MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF TRANSPORT, MANAGEMENT AND LOGISTICS
DEPARTMENT OF ORGANIZATION OF AVIATION WORKS AND SERVICES

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Head of the Department
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QUALIFICATION PAPER
(EXPLANATORY NOTES)

GRADUATE DEGREE OF EDUCATION
"MASTER"
SPECIALITY 275 “TRANSPORT TECHNOLOGIES (BY AIR)”
SPECIALIZATION 275.04 “TRANSPORT TECHNOLOGIES (BY AIR)”
EDUCATIONAL PROFESSIONAL PROGRAM "MULTIMODAL TRANSPORT AND LOGISTICS"

Topic: «Optimization of transport process technologies between logistics systems**»**

Done by: Kateryna Dmytrivna Nesterenko, MT-205Ma
(recipient, group, surname, first name, patronymic)

Head: Viktoriia V. Klymenko, PhD in Economics, Associate Professor
(academic degree, academic title, surname, first name, patronymic)

Standards Inspector: _________ Viktor E. Osmak________
(signature) (surname, first name, patronymic)

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NATIONAL AVIATION UNIVERSITY

Faculty of Transport, Management and Logistics
Department of Organization of Aviation Works and Services
Specialty 275 "Transport technologies (by air)"
Specialization 275.04 "Transport technologies (by air)"
Educational professional program: "Multimodal transport and logistics"

ADMIT TO DEFENSE
Head of the graduation department
_____________ K.M. Razumova
«____»_______________2023 р.

TASK
of completion the qualification paper
Kateryna Dmytrivna Nesterenko
(full name of the graduate)

1. The topic of the qualification paper entitled: " Optimization of transport process technologies between logistics systems" was approved by a decree of the Rector of September 21, 2023 order No. 1875.

2. Term performance of qualification paper is 01.09.2023 – 25.12.2023.

3. Initial data required for writing the qualification paper: data of Baryshivska Grain Company LLC, statistics of the Baryshivska Grain Company LLC, information about transport technologies at Baryshivska Grain Company LLC.

4. Content of the explanatory note to the qualification paper: peculiarities of logistic characteristics of optimization technologies in transport processes, mechanisms for evaluating transport processes within logistics system of Grain Alliance, improvement of “Grain Alliance” activities due to optimization of logistics system.

5. List of mandatory graphic (illustrated) material: statistical graphs and indicators of transportation and financial activity of Baryshivska Grain Company LLC, dynamics of financial indicators of activity of the company, technical characteristics of transport equipment.

6. Planning calendar

№	Assignment	Deadline for completion	Mark on completion
1.	Collection and processing of statistical data	01.09.2023 - 21.09.2023	done
2.	Writing of the analytical part	18.09.2023 - 13.10.2023	done
3.	Writing of the design part	13.10.2023 - 03.11.2023	done
4.	Writing of the introduction and summary	03.11.2023 - 22.11.2023.	done
5.	Execution of the explanatory note, graphic matters and the presentation	22.11.2023 - 09.12.2023.	done

7. Consultants from individual sections

Section	Consultant (position, P.I.B.)	Date, signature	
		Issued the task	I accepted the task
1. Theoretical part	Klymenko V.V.	07.09.2023	12.09.2023.
2. Analytical part	Klymenko V.V.	10.10.2023.	14.10.2023.
3. Project part	Klymenko V.V.	30.10.2023	15.11.2023.

8. Given date of the task: 29.08.2023

Supervisor of the qualification paper: ____________________ _Klymenko V.V. _
(signature) (surname, first name, patronymic)

Task was accepted for completion:____________________ _Kateryna D. Nesterenko_
(signature) (surname, first name, patronymic)

ABSTRACT

The explanatory notes to the qualification paper on the theme “Optimization of transport process technologies between logistics systems” comprises of 119 pages, 19 tables, 19 figures and 43 references.

KEY WORDS: LOGISTICS, ORTIMIZATION, TRANSPORT, TECHNOLOGIES.

The relevance of the qualification paper. In the current conditions in Ukraine, the relevance of the complex formation of the material and technical base in agriculture and its rational use is growing. One of the main places in the material and technical base is given to transport. The completeness and timeliness of technological processes, as well as the level of productivity of the crop and animal husbandry industries, depend on the coordinated and rhythmic operation of transport.

The purpose of the research is to analyze, justify and develop recommendations for optimizing the harvesting and transportation of grain to the elevator.

The object of the research is transport process technologies in logistics systems.

The subject of the research is the theoretical basis and practical solutions for improving the process of harvesting and transportation of grain crops of Grain Alliance (Baryshivska Grain Company LLC).

The research methods. The research methods such as statistical analysis, comparative and graphical analysis, SWOT-analysis, systematization and generalization, statistical methods of numerical data research were used: economic analysis method - for research changes in economic indicators of the enterprise, the method of discounting - to determine the effectiveness of the proposed project.

The results of work. It was proposed to implement a project for improving the process of harvesting and transportation of grain crops using a hopper-transloader of grain.

Recommendations for the use of work results. The results of the study can be used by domestic agricultural companies to improve the process of harvesting and transportation of grain crops, in particular LLC " Baryshivska Grain Company ".

The results of research implementation. The proposals developed in the thesis were presented to the management of Baryshivska Grain Company LLC, where the possibility of their practical application was recognized (Appendix A).

LIST OF CONVENTIONAL SIGNS, ABBREVIATIONS AND TERMS

LLC- Limited liability company

FCA- Functional cost analysis

UAH- Ukrainian Hryvnia

SEK- Swedish crown

LCC- Life Cycle Cost

EVA- Economic Value Added

WMS- Warehouse Management Systems

IoT- Internet of Things

CONTENT

INTRODUCTION

The relevance of the qualification paper. In the current conditions in Ukraine, the relevance of the complex formation of the material and technical base in agriculture and its rational use is growing. One of the main places in the material and technical base is given to transport. The completeness and timeliness of technological processes, as well as the level of productivity of the crop and animal husbandry industries, depend on the coordinated and rhythmic operation of transport.

The purpose of the research is to analyze, justify and develop recommendations for optimizing the harvesting and transportation of grain to the elevator.

The main tasks the research are:

- studying logistic criteria as diagnostic indicators of the level of efficiency of transport processes;
- disclosing the optimization principles as mechanisms for ensuring the efficiency of technologies in transport processes;
- analyzing the Grain Alliance (Baryshivska Grain Company LLC) economic activity and logistics system;
- assessing performance indicators of the Grain Alliance complex transport components and logistics system;
- determining possible ways to develop logistics system of Grain Alliance;
- developing proposals to optimize logistics processes of the "Grain Alliance" and evaluating their efficiency.

The object of the research is transport process technologies in logistics systems.

The subject of the research is the theoretical basis and practical solutions for improving the process of harvesting and transportation of grain crops of Grain Alliance (Baryshivska Grain Company LLC).

The theoretical basis of the research is the results of theoretical, research, experimental and analytical developments of domestic and foreign experts, scientists and specialists in the field of economic management and logistics activities, analytically processed statistical data on the development of logistics activities in agro business for 2016-2023, available reports and forecast data of international organizations regarding economic development trends.

The practical basis of the study is the analytically processed statistical data on the development of logistics activities for 2016-2023, the available reporting and forecast data of the Baryshivska Grain Company LLC regarding the management of logistics activities.

The basis of the research was Baryshivska Grain Company LLC.

Research methods. Research methods such as statistical analysis, comparative and graphic analysis, SWOT analysis, systematization and generalization, statistical methods of numerical data research were used in the work: the economic analysis method - for researching changes in the economic indicators of the enterprise, the discounting method - for determining the effectiveness of the proposed project.

The information base of the study was: laws of Ukraine, regulatory acts of the Cabinet of Ministers of Ukraine, official data of the State Statistics Service of Ukraine and the European Statistical Bureau, the Organization for Economic Cooperation and Development, the Agency for the Development of the Infrastructure of the Stock Market of Ukraine, data from the financial and management reporting of enterprises, the results of their own research, scientific publications, Internet resources.

Practical significance. Conclusions and recommendations be applied to the management of logistics activities of Baryshivska Grain Company LLC, which will allow to optimize the transport logistics of the enterprise, strengthen its position on the market, and increase the competitiveness of the enterprise.

CHAPTER 1

PECULIARITIES OF LOGISTIC CHARACTERISTICS OF OPTIMIZATION TECHNOLOGIES IN TRANSPORT PROCESSES

1.1. Logistic criteria as diagnostic indicators of the level of efficiency of transport processes.

It is very important for logistics companies to save on transport costs, and it is also very important for society as a whole. In order to minimize transport costs, an important issue is how to select and evaluate logistics service providers scientifically correctly. Evaluation of transportation efficiency is an important component for consideration of logistics service providers.

Evaluation of the efficiency of transportation refers to the evaluation of the efficiency of the transport activity or the transport process. As a rule, it meets the uniform evaluation criteria, adopting a certain system of indices, following certain procedures, using qualitative and quantitative methods, making a comprehensive judgment about a certain period of time of the transport activity or the efficiency and effectiveness of the process. Evaluation of transport efficiency is the main steps for logistics enterprises and other related enterprises. With the help of evaluation of transportation efficiency, logistics companies can optimize the process, improve economic benefits [1].

The process of cargo transportation affects a large number of participants in the transportation process and must be considered comprehensively on the basis of technology agreed by all parties and based on regulatory documents or the results of engineering preparation of transportation. Value and some natural indicators can characterize changes that occur both in separate systems of transportation, production, storage, consumption, and in total.

One of the main aspects is the criteria for the efficiency of product delivery. Its choice depends on the specific conditions of transportation and the task to be solved. The national economic efficiency of the delivery process depends on many factors that make it difficult to determine the criterion of optimality in general. The solution to the tasks of organizing the rational interaction of the processes of the production, material and technical supply and consumption systems with the processes of transport and the interaction of individual types of transport makes it necessary to consider integral integrated transport and technological systems.

At the same time, a higher overall efficiency is ensured in comparison with the total efficiency of the parts taken separately. The economic efficiency of the transport process is evaluated by local and complex, natural and economic indicators, as well as indicators of the non-transport effect. Local efficiency criteria are applied if the compared transportation options differ in one single indicator. Complex performance indicators are used when the measures taken simultaneously change several characteristics of the transport process. Technological parameters of the transport process are often used as local or partial efficiency indicators. Most scientists accept minimum costs as a criterion for optimization, although in some cases it is suggested to maximize volumes and profits. However, in the conditions of variable demand, cost minimization does not give a complete picture of the successful operation of the system [2].

Transport logistics, as an integral part of the overall logistics system, helps to solve three main tasks of this system, namely the tasks related to:

1) formation of service market areas, material flow forecasting, material flow processing in the serviced system (supplier, consumer, wholesale trade company warehouse) and other work on operational management and regulation of material flow;

2) development of a transport process organization system (transportation plan, activity distribution plan, cargo flow formation plan, vehicle movement schedule, etc.);

3) management of stocks and their maintenance by vehicles, information systems [3].

Based on the tasks of transport logistics, it is also possible to determine the main criteria for the efficiency of transport logistics (Table 1.1).

Table 1.1

The main criteria for the efficiency of transport logistics

Indicator	Calculation method	Explanation
Congestion of transport capacities	$\frac{Actual\ loading\ capacities}{Normative\ loading\ capacities} \times 100$	The indicator characterizes the actual load of transport capacities and reflects how efficiently the enterprise uses vehicles.
Profitability of sales channels	$\frac{The\ amount\ of\ gross\ profit}{Total\ expenses\ for\ sale\ of\ products} \times 100$	The indicator reflects how profitable the transport logistics of the enterprise is.
Reliability of delivery	$\frac{Number\ of\ on\ time\ completed\ orders}{Total\ number\ of\ orders} \times 100$	It is one of the basic indicators of the quality of work of a transport enterprise and is one of the decisive factors in the choice of a carrier by a client.
Summarized national economic expenses	$E_1 + k_n + E_2$, where E_1 is operating costs, k_n is the normative efficiency ratio of capital investments, E_2 is capital investment in permanent devices, rolling stock, cargo weight.	The indicator reflects the amount of current costs and capital investments in the transport component.
Productivity of the vehicle	$\frac{T \times g \times k}{\frac{2L}{V}+t}$, where T is the duration of the shift (8 hours), g is the carrying capacity of the car, t; k – coefficient of use of motor vehicles per shift, L - average distance of cargo transportation, km; V – average speed of movement, km/h; t is the idle time of the vehicle under load and unloading.	The indicator reflects how efficient the use of vehicles is.

Source: developed by the author based on [4]

Costs and delivery time play a key role in choosing a transportation method. Since costs are an assessment criterion for determining the optimal technological scheme of transportation, one cannot fail to take into account the fact that costs depend on the term of cargo delivery. As the delivery time increases or decreases, the transportation costs also change. In addition, delivery time is one of the main indicators, as it defines the latest logistics concepts, where time plays a key role.

