transport works, t-km			82306.40
LLC «Agrofirma «Zorya-Agro» of Myrhorod district			
Suppliers	Processing enterprises		
	«Hermes Trading» LLC	«Zernova Grupa» LLC	«Interstarch Ukraine» LLC
Composition No. 1		348.67	851.33
Composition No. 2	338.67	370.67	370.67
Composition No. 3	761.33	370.67	
The volume of transport works, t-km			209200.00
«Promin-privat» LLC of Myrhorod district			
Suppliers	Processing enterprises		
	"Clean Krynytsia" LLC	LLC «NVP Poltavaska Pal-yanitsa»	PJSC "State Food and Grain Corporation of Ukraine"
Composition No. 1			1050.00
Composition No. 2		1050.00	30.00
Composition No. 3	850.00	40.00	
The volume of transport works, t-km			80210.00

With such logistical plans for the transportation of the necessary products, in particular, winter wheat by agrarian enterprises to processors, the total amount of transport work will be minimal. Schematically, the plan of transportation of winter wheat of agricultural enterprises of the Poltava region from three warehouses of farms to three processing enterprises is presented in Figures 1-4.

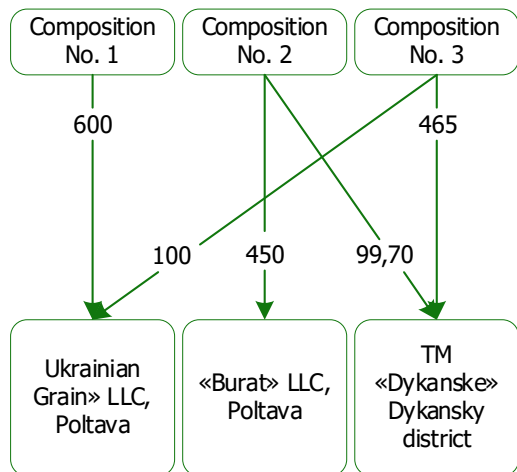


Figure 1. The optimal plan of transportation of winter wheat SE "DG Stepne" of Poltava district to processing enterprises (from three warehouses) to three processing enterprises, 2025.

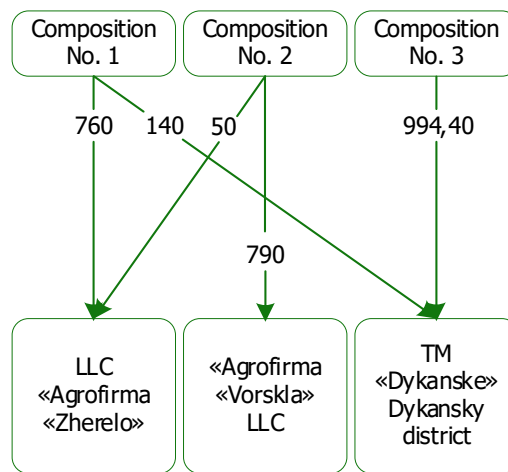


Figure 2. The optimal plan of transportation of winter wheat PP "named after Kalashnyk" of Poltava district to processing enterprises (from three warehouses) to three processing enterprises, 2025.

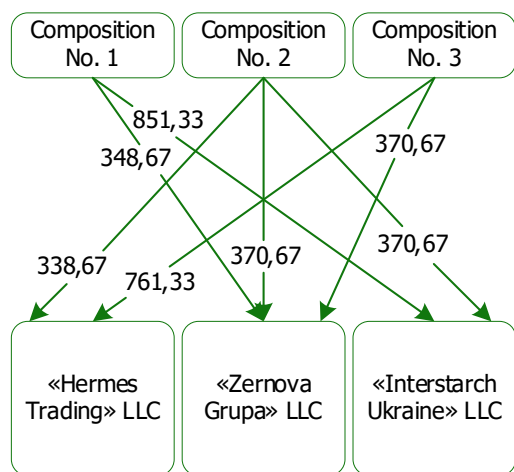


Figure 3. The optimal plan of transportation of winter wheat LLC "Agrofirma "Zorya-Agro" of Myrhorod district to processing enterprises (from three warehouses) to three processing enterprises, 2025.