On the other hand, it is the transit time that testifies to the reliability of the selected transportation scheme. In addition, reducing the delivery time usually gives the company significant competitive advantages in the finished products market. Therefore, it is worth setting the term of cargo delivery as a generalizing parameter.

Also, among the set of criteria that are used in solving problems of transportation organization, the following are of greatest interest:

- delivery of goods "just in time";
- duration of cargo delivery;
- cargo transportation costs;
- performance of vehicles;
- productivity of loading and unloading mechanisms;
- energy intensity of transport and technological operations;
- energy consumption of transportation;
- specific labor intensity of the complex of transport and technological operations;
- cost of transportation;
- profit from transportation [4].

"Just-in-time" cargo delivery is characterized by meeting the demands of consumers for cargo transportation within the scheduled time. This is achieved by the rational coordination of the operation of transport and systems that serve and consume transport products, that is, the service. The criterion is the actual time of cargo delivery, which must be less than the time specified in the cargo transportation contract. The actual delivery time affects the length of the turnover period of material resources. Its reduction allows you to free up part of the material resources for further production use. Nevertheless, the optimization criterion chosen for the specific conditions of the task (determination of a rational variant of the organization of delivery) should reflect the final results of production activities. For the carrier, the cost of delivery is of primary importance. One of the most important criteria from the point of view of the consumer of transport services is the total cost of delivering products from the supplier's warehouse to the consumer's warehouse, i.e. the total costs of the entire logistics chain. Therefore, the cost of transportation is often chosen as a criterion of optimality. The cost of transportation is a general indicator of the operation of transport and represents the cost of performing a unit of transport products. The authors in [5] proposed aggregated national and economic costs as a criterion for the efficiency of transport logistics.

Some authors claim that the criterion of efficiency should be profit maximization. However, such an approach can be focused on changing the tariff policy and increasing the volume of services without implementing rational technological measures. In the paper [6], the indicator that takes into account the ratio of profit and income using the energy approach when determining the constituent parts of these characteristics was chosen as a criterion for the efficiency of the operation of road transport in the logistics system.

In the paper [7], it is proposed to use the specific costs related to the completed transport work as a criterion for choosing a delivery scheme. This indicator can be used for significant transportation distances, which are relatively close in value for alternative schemes. Otherwise, it is clear in advance that the rational delivery scheme will turn out to be the one where the value of the transportation distance is the greatest, and this leads to the deterioration of other technological parameters, such as, delivery time, irrational use of rolling stock, etc. When choosing optimal routes based on the criterion of total transport costs, the costs of transportation in general are taken into account, but this does not give the delivery subjects complete information about the time of delivery of the cargo [8].

Since the operational costs of cargo delivery have the largest share, the total costs tend to increase with the increase of the consignment. In general, the proposed criterion has advantages, but the most appropriate is the use of specific costs. To choose the optimal type of connection in the work [9], the author proposed as an efficiency criterion the total costs, which take into account the total costs of the customer of the transport service, related to the costs of delivery and ensuring the quality of customer service. However, such a criterion takes into account only the interests of the cargo owner, does not take into account the size of the consignment and the competitive advantages of individual transport and technological schemes. In [10], a criterion for the effectiveness of the interaction between the RRC and cargo owners is proposed, which is an integrated total effect from a reduction in transportation costs, from a reduction in cargo delivery terms, as a result of which there is a decrease in the duration of the capital turnover cycle for cargo owners, from an increase in the inflow of funds in budget due to the reduction of cargo delivery times. However, this criterion does not take into account the risks that are characteristic of market situations, especially when individual subsystems interact.

Zeitgaml's gap model should also be considered to assess the reasons for consumer dissatisfaction with the quality of transport and forwarding services. This model describes the way to realize the expectations of buyers regarding the quality of the transport service and the reasons for possible dissatisfaction (Fig. 1.1).

In the scheme of Fig. 1.1 highlights five reasons and corresponding levels of customer dissatisfaction with the quality of transport and logistics services in the organization of freight transportation. Thus, we highlight five "discrepancies":

1. Gap 1 – the difference (gap) between the consumer's expectations of the quality of the transport and logistics service and the perception of these expectations by the company's logistics management;

2. Gap 2 – the difference between the perception of customer expectations by the company's logistics management and the specifications that determine the quality of the transport and logistics service;

3. Gap 3 – the difference between the service quality specification standards and the actual "delivery" of logistics services;

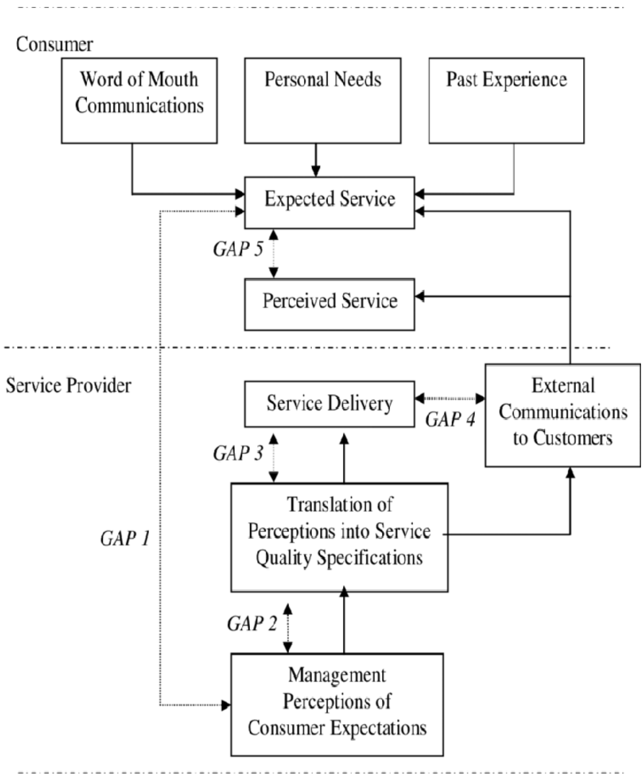

Fig. 1.1 Scheme of discrepancies in Zeitgaml's GAP model [11]

4. Gap 4 - gap between the quality of the provided services and external information about this quality, usually through marketing communications;

5. Gap 5 – the gap between the formed expectations of consumers regarding the quality of the service and the actually received service and, accordingly, its perception [11].

Therefore, the efficiency of transportation is evaluated by a system of indicators, among which special attention is paid to the following: duration and timeliness of cargo delivery; cargo loss during transportation; performance of vehicles and loading and unloading mechanisms; energy intensity of transportation; delivery cost, transport enterprise profit. The following criteria can also be used: general costs for cargo delivery, specific costs related to 1 ton of cargo, reduced costs, etc. Scientists propose to use a multi-criteria approach in transportation planning, which helps to choose a rational process flow technology and increase its efficiency. However, the criteria proposed by the authors do not describe in sufficient detail the process of transporting goods in international traffic, and do not take into account the peculiarities of customs procedures. Risks are not the least important.

Based on the results of the analysis, efficiency criteria can be classified by scope of application (choice of delivery method, choice of transport and technological scheme of delivery, evaluation of the effectiveness of the functioning of individual types of transport and logistics systems as a whole), by type of indicator (economic, technological, environmental), by the number of indicators, that are taken into account (one, several, multiple), taking into account the operating conditions (for constant conditions, for conditions of uncertainty, for the presence of risk). It was determined that most of the proposed criteria do not have a universal character, but take into account partial operating conditions. In order to assess the effectiveness of logistics systems during cargo delivery, the researchers do not fully take into account the requirements put forward by all participants in the delivery process in view of the competitive market environment. A multi-criteria assessment is necessary when forming criteria for the efficiency of logistics systems. The complexity of the multi-criteria approach to the considered problem of choosing a method of delivery organization lies in the multidirectionality of the criteria, the different dimensions, and the qualitative nature of many indicators. Approaches that take into account the complex nature should be noted as promising directions for the formation of criteria for the efficiency of logistics systems functioning, but they require formalization [4].

According to [12], the development of economic relations against the backdrop of globalization of the economies of the world is a source of further transformations in the relationships between market participants. There is a search for new methods and forms of business organization, the driving force of which is the actions of innovators. The logistics approach is becoming widespread. According to this approach, the activities of market participants can be considered as activities within the logistics system or a set of such systems. Against this background, the lines between the known concepts of other systems are blurred. This is especially evident in relation to transport systems. Thus, the transport system belongs to the group of logistics tools along with the warehousing system and information technology. In our opinion, it is more correct to use the term transport subsystem in this case, because in its pure form, the transport system of a city, region, etc. serves a number of logistics systems, and is not just part of a separate logistics system. The integration processes that are observed between participants in the promotion of material flows within the framework of the logistics approach necessitate the development and application of more advanced methods and management tools. A certain scientific and practical interest in this direction is represented by such an area as diagnostics. This direction is becoming widespread when considering economic systems, borrowing and adopting experience from systems of various natures (primarily biological and technical systems). In the field of transport, diagnostics, as a tool for optimizing organizational issues and planning activities, is just beginning to be explored. There are some attempts in this direction. You can give an example [13], which presents the section "Diagnostics of the functioning of the transport complex in the region." At the same time, no description of diagnostic tools, goals, objectives and other attributes of this area is given. There is experience in using diagnostics in transport from the perspective of "diagnostic analysis", which is the second stage in the analysis of transportation management systems. Giving diagnostic status to the second stage is consistent with the "monitoring" stage that is currently being formed. However, there is currently no clear division of tasks performed within the framework of monitoring and diagnostics of transport and logistics systems. Therefore, we can consider the experience of using diagnostic analysis of transportation management systems as the basis for the development of diagnostic methodology in transport systems and, accordingly, for transport subsystems of logistics entities (systems). What is different from this approach is the use of diagnostics as a set of methods when analyzing logistics systems without indicating the relationship with the management system. When analyzing logistics systems, twelve stages are distinguished [12]. For the four stages it is indicated that diagnostic methods (diagnostic methods) can be used. These stages include: the first stage - analysis of the problem in the field of logistics services to consumers; third stage – analysis of the structure of the logistics system; tenth stage – analysis of the existing logistics system; the twelfth stage is the development of a logistics organization to achieve the goals of the logistics system. Consequently, we can say that diagnostics can be used in two aspects: as a stage in decision-making systems (management) and as a block of methods for the purpose of analyzing various objects. This division of diagnostics requires further research.

A large layer of information for the formation of diagnostic methodology in transport and logistics is found in technical and biological sciences. For technical systems, there are developed and used systems of state standards and regulations (such as, ODN 218.0.006-2002 "Rules for diagnostics and assessment of the condition of highways. Basic provisions"; R 50-609-44-89 Methods for determining diagnostic indicators; DSTU B V.2.6-25-03. Automated systems for technical diagnostics of building structures. Additional technical aids, etc.) [12]. In technical systems, diagnostic issues are associated with reliability. Such as, technical diagnostics is presented as one of the methods for increasing the reliability of systems at the stage of their operation. From here we can make the assumption that diagnostics within transport and logistics systems can act as a tool for increasing the reliability, safety, and reducing the risks of these systems. In this case, diagnostics falls under the second group (second aspect) of application. To summarize, we can talk about the need for further research on the formation of a knowledge system on the use of diagnostics in transport and logistics systems.

The analysis showed the importance of effective development of transport logistics. The main part of costs in logistics activities falls on the transport component. It has been established that road transport occupies the largest specific weight in the structure of public transport services.

Therefore, for effective transport logistics, the technical, technological, economic, information and management components should be taken into account. When choosing a carrier, it is necessary to take into account its positive and negative characteristics and calculate the probable risks of loss or lack of profit based on the criteria of the efficiency of transport logistics.

1.2. Optimization principles as mechanisms for ensuring the efficiency of technologies in transport processes

In general, the optimization logistics problem looks like this [14]:

$$\left.\begin{array}{c} y = f(x) \rightarrow max(min) \\ x \in X \end{array}\right\} \tag{1.1}$$

where X is a set of admissible plans (alternatives, actions, previous variants of logistic solutions); f is a numerical function defined on the set X, which together with the maximization or minimization requirement is called the objective function.

The solution of the optimization logistic problem (1.1) forms a pair X *, y*, where X * is a set of optimal plans, y* is the optimal (maximum, largest or minimum, smallest – depending on the optimization direction) value of the objective function achieved by it on the set of admissible plans X. They are usually limited to a partial (rather than general) solution of the problem, determining only one among the set of optimal plans, and not the entire set.

They find a solution to the optimization logistics problem using special mathematical optimization methods, computer programs and computer tools based on the appropriate source information. [14]

An arbitrary optimization logistic problem contains two components: an objective function and constraints. The objective function formalizes the criterion of optimality, according to which the best one is determined among alternative options of logistics solutions. Constraints, on the other hand, define a set of acceptable alternatives. Constraints are given in the form of inequalities and/or equations.

For the most part, optimization logistics problems are multidimensional and generally look like this:

$$\left.\begin{aligned} y = f(x_1, \dots, x_n) \to max(min) \\ g_i(x_1, \dots, x_n) \le 0, i = \overline{1, m} \\ h_k(x_1, \dots, x_n) = 0, k = \overline{1, p} \end{aligned}\right\} \qquad (1.2)$$

where x_1, ..., x_n and y – are real variables (controlled parameters), the first n of which are the main ones and form the plan $x = (x_1, \dots, x_n)$ of the problem, and the last one shows the corresponding value of the objective function; f, g_i, $i = \overline{1, m}$, h_k, $k = \overline{1, p}$ are numerical functions of the variables x_1, ..., x_n (the first function is the target, and the others are used to reflect the set of admissible plans).

If in (1.2) each of the functions f, g_i, $i = \overline{1, m}$, h_k, $k = \overline{1, p}$, is linear, we have a linear programming problem; otherwise, it is a nonlinear programming problem. Common optimization logistic problems are linear. A non-linear objective function or individual constraints are found in cases where the dependencies between certain variables are non-linear. Among the constraints of the optimization logistic problem, there may be special ones, such as, restrictions on the sign of certain variables or requirements regarding their integer value. Such restrictions are distinguished by calling the non-distinguished restrictions the main ones, and the distinguished ones the additional ones. If there are no integer requirements among the additional constraints, we get a mathematical programming problem (linear or nonlinear) with continuous variables; otherwise, if one or more variables should acquire only integer (in the more general case – discrete) values – the problem of integer (discrete) mathematical programming.

Such as, the problem of optimizing the product transportation plan can be a problem of mathematical programming with continuous variables that reveal the volumes of transportation along the corresponding routes, and the problem of determining the optimal location of a new distribution center of the logistics network is a problem of mathematical programming with integer variables (more precisely, logical 0–1 variables), which values of 1 or 0 characterize the selection or, on the contrary, the refusal to select a certain point for placing a new distribution center in it.

The type of problem (linear, nonlinear, discrete) determines the methods that will be used to solve it, namely:

- linear programming (simplex method, dual simplex method, others);
- integer programming (methods of segmentation, branched search, combinatorial, heuristic, random search);
- non-linear programming (direct, indirect; design, linearization, etc.);
- others (depending on the specifics of the problem being solved).

A detailed description of linear, integer, and nonlinear programming methods is given in special literature on mathematical programming, as well as operations research, optimization methods, etc. [14–16].

It is advisable to implement optimization methods for solving optimization logistics tasks using computer equipment and special software. Important and interesting is the fact that progress in the field of economic-mathematical modeling and optimization methods occurs almost precisely in accordance with the progress in the field of computerization.

Optimization of logistics solutions is carried out on the basis of a comprehensive analysis of a complex of interdependent factors, definition and comparative evaluation of possible alternatives and permissible action plans.

Economic-mathematical modeling and optimization methods, as well as computing equipment and the necessary software, are used to find a solution to the optimization logistics problem.

The process of optimizing logistics solutions using economic and mathematical tools consists of the following main stages:

- awareness of the problem situation, formulation of the goal and determination of limitations;
- development of an economic-mathematical model;
- selection of methods and software tools for calculations;
- preparation of source information;
- search and analysis of solution options;
- adoption of the solution and approval of the plan for its implementation;

- control over the implementation of the solution and evaluation of the results;

- final analysis of the problem situation and its rethinking (with a return to the previous (initial) stage).

Therefore, it is appropriate to consider the optimization of logistics solutions as a cyclical process that is constantly renewed, and not only as a separate act of this process.

It is important that economic-mathematical modeling, i.e. recording in mathematical form the goals and constraints corresponding to the problem situation, is an important stage in the process of optimizing logistics solutions.

Examples of optimization logistics tasks are the following:

- formation of the most economical plan for transportation of products, raw materials or other production resources from suppliers to consumers - directly or through certain distribution centers;

- determination of the maximum capacity of the transport network;

- determination of the cheapest transport route between two specified points of the transport network;

- choosing the best location for the new distribution center of the logistics network;

- determination of the optimal management strategy for the supply of production resources or finished products;

- formation of an optimal real investment plan in order to ensure the necessary increase in the production capacity of logistics systems;

- development of systems for optimal management of stocks of raw materials, other production resources, manufactured products, etc.

Criterion is a basis for evaluating, defining or classifying something; measure. As is known, the criterion of the correctness of theoretical conclusions is practice. A logistic operation or an Ordinary Logistical Activity is any action that is not subject to further decomposition within the framework of a defined research or management task, related to the emergence, transformation or absorption of material and accompanying information and (or) financial flows [16].

The criteria of optimality (optimization) of logistics processes can be distinguished by the components of logistics activity: production, warehouse, transport, logistics system in general. In addition, two main groups of criteria can be distinguished - economic and technological. Of course, these criteria are closely related to each other, but it is considered appropriate to consider two separate groups.

The main economic criteria for optimizing logistics processes are costs and profit. All others are to varying degrees derived from these basic criteria. Such as, cost price, specified costs, market share, etc. [15].

In modern conditions, a question arises regarding modern cost optimization methods used in domestic enterprises (Fig. 1.2). But each of them has its advantages and disadvantages and can be used under certain conditions.

Such as, one of the most effective methods of identifying reserves for reducing the cost of production is functional cost analysis (FCA). Functional-cost analysis is a complex system analysis of the activity of the enterprise, its components (technical and technological, marketing, financial, sales units, management functions), as well as an assessment of the effectiveness of the use of costs for the implementation of each of these functions in order to identify inefficient, irrational costs, existing internal reserves and the development of programs to increase the efficiency of activities and increase the profitability of the enterprise.

The main advantages of FCA:

- a more accurate study of the cost of products, which makes it impossible to make sound strategic decisions regarding pricing of products, the choice between the possibilities of self-production and the purchase of semi-finished products;

- clarity of functions, with the help of which enterprises manage to pay more attention to increasing the efficiency of high-value operations, etc.

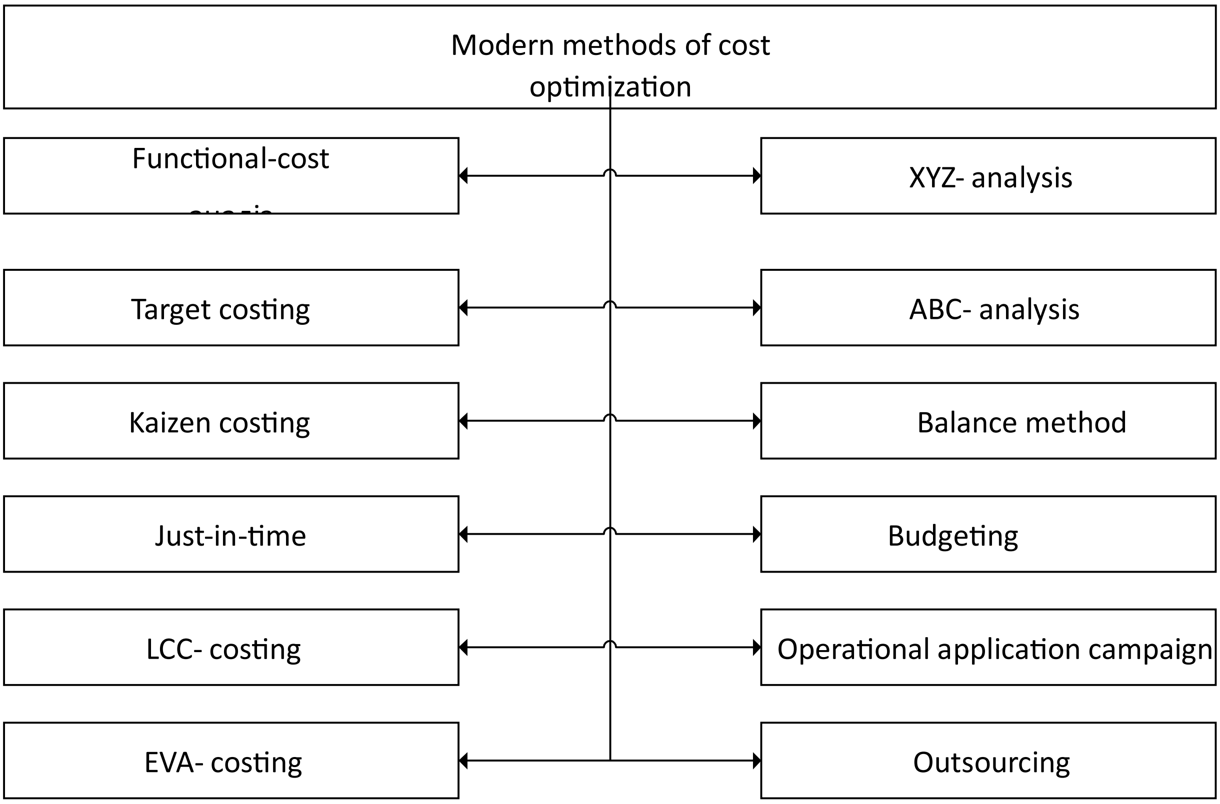

Fig. 1.2 Modern methods of cost optimization [15]

Disadvantages of functional cost analysis:

- the function description process may turn out to be too detailed; in addition, the model is quite complex to use, it is difficult to maintain;

- usually the stage of gathering information about data sources by functions is underestimated;

- for high-quality implementation of the method, special software tools are required;

- the method becomes "obsolete" in connection with organizational changes;

- the implementation of the method is considered as an unnecessary "fad" of financial management, not sufficiently supported by operational management.

A significant reduction in production costs is achieved as a result of the use of progressive methods of labor organization. An example of this is the "just-in-time" production organization system developed in Japan, which has become widely used throughout the world. The system reduces production costs due to the timely supply of resources.

The advantages of the "just-in-time" method include:

- reducing the production time of the final product;
- reduction of product storage costs;
- higher flexibility when modifying products;
- higher productivity;
- reduction of production preparation time;
- improved quality control;
- more uniform production schedule;
- minimum interruptions in production;
- low probability of overproduction.

The disadvantages of this method include:

- growing transport costs; storing goods in a warehouse may turn out to be cheaper than its constant supply;
- dependence on suppliers;
- the difficulty of ensuring high consistency between production states;
- significant risk of disruption of production and sale of products.

The next method - target costing - is a cost management method (costs for production of products), the essence of which is to reduce the cost of products during their entire production cycle due to the use of production, scientific research and development. "Target-costing" involves calculating the cost of the product on the basis of a predetermined sales price.

Advantages of target costing:

- marketing orientation of production;
- determination of target costs for new products;
- cost control at the product development stage.

Disadvantages of the method:

- targeted cost reduction may require a lot of time and investment;

- the technical capabilities of the enterprise do not always allow to reduce the cost price to a given level.

Another method - "kaizen-costing" - is the newest method of cost management, which is used to achieve target costing, but unlike "target-costing", it consists in continuous improvement of the quality of processes throughout the enterprise with the participation of all its employees, which enables reduce unproductive costs.

The main advantage of "kaizen-costing" is that it ensures a constant reduction of costs and keeping them at a given level, and the disadvantage is the need to motivate employees and corporate culture, which supports the involvement of personnel in the company's activities [15]. In addition, the disadvantage of this method is that it requires the motivation of employees, the involvement of additional personnel.

LCC (Life Cycle Cost) is a method of calculating costs by stages of the product life cycle. Planned costs are determined at each stage of the product life cycle. It is the only cost management method that takes into account the impact of inflation through cash flow discounting in decision making.

Advantages of the method:

- receiving in the long-term period an assessment of the incurred expenses and their coverage with the relevant income;

- provision of a clear forecast of all costs and the ratio of received income and costs for the production of the product in general;

- providing a strategic vision of the cost structure and comparing it with the income structure.

Disadvantages of the method:

- lack of periodization of financial results;

- uncertainty of overhead cost accounting;

- the probability of costs for obtaining significant additional information [15].

The newest method that has recently started to be used in cost management is EVA (Economic Value Added). This method makes it possible to tie the creation of value to certain groups of workers or units and thus obtain a criterion for differentiated remuneration for the work performed at the enterprise.

In addition, ABC analysis is becoming more widespread, which represents the justification and making of management decisions regarding the target localization of costs of a business entity for the needs of its profit management model. The basis of ABC analysis is the concept of "cost center" - a separate functional and organizational process or phenomenon associated with the formation of a homogeneous set of costs of the enterprise.