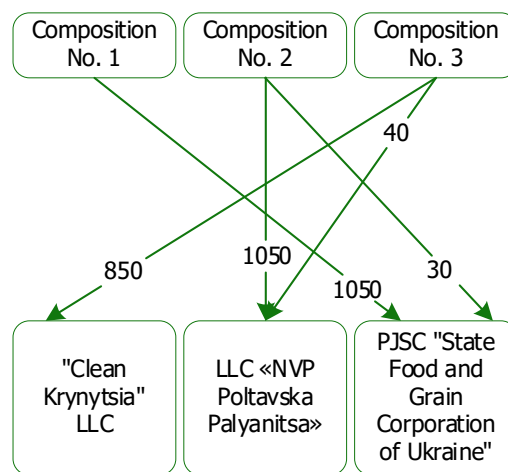


Figure 4. The optimal plan of transportation of winter wheat "Promin-privat" LLC of Myrhorod district to processing enterprises (from three warehouses) to three processing enterprises, 2025.

It should also be noted that an analysis of the actual and forecast volume of transport works from suppliers of agricultural enterprises of the Poltava region (three warehouses of farms) to three consumers was carried out (Table 7).

As a result of the comparative analysis, it can be concluded that when winter wheat is transported to consumers at the level of 2022, the volume of transport works will decrease as a result of optimal modeling in the forecast year of 2025, this is a positive result, but at the same time, the peculiarities of the activities of agricultural enterprises and a number of logistical issues should be taken into account, economic and financial factors affecting their functioning.

Table 7. Actual and forecast volume of transport works from suppliers of agricultural enterprises of the Poltava region (three warehouses of farms) to three consumers, 2022, 2025.

Actual and forecast volume of transport works from the supplier (three warehouses) SE "DG Stepne" of Poltava district to three consumers, 2022, 2025.					
Consumers	The average distance from the supplier to the consumer, km	Cargo transportation, tons of 2022	Forecast cargo transportation, t in 2025.	Volume of transport works, t-km, 2022	Volume of transport works, t-km, 2025
«Ukrainian Grain» LLC, Poltava	26.33	680.00	700.00	17906.67	18100.00
«Burat» LLC, Poltava	26.00	390.70	450.00	10158.20	10800.00
TM «Dykanske» Dykansky district	58.00	644.00	564.70	37352.00	31822.60
In total		1714.70	1714.70	65416.87	60722.60
Actual and forecast volume of transport works from the supplier (three warehouses) PP "named after Kalashnyk" of Poltava district to three consumers, 2022, 2025.					
Consumers	The average distance from the supplier to the consumer, km	Cargo transportation, tons of 2022	Forecast cargo transportation, t in 2025.	Volume of transport works, t-km, 2022	Volume of transport works, t-km, 2025
LLC «Agrofirma «Zherelo»	15.00	880.00	810.00	13200.00	11900.00
«Agrofirma «Vorskla» LLC	13.33	600.00	790.00	8000.00	6320.00
TM «Dykanske» Dykansky district	58.00	1254.40	1134.40	72755.20	64086.40
In total		2734.40	2734.40	93955.20	82306.40
Actual and forecast volume of transport works from the supplier (three warehouses) LLC "Agrofirma "Zorya-Agro" of Myrhorod district to three consumers, 2022, 2025.					
Consumers	The average distance from the supplier to the consumer, km	Cargo transportation, tons of 2022	Forecast cargo transportation, t in 2025.	Volume of transport works, t-km, 2022	The volume of transport works, t-km, 2025
«Hermes Trading» LLC	61.00	990.00	1100.00	60390.00	68675.99
«Zernova Grupa» LLC	71.67	1100.00	1090.00	78833.33	67024.02
«Interstarch Ukraine» LLC	54.67	1322.00	1222.00	72269.33	73500.00
In total		3412.00	3412.00	211492.67	209200.00
The actual and forecast volume of transport works from the supplier (three warehouses) "Promin-privat" LLC of Myrhorod district to three consumers, 2022, 2025.					
Consumers	The average distance from the supplier to the consumer, km	Cargo transportation, tons of 2022	Forecast cargo transportation, t in 2025.	Volume of transport works, t-km, 2022	The volume of transport works, t-km, 2025
Clean Krynytsia" LLC	25.00	960.00	850.00	24000.00	44100.00
LLC «NVP Poltavska Palyanitsa»	15.00	752.00	1090.00	11280.00	15030.00
PJSC "State Food and Grain Corporation of Ukraine"	45.33	1308.00	1080.00	59296.00	21080.00
In total		3020.00	3020.00	94576.00	80210.00

The volume of transportation of winter wheat (in per cent) by agricultural enterprises of the Poltava region in 2022 and the forecast volume of transportation of this product in 2025 are graphically presented. Analyzing the graphic image, it is possible to note some fluctuation (decrease or increase) in the supply of products to consumers - processing enterprises (Figures 5 -8).

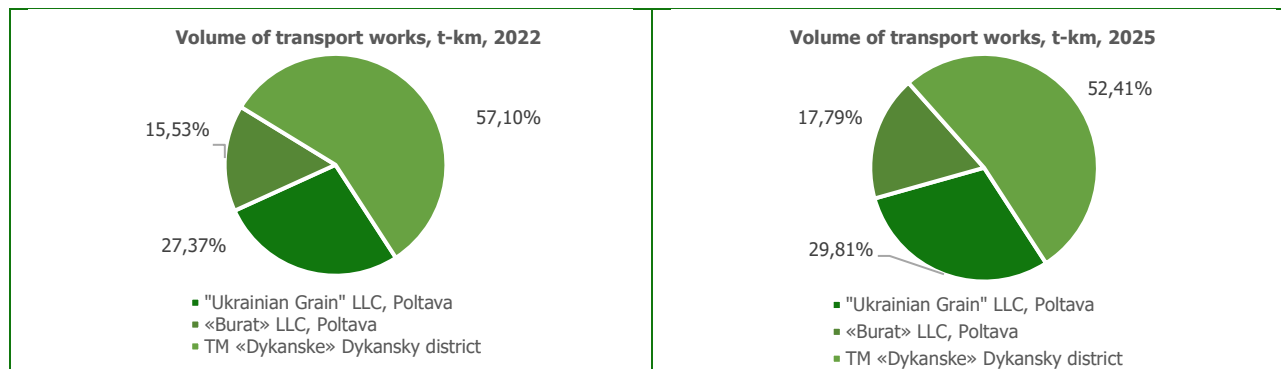


Figure 5. Actual and forecast volume of transport works from the supplier (three warehouses) SE "DG Stepne" of Poltava district to three consumers, 2022, 2025.

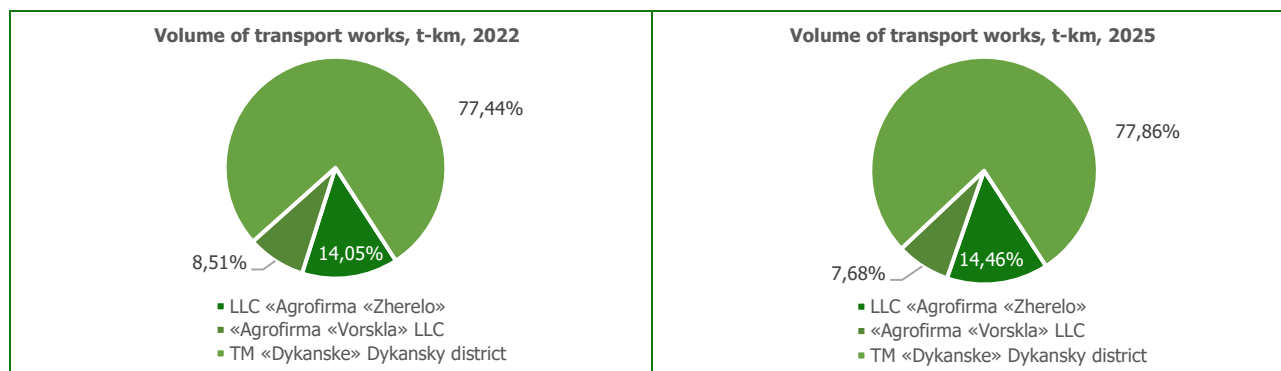


Figure 6. Actual and forecast volume of transport works from the supplier (three warehouses) of the PE "named after Kalashnikov" of the Poltava district to three consumers, 2022, 2025.