Advantages of ABC analysis:

- a significant increase in the substantiation of the allocation of overhead costs to a specific product, a clearer calculation of the cost price;

- ensuring the relationship of received information with the process of cost formation.

The main drawback of the method is that it requires a significant change in the accounting system and improvement of information support systems, which implies an increase in management costs.

An equally important method of cost optimization at the enterprise is the XYZ analysis, which is a technology for justifying management decisions regarding the optimization of the absolute value of the enterprise's costs by identifying and identifying reserves for their reduction, as well as determining methods for mobilizing such reserves.

Advantages of XYZ analysis:

- simplicity, accuracy and visibility,

- possibility of automation.

The disadvantages of the method are that it does not ensure the correctness of conclusions when building a complex, weakly structured product range.

Another cost optimization method is the balance method. As one of the strategic approaches to cost management, it is related to the fact that the goals set by the company are always balanced on the same scales as costs. Such as, if we want to produce higher quality products, the costs for quality assurance will be higher.

Budgeting, as a method of cost optimization, is based on drawing up operational, monthly, quarterly and annual budgets and linking them to strategic goals (using a system of balanced indicators), which makes it possible, at least, to make the appearance of costs predictable.

They also use such a method as cost optimization, an operational application campaign and a system for monitoring the implementation and appropriateness of costs. The essence of this method is that with daily expenses, line managers constantly need to confirm the feasibility of certain expenses. This system will work only when the enterprise has a correctly formed budget, outlined goals and has a motivational program to reduce costs.

Therefore, the listed methods (balances, budgeting, operational application campaign) require the introduction of information technologies. After all, if there is no system that will oblige everyone to report and control processes, the intentions to optimize costs will remain only on paper. With this in mind, among the methods of strategic cost management, it is worth highlighting outsourcing, i.e. the transfer of a part of the company's functions to third parties, or another type of outsourcing related to functions that are not key for the company. In this case, you need to find a contractor who can perform the same functions, but for less money.

The technological criteria include those that characterize or describe the technology of processes in the subsystems of the logistics system and in the system in general, in particular, the technology of transport, warehouse, production, etc. Examples of such criteria are idle mileage of the vehicle, delivery time, order fulfillment time, number of losses, number of stocks, etc.

A detailed analysis of the technological indicators of the optimization of the transport process in the logistics system is given in [17]. Evaluation of efficiency is always subjective and depends on who is interested in it and from which position of the transportation participant it is carried out. At the same time, many researchers emphasize the need to consider the efficiency of the transport process from the perspective of the system, that is, to take into account the interests of all participants. Such as, in the works, the authors define the following efficiency criteria from the point of view of the logistics system: speed and reliability of delivery, safety, volume of transported cargo, delivery costs. The researchers offer the following definition of the term logistics system efficiency: "This is an indicator (or a system of indicators) that characterizes the level of quality of the operation of the logistics system at a given level of total logistics costs." However, the authors do not provide adequate clarification regarding the term "quality level". This definition is abstract because the level of quality is very difficult to define, and sometimes impossible. At the same time, indicators that characterize the economic result of the operation of this system are mostly used as criteria for the functioning of the logistics system. The study of all aspects related to profit led to the understanding that the profit calculated in accounting does not reflect the true result of economic activity. Accounting profit is the result of carrying out various economic operations and comparing income with company expenses, and economic profit is a full-fledged, resulting assessment of the company's functioning.

Performance criteria from the point of view of the transport participant are local and complex indicators of performance evaluation. Local indicators include energy intensity, material intensity, technological indicators (average delivery distance, speed, zero mileage, etc.). Performance criteria of transportation, cost price, profit, income, reduced costs, profitability, labor intensity, transportation quality indicators are also considered as efficiency criteria. The criterion of efficiency is called the coefficient of efficiency of the transportation process. Some authors single out the following indicators of the efficiency of the technology of the transportation process: cost of transportation, transportation costs, productivity of vehicles, transportation quality.

It is also proposed to measure efficiency in logistics companies using a process approach based on cross-functional business process reengineering, customer-oriented, rather than a functional approach. The efficiency criteria are the following indicators: the coefficient of savings of contingent and permanent direct costs by operational departments and the integral indicator of client satisfaction in relation to the normative value. The disadvantage is the need to use weighting coefficients of significance, which can differ significantly for each individual client.

It is proposed to design a transport and technological system for the delivery of goods by road and rail modes of transport according to such an efficiency criterion as the minimum specific costs, taking into account the volume of transportation, the distance of transportation, the order arrival interval, and the number of available terminals. But in this case, other important factors that affect the choice of the mode of transport, such as the timeliness of transportation, the safety of the cargo, are not taken into account.

Therefore, according to the existing transport infrastructure, it is possible to distinguish different situations in which the optimal mode of transport is chosen according to different types of costs (Fig. 1.3).

Capital costs are considered to be the most important criterion in the absence of transport infrastructure, and operational costs in the case of its presence. The problem of determining rational areas of use in the logistics system in the presence of road and rail connections remains relevant even in our time. Further analysis of methods and models is carried out under the condition of availability of road and rail connections. The main efficiency criteria when choosing a mode of transport in the presence of transport infrastructure are the following: reduced costs for transportation; minimum reduced costs for production, transportation and consumption of products; expenses of the customer of the transport service; the profit that can be obtained from reducing the delivery time; equivalent distance; safety and environmental friendliness.

The author proposes to minimize the costs of production, transportation and consumption of products, that is, the system of participants in the transport process is considered. The criterion of specific costs is not sufficiently correlated with the obtained result regarding costs and does not fully meet the requirements of the market economy and the logistics system, because it cannot be determined for a separate logistics system.

Further analysis of the approaches is based on the calculation of costs that take into account the interests of the cargo owner or the requirements of the customer of the service.

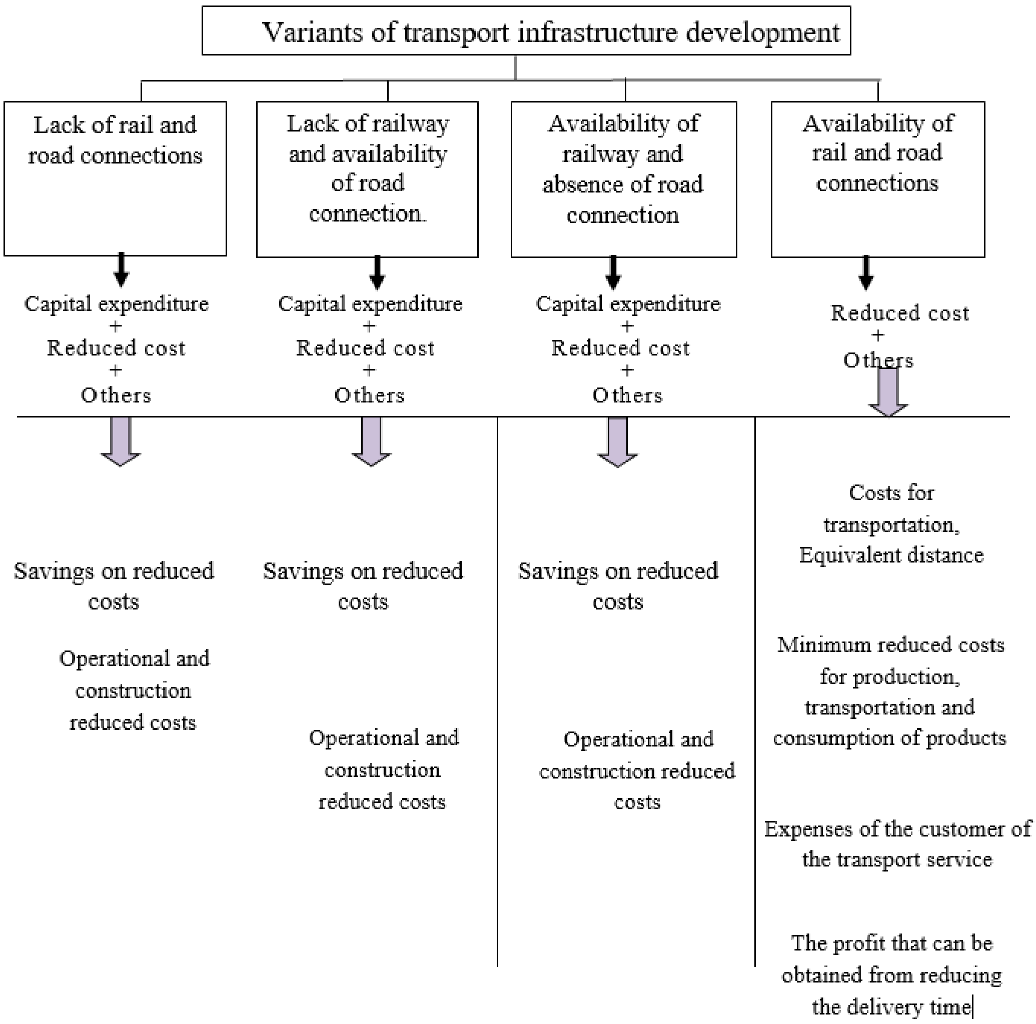

Fig. 1.3. Determination of the optimization (efficiency) criterion depending on the existing transport infrastructure

The criterion for the effectiveness of the functioning of the logistics systems of transport hubs is the proposed integrated total effect from the reduction of transportation costs, from the mobilization of free funds obtained during the reduction of cargo transportation terms, from the reduction of cargo losses during transportation, from the reduction of environmental damage. The disadvantage of this approach is that only the process of cargo transportation in the transport hub is investigated, but the technology of cargo transportation to the transport hub is not taken into account.

Areas of rational use of universal and perishable goods in international transport, which are calculated on the basis of the customer's costs, small batch goods and transportation for container goods, are considered. The disadvantage of these studies is the lack of a systematic approach to the participants of the transport process.

Conclusions to Chapter 1

In order to save transport costs, which play an important role both for a specific enterprise and for society as a whole, and for a more objective assessment and choice of transportation, a number of criteria for the efficiency of transport logistics were determined, namely: minimum costs for transportation, specified transit time, maximum reliability and safety, capacity and availability of the mode of transport, minimum costs (losses) associated with stocks in transit. The works of several authors were studied, from which it can be concluded that the efficiency of transportation is evaluated by a system of indicators, among which special attention is also paid to the following: duration and timeliness of cargo delivery; cargo loss during transportation; performance of vehicles and loading and unloading mechanisms; energy intensity of transportation; cost of delivery, profit.

Summarizing the above, it can be concluded that the existing approaches to determining the areas of use of modes of transport do not reflect the development of logistics concepts and modern requirements for the organization and implementation of the transport process, do not fully take into account the indicators of the choice of modes of transport and the influence of technological and economic parameters of the transport process on the distribution of volumes transportation between modes of transport. Researchers do not indicate the importance of one or another criterion when choosing road and rail modes of transport. Approaches and factors identified by researchers as the most important do not reflect modern realities. It is necessary to conduct a survey to rank the criteria for choosing a mode of transport in order to compare the theoretical and practical bases. This will make it possible to take into account the most significant criteria during the research.

Therefore, for the effective development of transport logistics, systematicity and consistency in decision-making are important: the unity of technical, technological, economic, informational and managerial components.

To make a decision and make calculations, you need to have one criteria. However, in practice, a situation often arises when it is necessary to use two, three or even more criteria. For this purpose, the applied problems refer to the problem of multi-criteria optimization.

CHAPTER 2
MECHANISMS FOR EVALUATING TRANSPORT PROCESSES WITHIN LOGISTICS SYSTEM OF GRAIN ALLIANCE

2.1. General characteristics of the Grain Alliance

Grain Alliance is one of the leading agricultural companies in Ukraine. The company cultivates around 57,000 hectares of arable land in central Ukraine. The company began operations in 1998 (Fig. 2.1). Initially, the company had no land, only equipment. Today it is a powerful enterprise that leases significant amounts of land in Kyiv, Poltava, Chernihiv and Cherkasy regions.

Fig. 2.1. Logo of Grain Alliance [21]

The geography of the company is constantly expanding, which indicates the confidence of landowners in it. Baryshivska Grain Company LLC grows and sells grain, oil and industrial crops, and produces meat and milk. It provides serviceson reception, primary processing and storage of grain in Baryshivskyi and Yahotynskyi districts of Kyiv region, Pyriatyn and Nizhyn. It has a bank of elevators with a total drying and storage capacityof 250 thousand tons. In addition, it carries out intermediary commercial activities for the purchase and sale of agricultural products. Profile crops of agricultural enterprises - corn, wheat, sunflower, soybeans.

However, the company's strategy is not to make a profit above all, but to manage wisely through the optimization of sown areas, soil conservation, respect for employees and landlords.