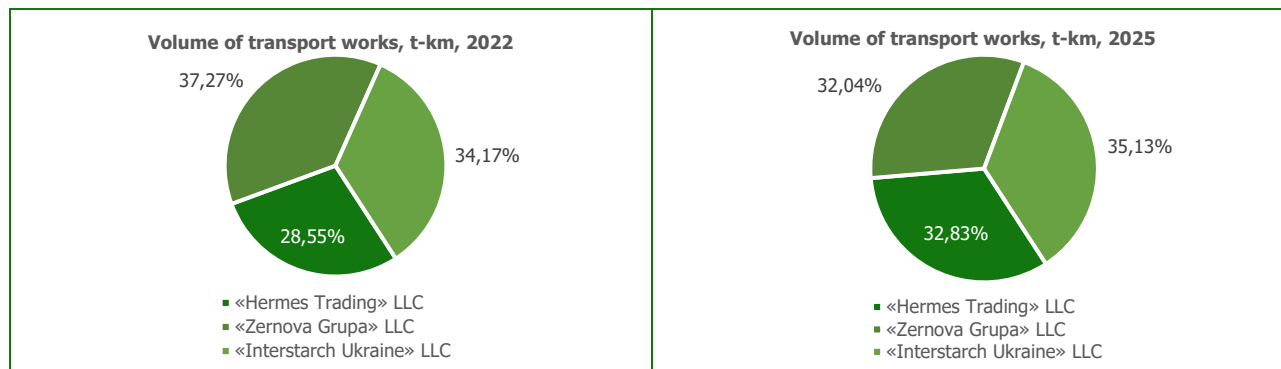


Figure 7. Actual and forecast volume of transport works from the supplier (three warehouses) LLC "Agrofirma "Zorya-Agro" of Myrhorod district to three consumers, 2022, 2025.

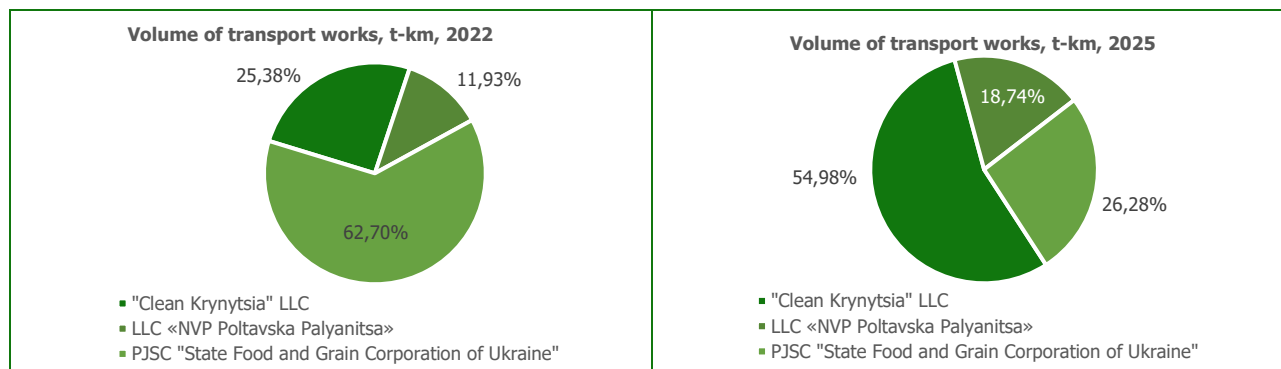


Figure 8. Actual and forecast volume of transport works from the supplier (three warehouses) "Promin-privat" LLC of Myrhorod district to three consumers, 2022, 2025.

Also, based on the calculations, Table 7 shows a comparison of the actual indicators of the volume of transport works in 2022, their forecast value in 2025, the absolute and relative deviation of the forecast 2025 from 2022, as well as their percentage increase or decrease in the investigated agricultural enterprises that transport agricultural products, in particular winter wheat to processors.

Table 8. Actual and forecast volume of transport work of agricultural enterprises when transporting winter wheat to processing enterprises, 2022, 2025.

Agricultural enterprises	Volume of transport works, t-km, 2022	Volume of transport works, t-km, 2025	Absolute deviation, +, -, 2025 from 2022.	Relative deviation, %, 2025 to 2022	Percentage increase/decrease
SE «DG Stepne» of Poltava district	65416.87	60722.60	-4694.27	92.82%	7.18%
PP «named after Kalashnyk» of Poltava district	93955.20	82306.40	-11648.80	87.60%	12.40%
LLC «Agrofirma «Zorya-Agro» of Myrhorod district	211492.67	209200.00	-2292.67	98.92%	1.08%
«Promin-privat» LLC of Myrhorod district	94576.00	80210.00	-14366.00	84.81%	15.19%

It is possible to trace the reduction of the volume of transport work of agricultural enterprises in the forecast year of 2025 thanks to the optimization of the winter wheat transportation plan of agricultural enterprises of the Poltava region from three warehouses of farms to three processing enterprises. Graphically, the actual and forecast volume of transport work of agricultural enterprises when transporting winter wheat to processing enterprises, in 2022 and 2025, is presented in Figure 9.

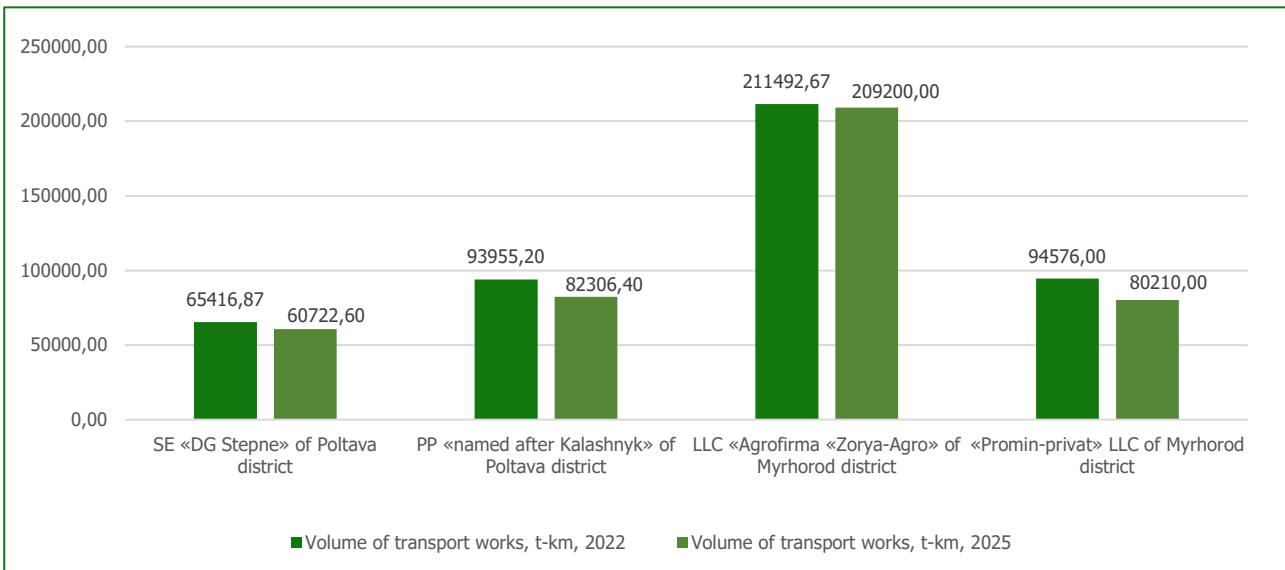


Figure 9. Actual and forecast volume of transport work of agricultural enterprises when transporting winter wheat to processing enterprises, 2022, 2025.

It should be noted that on the basis of the statistical reporting of the studied agricultural enterprises of the Poltava region and the previous optimization of the sown areas of these farms and obtaining the maximum profit of agricultural crops, in particular winter wheat, a comparative analysis of the actual and forecast indicators of production, sales, profit from sales and the determined level of marketability was carried out winter wheat. Such a comparative analysis was carried out to guide the direction of winter wheat sales to processing enterprises (Table 9).

Table 9. Main indicators of production activity of agricultural enterprises of the Poltava region, 2022, 2025.