In 2008, the company was joined by Swedish investors Grain Alliance, which became full shareholders of the company. The company is currently headquartered in Stockholm, but all operations are concentrated in Ukraine. It is worth noting that the Ukrainian head office is located in the small town of Berezan, about 80 kilometres from Kyiv.

With the arrival of Swedish investors, a new stage in the development of Baryshevska Grain Company LLC began. During the first years of operation, more than $ 40 mln was investedin the development of the Company, which is aimed at technical re-equipment, introduction of new production technologies and selection of highly qualified personnel.[21]

The company's staff today has more than one thousand employees (Fig 2.2.).

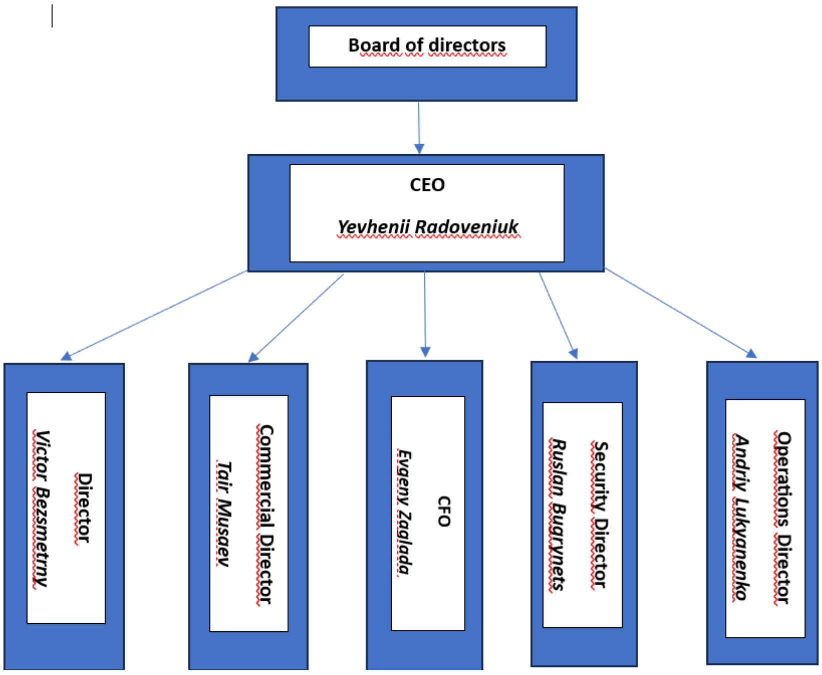

Fig. 2.2. Organizational structure of Grain Alliance [21]

For 20 years, the company has been actively developing and already has high achievements. In 2015, in the ranking of Forbes magazine, Baryshivska Grain Company

LLC took the second place in terms of efficiency in the agrarian business (in terms of profitability).

The agricultural enterprise attaches great importance to the culture of agriculture, development of all branches of agro-industrial complex, creation of new jobs. An important point is cooperation with local communities, creating good conditions for work, recreation and development.

Baryshivska Grain Company LLC carries out production activities in the following areas:

Crop production: the company currently leases almost 5,000 hectares of agricultural land in Kyiv, Cherkasy, Poltava and Chernihiv regions. The whole cycle of growing cereals is carried out by our own equipment.

Livestock: in the Poltava region there are two dairy farms of 1,000 cattle. Thanks to selection work, investments in farm equipment and a quality fodder base, we increase the quantitative and qualitative indicators of milk and maintain the profitability of production.

Elevators: the company has 5 elevators in Kyiv, Poltava and Chernihiv regions with a total storage capacity of 250 thousand tons. The Berezan and Yahotyn elevators have been modernized and their production capacities have been increased by 50,000 tons. The construction of the Pyriatyn elevator for 100,000 tons of storage has been completed. For the Nizhyn elevator the project for the second stage of construction has been developed (Table 2.1.).

Calibration facility: a modern grain calibration facility made in Japan is located in the village of Baryshivka with a capacity of 8 tons/hour. It enables to prepare high-quality sowing material and bring the quality of soybean grain to the requirements of world standards.

Table 2.1

Information on the activities of Baryshivska Grain Company LLC [21]

The area where the land is leased	***Structural unit***
Kyiv region:	
Baryshivka urban-type settlement	Baryshivskyi Elevator Division
Berezan	Head office, production base of Kyiv region,garage, Berezan Elevator Division
Yahotyn	Yahotyn Elevator Division
Sotnykivka village, Yahotynskyi district	Central repair base of agricultural machinery
Cherkasy region	
Mykhailivka village, Drabivskyi district	Production base of the Southern region
Poltava region	
Ovsiuky village, Hrebinkivskyi district	Commercial Dairy Farm
Chutivka village, Orzhytskyi district	Commercial Dairy Farm
Piznyky village, Chornukhynskyi district	Production base of Poltava region
Pyriatyn	Pyriatyn Elevator Division
Chernihiv region	
Nizhyn	Nizhyn Elevator Division
Chemer village, Kozeletskyi district	Production base of Chernihiv region

The end of the Table 2.1

Property	Swedish company "BZK GRAIN ALLIANCE" - 100%
Employees	The total number of employees is 1,085 people (average number for 2020)
Main products	- Production of grain and oilseeds. - Milk production - Provision of seed calibration services - Providing services to farmers to bring grain to marketable condition
Increasing production capacity	The expansion program provides: - Construction of the second stage of the Nizhyn elevator - Increasing the area of leased land to 100 thousand hectares

Source: developed by the author based on [21]

Grain Alliance’s business concept is to generate sustainable returns by increasing productivity and efficiency in the Ukrainian agriculture by implementing best agricultural practices, modern equipment and strict financial control.

Since launch Grain Alliance has created a solid organization, which can efficiently and sustainable run a large scale agriculture operation. The long term goal is to grow up to more than 100 000 hectares of cultivated land and outreach western producers in terms of productivity. The strategy to reach these goals is based on focus on the following:

- Maintain long term profitability
- A limited geographical area
- A limited set of crops
- Financial management and internal control
- Expansion, but not on the expense of productivity, efficiency and control.

Baryshivska Grain Company LLC adheres to the best international practices of effective involvement of the stakeholders in its activity, namely:

a. transparency and openness of activity;

b. providing meaningful information in a format and language that is understandable and adapted to the needs of target stakeholders;

c. providing information before consultations and decision-making;

d. providing information to stakeholders in easily accessible ways, as well as at the appropriate cultural level

e. respect for local traditions, languages, terms and decision-making processes;

f. two-way dialogue, which provides an opportunity for both parties to exchange views and information, listen, address problematic questions and hear answers to them;

g. forming a dialogue, establishing a convenient feedback format;

h. providing a wide range of views, including age, women and men, vulnerable groups and/or national minorities;

i. carrying out activities without intimidation, coercion or encouragement;

j. clear mechanisms for responding to problems, suggestions and complaints of the population;

k. creating, where appropriate and possible, project or program feedback and reporting to stakeholders.

Baryshivska Grain Company LLC implements the Social Partnership Policy through its own corporate charity foundation, which cooperates with village councils and united communities on the territory of which the Company operates. The Foundation has developed a number of community support programs.

Programs include specific projects that have the greatest impact on the community. Decisions to include projects in the annual program are made collectively through the company's Board of Directors, considering the views and wishes of local authorities, community activists, shareholders, local experts and leaders, opinions, local representatives, vulnerable groups (retirees, people with special needs).

In modern economic conditions, the activity of each business entity is the subject of attention of a large circle of participants in market relations who are interested in the results of its functioning. The analysis of economic activity is related to the statistical reporting of the company and the analysis of the obtained trends.

2021 seeding campaign was well prepared to provide excellent operating results. The biggest challenge for the company was 30 000 hectares of corn seeding. Almost 17 000 hectares of corn were seeded in the Poltava cluster alone (Fig. 2.3). During 2021, the company continued further improvement of the machinery fleet. The company has purchased two brand-new John Deere tractors 8340 together with the new precision seeder Väderstad Tempo L18 financed in the frames of the EBRD Capex Project [21].

Crop production is one of the few industries that has not experienced the negative impact of quarantine restrictions. Yields mainly depended on weather conditions. In winter wheat was good conditions, all spring crops, in turn, were late with their vegetation due to high precipitation in spring. It resulted into later harvesting for corn, soybeans and sunflower.

Four main crops of GA: Corn, Soybeans, Sunflower and Winter Wheat were cultivated on 57 000 ha in 2021 [21].

The biggest part in crop rotation takes corn – 30 400 ha or 54% of GA's arable land. Poltava cluster brings 57% of corn cultivation land.

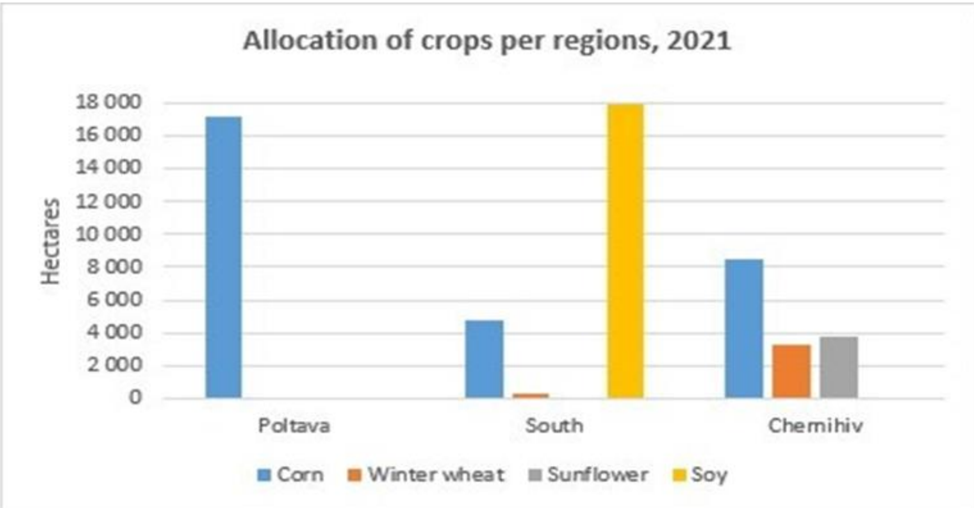

Fig. 2.3. Allocation of crops per regions 2021 (according to data provided by the company)

The soy area was cultivated on 17 900 ha in 2021. The South cluster is the only one in which soy was grown. Soy cultivation area was increased for 5 300 ha to 2020 (Fig. 2.4.). The Company improves its scientific approach in the growing soy.[21]

The sunflower was cultivated on 3 800 ha in 2021. It is 4 700ha less than the previous year. Sunflower is concentrated only in the Chernihiv cluster. Considering the gradual increase of sales prices and yield levels for all crops, soy, corn and wheat profitability becomes equal, slightly higher for sunflower.

Winter wheat is historically the least profitable crop for Grain Alliance. The sowing area of the winter wheat has not significantly changed compared to the previous year. The main reason for that is the preferable position of Corn and Soy for cultivation in GA.

GA cares for small areas for forage corn and alfalfa for its two cattle farms in the South region.

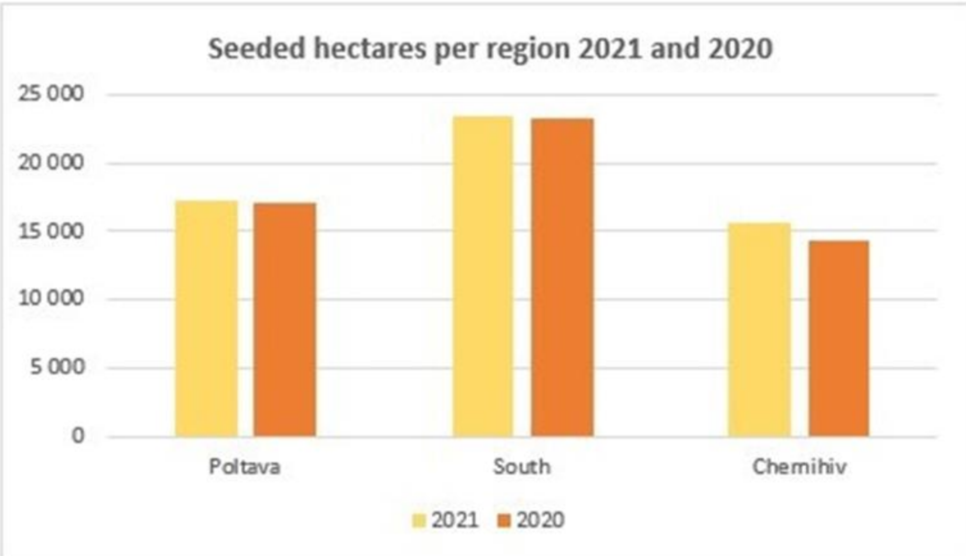

Fig 2.4. Seeded hectares per region 2021 and 2020 (according to data provided by the company).