Agricultural enterprises	Produced winter wheat in physical mass, annual report 2022, c.	Realized winter wheat in physical mass annual report 2022, c.	Marketability of winter wheat, %	Profit from the sale of winter wheat annual report 2022, UAH thousand	Maximum profit with the optimized area, UAH thousand	Optimized area, hect.
SE «DG Stepne» of Poltava district	17817	17147	96.24%	1811.00	1941.82	436
PP «named after Kalashnyk» of Poltava district	28090	27344	97.34%	2246.00	2264.34	327
LLC «Agrofirma «Zorya-Agro» of Myrhorod district	36400	34120	93.74%	3046.00	3180.85	1789
«Promin-privat» LLC of Myrhorod district	32120	30200	94.02%	6980.00	7296.88	909

Analyzing the main indicators of production and sale, marketability, profit and the forecast value of the profit of the studied agricultural enterprises, it should be noted a fairly high level of marketability, that is, agricultural products are high-quality, competitive, in demand and sold to processing enterprises. The forecast value of profit for 2025 when optimizing the sown areas of farms is higher than the value of 2022, which can positively affect production, sales activities and the efficiency of agriculture in general. At the end of the study, research, modelling and forecasting of logistics processes in agricultural enterprises, we will analyze the costs of production and sale of winter wheat by cost items, including costs of transportation, their absolute, relative deviation and percentage increase or decrease of these indicators (Table 10). Statistical reporting form No. 50 of the current year, primary documents of economic entities and modelled, forecasted and optimized volumes of transport works serve as information for processing these data of the studied agricultural enterprises.

Table 10. Costs for the production and sale of winter wheat by agricultural enterprises, 2022, 2025.

Agricultural enterprises	Costs for the production of winter wheat, UAH thousand						Total costs for the production of winter wheat, UAH thousand	Costs for transportation of winter wheat, UAH thousand, 2022	Costs for transportation of winter wheat, UAH thousand, 2025.	Absolute deviation, +, -, 2025 from 2022.	Relative deviation, %, 2025 to 2022	Percentage increase/decrease
	Salary expenses	Deductions for social events	The cost of oil products	The cost of fuel	Cost of spare parts	Amortization						
SE «DG Stepne» of Poltava district	462.95	101.82	230.82	21.50	237.86	92.27	1147.23	175.37	178.93	3.56	102.03%	2.03%
PP «named after Kalashnyk» of Poltava district	509.55	105.00	226.36	27.00	225.73	95.45	1189.09	126.56	128.47	1.91	101.51%	1.51%
LLC «Agrofirma «Zorya-Agro» of Myrhorod district	556.14	108.18	221.91	32.50	213.59	98.64	1230.95	171.81	169.95	-1.86	98.92%	1.08%
«Promin-privat» LLC of Myrhorod district	511.82	106.82	217.45	34.00	201.45	92.73	1164.27	123.10	128.15	5.05	104.10%	4.10%

Analyzing the calculation, we can conclude that winter wheat transportation costs are increasing to some extent: SE "DG Stepne" of Poltava district by 2.03%; PP "named after Kalashnyk" of Poltava district by 1.51%; "Promin-privat" LLC of Myrhorod district 4.10%. Only transport costs of LLC "Agrofirma "Zorya-Agro" of Myrhorod district decreased by 1.08%. The increase in costs for the transportation of winter wheat and agricultural products, in general, is natural and logical

when the cost of all components of the logistics system increases both internally and externally, regardless of the influence of the business entity. Graphically, the cumulative histogram of costs for the production and sale of winter wheat by agricultural enterprises, in 2022, according to their articles, is presented in Figure 10.