The harvesting campaign of soy and sunflower was very successful for the Grain Alliance as it was finished promptly. The team has done its best and finished harvesting at the end of October 2021. Corn harvesting lasted until the end of the year.[21]

In order to maintain liquidity at the proper level, the Group actively enters into contracts for the supply of grain throughout the year, including the pre-sowing season. Forward contracts are usually made to hedge against unforeseen events, including waring prices and bad weather.

During Q1-Q2 2021, the Company has finished the execution of the sales contracts of grain harvested in 2020. There were no breaches of the sales contract's terms and conditions.

A sharp increase in world agricultural prices in the 2020-2021 marketing year has lifted forward grain and oilseed prices for the new season starting on the 1st of July with prices standing at multi-year highs.

According to the State Customs Service of Ukraine, in 2021, Ukraine exported agricultural food in the amount of 27.9 billion dollars, almost 25% above the 2020 record of 22.4 billion dollars. Thus, for the fourth year in a row, our country has updated the historical record of agricultural exports.[21]

Grain Alliance continues sales in USD, CPT sea port or DAP Ukrainian border compared to 5 years average and managed to ensure timely deliveries.

As of December 31, 2021, the Company had approximately 196 thousand tons of grain in a stock.

Production of 2021 was evenly sold and shipped to buyers during the marketing year. The grain sales prices have continued a sharp increase since the middle of the year. Grain Alliance managed to have sales higher than budget prices.

During the year ended 31 December 2021, the Ukrainian Hryvnia appreciated against the EUR and US dollar by 11% and 4% respectively; Swedish Krona depreciated against the EUR and US dollar by 3% and 10% respectively (2020: depreciated against EUR by 30%, against the US dollar by 20%; Swedish Krona – 36%).

The Company's operational currency is the Ukrainian hryvnia.

The financial sector has successfully gone through the coronavirus crisis and properly performed its functions. The Ukrainian banks have entered the pandemic with enough capital and high liquidity. Still, the banking sector remains highly profitable due to stable operating income.

The National Bank of Ukraine has encouraged banks to restructure loans to the borrowers who face temporary financial difficulties during the crisis.

Grain Alliance has properly executed all obligations with the commercial and international banks.

In 2021, the National bank of Ukraine has increased its key policy rate from 6.0% to 9.0%. The interest rates on loans in commercial banks have correspondingly grown.[21]

According to the updated production policy, Grain Alliance still considers soy and corn as the most profitable crops. Grain Alliance continues to pay much attention to improving the quality of seeding, protection and timing. During 2021, Grain Alliance has invested into purchase of its own railcars in quantity 54 units, updated its tractor fleet with the brand-new John Deere tractors, corn planter Väderstad Tempo L18 and Subsoilers Quivogne SSDR 7/300.

Grain Alliance continues cooperation with the EBRD in the frames of the 7-years capex loan agreement and Grant agreement with Taiwan ICDF.

For the year ended 31 December 2021, the Group's profit amounted to SEK 362 550 thousand (for the year ended 31 December 2020 – SEK 47 494 thousand). At the same time, as of 31 December 2021, the current assets of the Group exceeded its current liabilities by SEK 631 166 thousand (as of 31 December 2020 SEK 210 688 thousand), which indicates a sufficient level of liquidity.

The Group has positive operating cash flow in the amount of SEK 151 606 thousand in 2021 (SEK 114 309 thousand in 2020), which means the Group is in a better position to cover its current liabilities and expenses. As of 31 March 2022, the Group's liquidity amounted to SEK 177 371 thousand (an increase of SEK 137 432 thousand from 31 December 2021). The leverage ratio as of 31 March 2022 amounted to 22%, calculated on the Group's financial debts in relation to equity.

On February 24, 2022, russia launched a full-scale invasion of Ukraine, where the Group's key assets are located, escalating its aggression against Ukraine that began in 2014. In late February – March 2022, the most intense hostilities are localized in northern Ukraine (including the Chernihiv and Kyiv regions), where the Group conducts agricultural activities. In April, these territories were completely liberated from russian occupiers.[21]

As a result, the Group was able to plant 55,472 ha, which is 98% of the planted area in the previous year, and 96% of the Group's existing land bank.

For the period after the reporting date, the Group sold more than 86 000 tons of grain. It remains to sell less than 30% of corn and 49% of soybeans from the 2021 harvest. The Group's gross profit for the period January 2022 – March 2022 amounted to SEK 8 375 thousand.[22]

Table 2.2.

Financial activities of the company

The Parent Company			
	Notes	**2021**	**2020**
Revenue from sales	2	236 282	258 599
Cost of sales		-236 400	-247 115
Gross profit		**-118**	**11 484**
General and administrative expenses	3	-2 976	-3 062
Operating profit / (loss)		**-3 094**	**8 422**
Finance costs	4	-749	-709
Finance income	5	1 479	1 586
Foreign exchange gain	6	5 318	-8 057
Profit / (loss) before tax		**2 954**	**1 242**
Income tax expense	19	-	-
Profit / (loss) for the year		**2 954**	**1 242**

The end of the Table 2.2.

Other comprehensive income:		-	-
Total comprehensive income for the year		**2 954**	**1 242**

Source: developed by the author based on [21]

In the beginning of 2022, the Group has not fully complied with the agreed covenants with the Group's creditors, giving the bank the formal right to terminate the credit. However, this has not affected the lenders' willingness to continue lending [23].

The situation above means that there is a significant uncertainty in the Group's ability to continue its operations as going concern. The management assesses, after having drawn up forecasts of financial position, statement of comprehensive income and cash-flow up to June 2023, despite the ongoing russian military invasion and difficulties in exporting grain, that the possibility of conducting business further is good enough to consider that conditions for preparing the annual accounts, taking the conditions for going concern into account, exists.

The crisis situation was saved by strategy and planning. When prices for all components of agricultural production began to rise, Grain Alliance had everything for that period: PPE, fuel stock, and the most necessary components had already been purchased. There were, however, problems with the supply of some plant protection products and seeds due to the closure of the ports. In Transcarpathia, premises were quickly rented for newly purchased equipment, seed material, agricultural machinery. In general, preparations were made in advance for the increase in prices of all components of agricultural production, and the negative consequences were minimal [24].

A SWOT analysis for Grain Alliance, including logistics, will help identify the company's strengths and weaknesses, as well as identify opportunities and threats in its operations. Here is Grain Alliance's SWOT analysis:

Table 2.3

SWOT analysis of "Grain Alliance" company (developed by author)

Strengths:	**Weaknesses:**
1. Experience and efficiency in agriculture: Grain Alliance has many years of experience and expertise in the cultivation and processing of grain crops. 2. Modern technologies: The use of advanced technologies of production, logistics and grain processing allows to optimize processes. 3. Large volume of production: The company has a significant volume of grain production and a large land area for cultivating crops. 4. International presence: Grain Alliance successfully exports its products to international markets, which expands its sales geography.	1. Dependence on weather conditions: Changes in weather conditions can affect the yield and quality of grain. 2. Dependence on foreign markets: Changes in international markets can affect grain prices and product sales. 3. Dependence on external carriers: Grain Alliance is dependent on external carriers for logistics and exports.

The end of the Table 2.3

Opportunities :	**Threats:**
1. Expanding the range of products: Introducing new types of cereals or additional agricultural products can expand the range and attract new customers. 2. Increasing demand for quality grains: Increasing demand for organic or high-quality grains can be an incentive for development. 3. Globalization: Expanding into new international markets can increase sales and the ability to compete globally. 4. Logistics Optimization: Improving logistics processes can increase efficiency and reduce costs in this industry.	1. Competition: Intense competition in the grain market and logistics can affect prices and profitability. 2. Changes in legislation: Changes in agricultural or logistics legislation may affect business processes and product quality requirements. 3. Weather disasters and natural disasters: Weather disasters can damage crops and enterprise infrastructure.

Source: developed by the author

Grain Alliance's SWOT analysis helps a company assess its current situation and determine how to leverage its strengths, minimize its weaknesses, capitalize on opportunities, and protect itself from threats. With this understanding, a company can develop strategies to improve its operations and increase its competitiveness.

2.2 Analysis of the Grain Alliance logistics system

Producers of agricultural products, the processing industry and other farmers come to the conclusion that it is expedient to manage not only their own business, but also the network of all business entities that have a direct or indirect relationship with their activities, that is, the supply chain.

Agrosupply Chain - covers all organizations of all types of activity in agribusiness, which participate in the production of value in the form of goods and services and their delivery to the final consumer (Fig. 2.5).

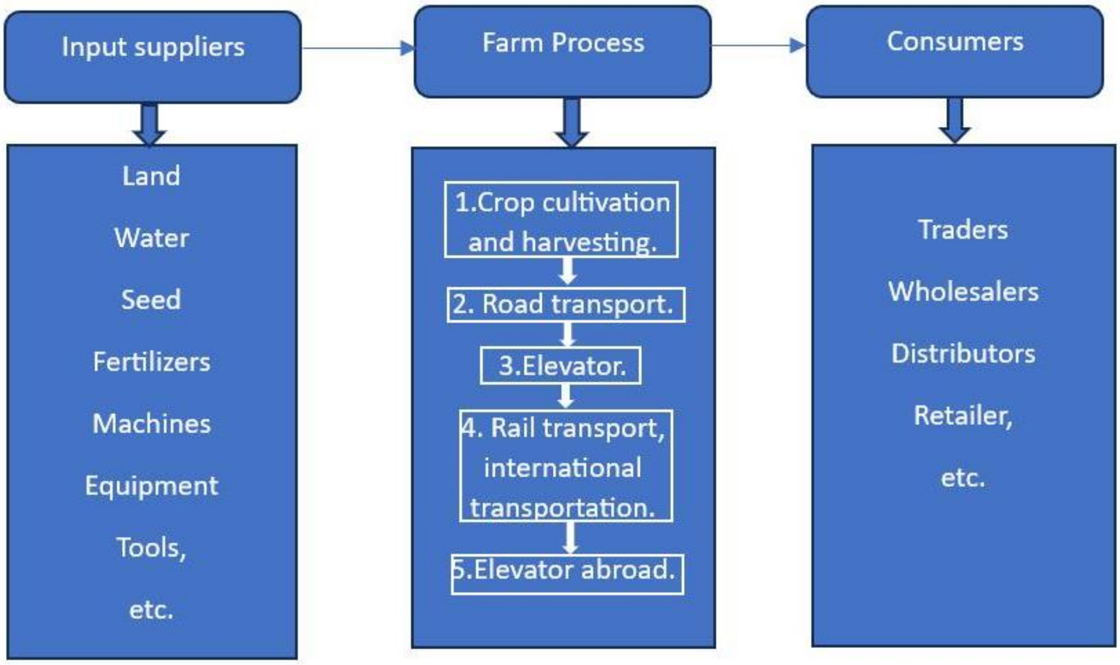

Fig. 2.5 Supply Chain at Grain Alliance (developed by author)

Over the past decade, agribusiness has been confidently mastering new strategies – products, marketing, finance, etc. An integral part of the overall strategy of agribusiness should be the strategy of managing the agricultural supply chain. Skilled management of multiple connections in the agricultural supply chain can increase the efficiency of this chain.

Grain Alliance is an agricultural company specializing in the cultivation and export of grain crops such as wheat, barley, corn, and more. Logistics play a crucial role in their operations, as efficient grain delivery and storage are essential for the success of their business. Here's a description of some of the logistics business processes at Grain Alliance:

1. Harvesting and Transportation:

- Harvesting: When grain crops are ready for harvesting, farmers and workers engage in the harvesting process.
- Transportation to Storage: The harvested grain is transported to the company's storage facilities or elevators, where it will be stored for further processing and sale.

2. Storage:

- Grain Storage: The harvested grain is stored in dedicated warehouses and containers, maintaining the appropriate temperature and humidity levels to preserve product quality.
- Inventory Monitoring: Computer systems and sensors are used to monitor inventory levels and grain quality.

3. Planning and Distribution:

- Demand Forecasting: Grain Alliance studies the market and utilizes demand data to plan production and shipments accordingly.
- Grain Distribution: Grain is allocated to different markets, including domestic and international markets, based on demand and contracts.

4. Transportation:

- Mode Selection: The company determines the most efficient means of transporting grain, including road transport, rail transport, and maritime container shipments.
- Customs Procedures: Since Grain Alliance exports its products, it is important to complete all necessary customs and export formalities.

5. Monitoring and Management:

- Cargo Tracking: The company employs modern technologies to track the movement and status of cargoes during transportation.
- Supply Chain Management: Grain Alliance collaborates with suppliers and carriers to ensure the smooth flow of goods throughout the supply chain.