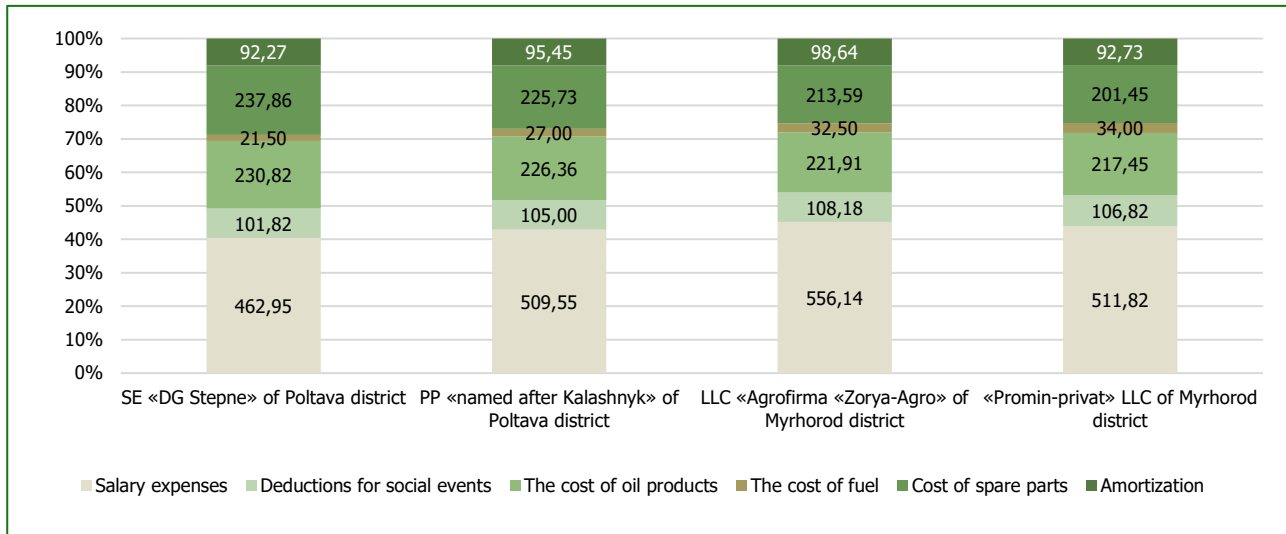


Figure 10. Costs for the production and sale of winter wheat by agricultural enterprises, 2022.

Also, the actual and forecasted costs of transporting winter wheat by agricultural enterprises to processing enterprises, in 2022 and 2025, are presented (Figure 11).

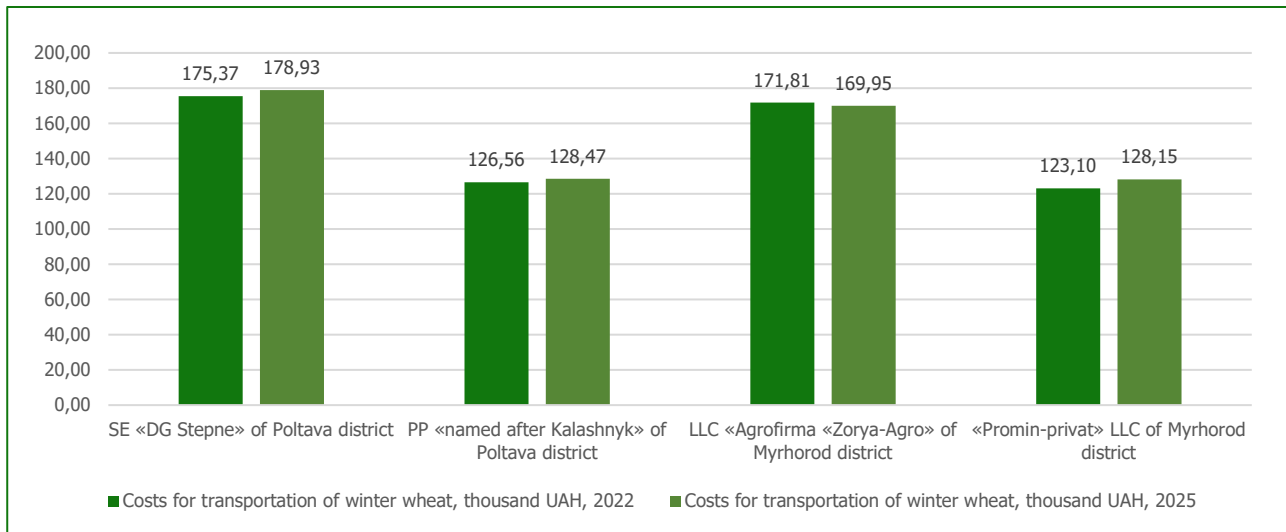


Figure 11. Actual and forecast costs for the transportation of winter wheat by agricultural enterprises to processing enterprises, 2022, 2025.

We are obviously observing, as previously mentioned, the growth of costs for the transportation of winter wheat from agrarian enterprises to processing enterprises. Therefore, business entities need to find reserves to reduce costs, which is quite problematic, but possible.