6. Quality and Control:

- Quality Control: The company takes measures to ensure the quality of its grain and compliance with safety and quality standards.
- Processing Logistics: If necessary, grain may undergo further processing before reaching the market.

7. After-Sales Service:

- Customer Support: Grain Alliance provides customers and partners with information and support regarding delivery schedules and other logistics aspects.

The main goal of the logistics business processes at Grain Alliance is to ensure efficient and reliable grain delivery to the markets and to maintain product quality throughout the entire supply chain.[25]

At the turn of 2021, Grain Alliance has decided to revert to the initial program. Due to the rapidly increasing land bank of the Chernihiv cluster in combination with the production policy, the company has pursued investments into further development of the drying and storage capacities of the Nizhyn elevator (Chernihiv district). The main works on the construction of the Nizhyn elevator were completed in September 2021. Thus, the total storage capacity at the facility is around 70 thousand tons, and the drying capacity is more than 2300 tons of corn per day (Table 2.4). A unique feature of the facility is the operation of dryers exclusively on solid biofuel including production waste, sunflower husk and biomass pellets. Thus, with nil use of natural gas, the facility will dry about 100 thousand tons of corn per year of its own and the third parties' grain. It is estimated this to save about 600 thousand m3 to 1 million m3 of natural gas per season. Thus, this facility not only increases the economic potential of the region but also makes a significant contribution to environmental safety, as well as the energy independence of Ukraine.[26]

Table 2.4

Storage and drying capacity 2021-12-31 [21]

Elevators	**Baryshivka**	**Berezan**	**Yahotyn**	**Pyriatyn**	**Nizhyn**	**Yarmolyntsi**
Max storage capacity	18 000 t.	44 000 t.	55 000 t.	105 000 t.	69 000 t.	16 000 t.
Type of storage	Flat bed	Flat bed + steel silos	Flat bed + steel silos	Steel silos	Steel silos	Flat bed + steel silos
Drying capacity	650 t/day	1000 t/day	1000 t/day	2600 t/day	2300 t/day	600 t/day
Railroad	On site	On site	8 km	On site	On site	5,5 km
Shipment capacity	800 t/day	1000 t/day	1750 t/day	2000 t/day	1750 t/day	800 t/day

Source: developed by the author according [21]

The average number of employees in 2021 was 1044, divided between 219 women and 825 men. However, it is important to keep in mind that the number of employees depends on the season. The vast majority of employees are seasonal employees who assist during seeding or harvest. The Company continues implementation of its regular plan of staff optimization in the frame of the operational efficiency increase program.[21]

In total, there are 7,807,775 shares in the company. The principal owner Agro Ukraina AB, owns 7, 801 155 (99.92%) of the shares. Behind it stands the CA group.

Regarding warehouse logistics, the situation is as follows:

- Baryshivka: 7 grain warehouses with a total storage capacity of 15,900 tons (grain/oil);

- Berezan: 8 grain warehouses and 2 silos with a total storage capacity of 44,400 tons (corn, soybeans, wheat);

- Yagotyn: corn-3 silos, 5th and 6th rows and a new warehouse with a total storage capacity of 50,700 tons;

sunflower-3 silos and a new warehouse with a total storage capacity of 23,100 tons;

-Nizhyn: 4 silos and 1 damaged silo with a total storage capacity of 72,000 tons;

-Piryatin: 13 silos with a mysterious storage capacity of 98,500 tons.[21]

Due to hostilities in southern Ukraine, the Group has suspended its grain export operations by sea. Work is underway to reorient the export of agricultural products from shipment by sea to shipment through the western regions of Ukraine and Europe.[21]

For these purposes, the Group purchased a transshipment elevator in the Slovak Republic with a capacity of 20 thousand tons as silos and 5 thousand tons as flat warehouses. The elevator is adjacent to the railway with 4 railway tracks.

One of the problems in the transportation of grain to the EU countries is the difference in the width of the railway tracks. Ukrainian wagons are not compatible with most EU rail networks.[27]

However, the acquired elevator has 2 types of tracks—2 Ukrainian and 2 European standards of ones, which allows unhindered reloading of grain.[22]

The Group excepts to deliver grain by own wagons. The wagon park consists of 236 units on November 2023. The company also has 15 MAN grain trucks and 30 Kamaz trucks in its transport fleet. [22]

The company operates in closed-type hopper cars (Fig. 2.6).

Fig. 2.6 The closed-type hopper cars of “Grain Alliance” [22]

The hopper car model 19-6869 is designed for transportation along main railway tracks with a track width of 1520 mm and along the tracks of industrial enterprises, grain and other bulk food cargo requiring shelter from precipitation. (Fig. 2.7) A significant advantage of the hopper car model 19-6869 over others is the increased volume of the body - 120 m^3. The cargo is unloaded into the inter-rail space.[23]

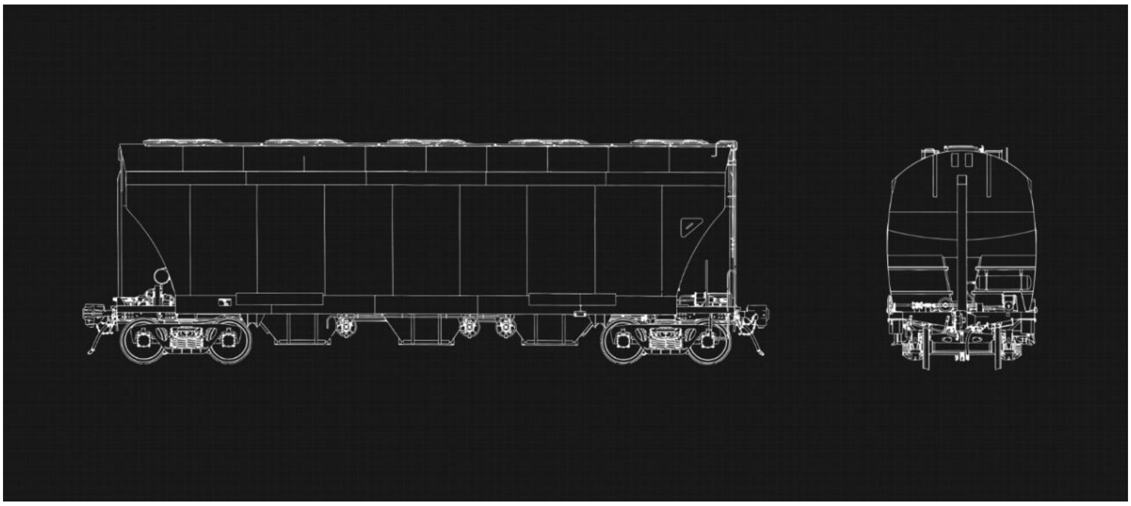

Fig. 2.7. Sketch of a hopper car model 19-6869 [23]

Below are the technical characteristics of the hopper wagon model 19-6869 (Table 2.5).

Table 2.5

The technical characteristics of the hopper wagon model 19-6869 [23]

1	Body volume, m^3	120
2	Wagon tare weight, t	23.5
3	Carrying capacity, t	70.5
4	Design speed, km/h	120

The MAN TGX 18.440 model is a new generation tractor unit with a 4x2 wheel formula (Fig. 2.8). Its purpose is the transportation of various cargoes as part of road trains over medium or long distances.[28]

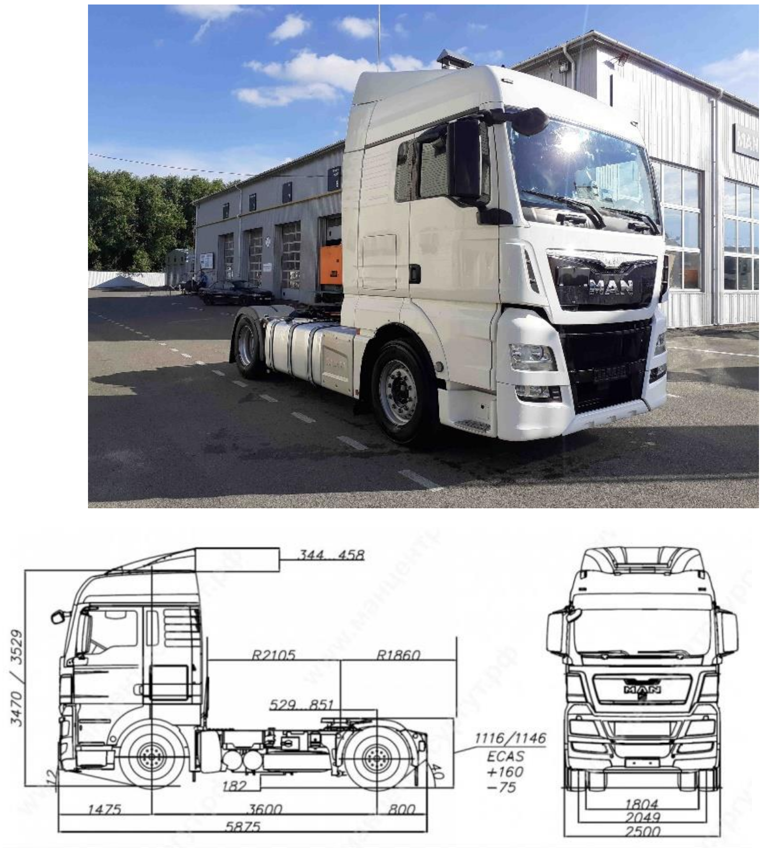

Fig. 2.8 The MAN TGX 18.440 [28]

Under the cab of the tractor there is a turbocharged diesel engine with the following data:

Table 2.6

The technical characteristics of the MAN TGX 18.440 [28]

1	Number of cylinders	6
2	Power	440 hp

The end of the Table 2.6

3	Volume	10.5 l
4	Maximum speed	90 km/h
5	Fuel consumption	25 l/100 km
6	The total weight of the road train	40

The BODEX KIS 3WA 50 m³ dump aluminum semi-trailer is used as part of the road train with the MAN TGX 18.440 tractor (Fig. 2.9).

Fig. 2.9 The semi-trailer BODEX KIS 3WA

Three-axle dump truck semi-trailer BODEX KIS 3WA with an aluminum body, volume 50 m³, load capacity from 29 to 38.3 tons and a tare weight of 6,500 kg with spaced axles, designed for unloading and transporting grain.[29]

The KamAZ 55102 is a three-axle, frame, rear-wheel drive truck with a front-mounted power plant. The model has a 6*4 wheel arrangement with steering wheels on the front axle.

The length of the base model is 7570 millimeters, width 2500 mm, height with the body and cab lowered - 2830 millimeters. When transporting bulk cargo, the volume of the body is important; in the basic configuration it is 7.9 m3; when equipped with additional extension sides, the useful space can increase to 15.8 cubic meters. The nominal weight of an unloaded vehicle in running order does not exceed 8,500 kilograms, its carrying capacity without a trailer is 7 tons, and the same amount can be loaded onto a trailer (Fig. 2.10).

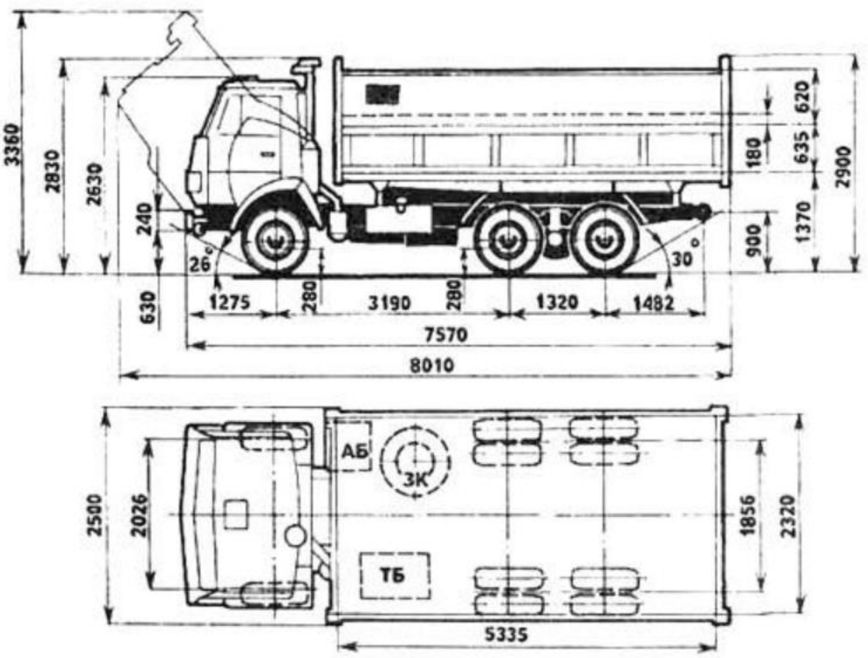

Fig. 2.10 Sketch of a KamAZ 55102 [21]

KamAZ 55102 is characterized by fairly low fuel consumption - about 25 liters per 100 kilometers when driving without a load; a loaded vehicle consumes up to 31 liters when operating under normal conditions. Fuel consumption largely depends on the speed of the truck, and can increase to 40 l/100 km when driving at a speed of 80 km/h. This vehicle has a fuel tank that can hold 210 liters of diesel fuel (Fig. 2.11).