DISCUSSION

A thorough analysis of the issue of sustainable development of innovatively oriented enterprises by means of logistics management testifies to the ambiguity and fragmentation of its illumination in the scientific world. Many authors thoroughly analyze logistics processes (Vyshnevskaya et al., 2015; Kovalchuk, 2011; Bosona and Gebresenbet, 2013), but their research does not meet the modern requirements of the market in which agribusiness operates. These works are important for scientists but require improvement and deepening of the methodological component. In the works (Zhyvko et al., 2022;

Gryshchenko et al., 2021; Ovcharenko et al., 2022), a valuable toolkit that can be adapted for agricultural enterprises is proposed, at the same time, they do not take into account the activities of innovative enterprises. There is no such problem in our methodology because we have adapted our methodology to the activities of innovative entrepreneurs. The authors (Tzounis et al., 2017; Coley et al., 2009) examine the agricultural sector in a fragmented way and offer almost no real proposals for improving the storage and transportation of products, which is absolutely necessary for modern agribusiness. In general, our research solves the problems of logistics management more thoroughly than the literary sources we analyze, namely, our research takes into account the temporal theory. Temporal theory in the logistics of agricultural enterprises studies the temporal aspects of logistics processes and the influence of time on the efficiency of these enterprises. It takes into account various aspects of time, such as delivery times, scheduling, storage time, operating cycles and others. With the use of our methodology, it is possible to take into account and optimize the time of delivery of agricultural products from the field to the receiver, which is an important aspect of temporal logistics. This includes developing optimal delivery routes and schedules to ensure on-time deliveries. In general, our methodology, relative to others existing in the scientific world, helps enterprises to effectively use time resources, improve the efficiency of logistics processes and ensure timely deliveries, which affects the overall competitiveness and success of the business.

CONCLUSIONS

We can state the key role of logistics management at agricultural enterprises in reducing operational costs and ensuring sustainable development. Logistics management is becoming increasingly important, as it covers all stages of product transportation, which are fundamental aspects for maintaining the sustainability of agricultural business. One of the key elements of effective logistics management is the provision of the required amount of information and the optimization of complex of information flows, which allows enterprises to effectively plan, manage stocks, coordinate deliveries and ensure timely transportation. The involvement of economic-mathematical methods and models in the analysis and optimization of logistics management allows to detail and forecast its result, which contributes to the adoption of more reasonable management decisions. Effective logistics management at agricultural enterprises not only helps to increase profitability but also creates conditions for further innovative business development, improvement of competitiveness and expansion of sales markets. Therefore, improving logistics management and systems in agriculture is an important step to ensure the sustainable development of the industry.

ADDITIONAL INFORMATION

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Writing – original draft: Volodymyr Pysarenko, Nadia Bahan, Vitalii Sobchyshyn, Roman Gawrych, Ireneusz Zuchowski, Nataliia Moshenets

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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СТАЛИЙ РОЗВИТОК АГРАРНИХ ІННОВАЦІЙНО ОРІЄНТОВАНИХ ПІДПРИЄМСТВ ЗАСОБАМИ ЛОГІСТИЧНОГО МЕНЕДЖМЕНТУ

У статті визначені ключові аспекти забезпечення та діагностики сталого розвитку аграрних інноваційно орієнтованих підприємств засобами логістичного менеджменту. Акцентовано увагу на важливості вдосконалення логістичного менеджменту, який відіграє значну роль у забезпеченні ефективного руху сільськогосподарської продукції від виробника до споживача. Визначено, що ефективний логістичний менеджмент спроможний забезпечити сталий розвиток аграрних інноваційно орієнтованих підприємств, які через специфіку своєї діяльності особливо ризикують на ринкові. Діагностику сталого розвитку аграрних інноваційно орієнтованих підприємств засобами логістичного менеджменту запропоновано здійснювати методом транспортного лінійного програмування. Цей метод апробовано на прикладі діяльності чотирьох інноваційно орієнтованих аграрних підприємств: ДП «ДГ «Степне» Полтавського району, ПП «ім. Калашника» Полтавського району, ТОВ «Агрофірма «Зоря-Агро» Миргородського району та ТОВ «Промінь-приват» Миргородського району. Отримані результати дозволяють будь-якому підприємству з використанням інструментарію лінійного програмування моделювати стратегію сталого розвитку аграрних інноваційно орієнтованих підприємств засобами логістичного менеджменту.

Ключові слова: логістичний менеджмент, аграрні підприємства, сталий розвиток, витрати на виробництво, сільськогосподарська продукція, переробні підприємства, інноваційна діяльність

JEL Класифікація: J43, O32, Q16