Fig. 2.11 The KamAZ 55102 6x4 [21]

According to Table 2.7, comparing the latest data on the amount of grain shipped, it can be concluded that in 2022, most of the corn was transported by rail across Ukraine. And in 2023, most corn was transported by rail to Slovakia. In second place are soybeans and wheat.

Table 2.7

Information on the shipment of grain (developed by author)

2022 year			2023 year	
	weight, tone	Culture	weight, tone	Culture
Export contract motor transport	625	Soybeans	162,2	Soybeans
			20,9	sunflower
			39,7	wheat
Contracts for railway transport in Ukraine	703	Soybeans	10262,6	sunflower
			34618,9	Soybeans
Export contract Ukrainian ports railway transport	4153,2	Soybeans	7053,3	Soybeans
	80645,7	Corn	40135,7	Corn
			1054,6	wheat
Export contract Slovakia rail transport	74391,8	Corn	67620,2	Corn
	7303,4	wheat	5054,1	wheat
	15147	Soybeans	9771,3	Soybeans
	182969,1		175793,5	

Since grain is critical to global food security, the EU plans to support logistics in and out of Ukraine.

The European Commission has proposed a plan to help Ukraine with the export of grain and other agricultural products. It provides:

— urgent measures to increase cargo capacity for sending Ukrainian goods abroad,

— increase the throughput of transport networks and transshipment terminals,

— prioritize grain export supplies from Ukraine,

— simplify customs operations and other checks,

— organize temporary storage of grain in the EU.

General information about a typical Grain Alliance transport fleet specializing in the cultivation and export of grain crops:

1. Trucks: Trucks, such as large trucks, are used to transport grain from fields to storage facilities or elevators. They can have a large capacity for transporting large volumes of grain.

2. Agricultural machinery: For growing and harvesting crops, such as combines, tractors and other agricultural machinery.

3. Wagons: To transport large volumes of grain over long distances, the company uses railway transport and railway wagons.

4. Sea and river vessels: To export grain to international markets, the company uses sea and river vessels to transport large shipments of grain.

5. Specialized logistics equipment: For grain storage and processing, the company has specialized logistics equipment such as elevators, dryers, containers and silos.

6. Freight carriers and suppliers: In addition to its own machinery, the company cooperates with external carriers and logistics providers to ensure the transportation and logistics of grain.

The company uses 14 John Deere, 8 Case combines and 28 John Deere tractors, 9 Landini tractors, 3 Massey Ferguson tractors, and 12 MTZ-12 tractors for grain harvesting and cultivation.[22]

The John Deere S690 combine harvester is one of the most popular in Ukraine and the world, because it is designed for harvesting heavy and dense crops with a high yield, for example, rapeseed, corn or sunflower (Fig. 2.12)

Fig. 2.12 The John Deere S690 combine [22]

Below are the technical characteristics of the John Deere S690 combine (Table 2.8).

Table 2.8

The technical characteristics of the John Deere S690 combine [22]

1	Grain hopper volume, m^3	14.1
2	Harvester width, m	10.7
3	Fuel tank volume, l	1155
4	Unloading speed, l/sec	135

The front pair of wheels in the S690 has been replaced with tracks. The grain supply scheme has 3 flows. The shape of the rotor allows you to save fuel. The sharp front cone increases throughput. Thanks to the increased space around the shaft, the threshing is soft, the straw is of better quality, and the kernels are preserved even in sensitive crops.

A company that specializes in the grain business usually has a diverse fleet of vehicles that allows it to efficiently produce, store and transport grain to different markets.

2.3 Evaluation of performance indicators of complex transport components and logistics systems

The design and operation of complex systems have identified problems whose solution is only possible on the basis of a comprehensive assessment of factors that are different in nature, heterogeneous connections, external conditions, etc. In this regard, in system analysis there is a section related to determining the quality of systems and the efficiency of processes implemented in these systems.

Objectives of assessing complex systems:

- optimization – selection of the best algorithm from several that implement one law of system operation;

- identification – determination of the system, the quality of which most closely matches the real object under given conditions;

-to make decisions on system management.

In systems analysis, a distinction is made between “estimation” – the process and “assessment” – the result of the process.

There are four main stages in assessing complex systems.

1. Determining the purpose of the assessment.

There are two types of goals: qualitative - achievement is expressed on a nominal scale or on an order scale, and quantitative - achievement is expressed on a quantitative scale. The definition of the goal must be carried out in relation to the system in which the system being assessed is a subsystem (element).

2. Measuring system properties.

The essential properties of the system, from the point of view of assessment purposes, are identified. The appropriate scales for measuring properties are selected and all properties are assigned certain values on these scales.

3. Justification of quality criteria and criteria for the effectiveness of the system.

It is carried out based on the results of measuring properties (stage 2).

4. Assessment.

All systems under study are considered as alternative, compared according to reasonable criteria and (depending on the purposes of the assessment) ranked, selected, optimized, etc.

Artificial systems are created, as a rule, for specific purposes, the implementation of which involves certain types of activities. In this case, the planned and actual results at the system output may differ. The degree of difference depends on the conditions of the transformation process (quality of resources, quality of the system, environmental factors, etc.).

Therefore, when evaluating systems, it is customary to distinguish between the quality of systems and the effectiveness of the transformation processes implemented by the system. The relationship between the concepts of quality and efficiency is presented in Table 2.9.

Table 2.9

The relationship between the concepts of quality and efficiency

Parameter	**Quality**	**Efficiency**
Definition of the concept	A property or set of essential properties of a system that ensures its suitability for its intended use	A complex operational property of the system's functioning process, characterizing its compliance with achieving the system's goal.
Application area	Objects of any nature, including elements of systems	Only targeted processes carried out by the system
Main characteristics	The set of properties of a system that are essential for its intended use	The degree to which the results of the transformation correspond to its goals

The end of the Table 2.9

Structural Analysis Factor	System structure (composition and properties of components, structure, organization)	Functioning algorithm, quality of the system implementing the algorithm, environmental influences
Dimension	Quality indicator – vector of indicators of essential properties	Indicators of effectiveness, resource intensity, efficiency in terms of the outcome of the transformation and the quality of the algorithm that provides the result
Assessment method	Criteria for suitability, optimality, superiority	Suitability or optimality criteria determined depending on the type of transformation (deterministic, probabilistic, uncertain)

Each significant (from the point of view of system quality) characteristic of the system (social, legal, technical, economic, etc.) can be described using one or more indicators, the values of which characterize the measure (intensity) of this property. This measure is called a partial indicator of system quality. Indicators can be quantitative or qualitative

Quantitative indicators (parameters) can be measured and evaluated numerically (such as, productivity, cost). Quality indicators do not have generally accepted units of measurement (such as, aesthetic properties, ease of use, etc.). However, it should be borne in mind that clearly understood quality indicators, as a rule, are also evaluated by numbers (such as, ease of maintenance is measured by the time required to detect and eliminate a malfunction).

Any solar power system is a set of subsystems: technical units, people, structural units, etc. Methods for determining the parameters of each of the subsystems depend on their nature and are established using the appropriate disciplines. In a solar power system, subsystems can be connected to each other in parallel, in series or in a mixed way. Thus, the type of dependence of the solar power system parameters on the parameters of the component subsystems is determined by the method of connecting the subsystems and their nature. According to the type of dependence connecting the values of the parameters of the subsystems and the solar power system, all parameters can be divided into additive, multiplicative and logical.

For additive parameters, the following relationship holds:

$$x_c = \sum_{i=1}^{m} x_i \tag{2.1}$$

where x_c is a system parameter; x_i − parameter of the i-th subsystem; m is the number of subsystems in the solar power system. An example of an additive parameter is the cost of the system ($C_C = C_p + C_u + C_e$, where C_p, C_u, C_e are the costs of development, manufacturing and operation, respectively).

Multiplicative parameters are those parameters that obey the following law:

$$x_c = \prod_{i=1}^{m} x_i \tag{2.2}$$

The probability value of the system operating in accordance with the plan can be considered an example of a multiplicative parameter.

Logical parameters:

$$x_c = min\{x_i\} \tag{2.3}$$

or

$$x_c = max\{x_i\}. \tag{2.4}$$

By their nature, parameter values can be deterministic or random. Based on their impact on the quality of the system, a distinction is made between increasing and decreasing parameters.

Choosing the right indicator determines the results of evaluating various decision options.

A generalized indicator of the quality of a system is a vector $Y = \{y_1, y_2, \dots, y_n\}$ whose components are partial indicators of individual properties of the system. The dimension n is determined by the number of essential properties of the system.

In the general case, particular indicators have different physical natures and dimensions. In this regard, when determining a general indicator of system quality, they use not natural partial indicators, but their normalized values, which ensures that the indicators are brought to the same scale:

$$y_i^{HOPM} = \frac{y_i}{y_i^*}, i = 1,2, \dots, n, \tag{2.5}$$

where y_i^* is some "ideal" value of the i-th indicator.

There are several options for choosing the "ideal" value of the indicator:

- the "ideal" value is set by the decision maker and is "exemplary";

-as "ideal" you can choose the maximum permissible value of a particular indicator;

-as "ideal" you can choose the difference between the maximum and minimum values of particular indicators.

An ideal system is usually called a hypothetical model of the system under study that satisfies all quality criteria:

$$Y^* = \{y_1^*, y_2^*, \dots, y_3^*\}. \tag{2.6}$$

The adequacy region is a certain neighborhood of the values of indicators of essential properties of the system, the radius of which has a normalized value determined by the following dependence:

$$\delta = \frac{|Y^{gon} - Y^*|}{|Y^*|}. \tag{2.7}$$

Over the past fifteen years, the corporate status of logistics in most Ukrainian and global companies has undergone impressive changes: from an auxiliary to a strategic function of the main production. Strategic alliances, expanding product ranges, market segmentation, environmental impacts and the global economy will continue to increase planning requirements in the face of uncertainty. The problem of strategic design and scientific management of logistics systems gained particular importance after the post-industrial revolution, but only recently has it become possible to develop full-fledged distribution systems using modern means of computing, telecommunications and information technologies, which are really optimal for practical use in the largest companies. Along with information technologies, the application areas of logistics system design software have changed. Many individual management functions are grouped under the functions of material flow management in the integrated logistics of an enterprise or a group of enterprises.

The goal of supply chain management is to maximize the total value created by the supply chain. This value is defined as the difference between the time that the customer is willing to pay for the product and the costs that occur in the aggregate in supply chains. For most supply chains, this indicator can be called "supply chain profitability", defined as the difference between the revenue received from the customer and the total costs in the supply chain.

Therefore, there is a need to define the main indicators for evaluating the efficiency of supply chains.

When studying the mechanism of the supply chain, it was established that one of the main stages of its application is the stage of evaluating the effectiveness of the proposed logistics chain, because based on its results, a decision is made on the implementation of the supply chain in case of satisfaction with the final effect. Otherwise, restructuring or modification of the supply chain is required. According to the concept of implementing SCM (Supply Chain Management), the majority of scientists determine the directions and sources of improving the efficiency of the enterprise (Table 2.10).

Table 2.10

The effectiveness of the implementation of the SCM concept

Directions for improving the efficiency of the enterprise	Sources of increasing the efficiency of the enterprise
1. Increasing the number of orders and increasing the stability of demand	1. Increasing accuracy in planning based on unified information channels
2. Reduction of insurance reserves	2. Improving the quality of operational management due to continuous monitoring of the entire logistics chain, timely identification of deviations and violations in the functioning of the logistics chain.
3. Reducing risks and increasing the reliability of execution of plans and deliveries	3. Reduction of some marketing and logistics costs due to the elimination of business processes associated with uncertainty in procurement, warehousing and sales.

Establishing evaluation indicators for each basic process of the supply chain (according to the SCOR model) (Table 2.11).

Table 2.11

Key performance indicators of supply chains

Basic supply chain processes	Indicators that have a direct impact on increasing the efficiency of supply chains
1	2
Planning	production volumes distribution system accuracy of forecasts number of channels production facilities in channels
	inventory holding costs planning costs stocks of obsolete products duration of the planning cycle
Purchase of stocks	quality of supplies efficiency of supplier selection supply efficiency
	inventory level product range share of costs for long-distance deliveries resource acquisition costs duration of supply raw material utilization factor

The end of the Table 2.11

Production	↑	product quality pace of implementation of production orders product range production elasticity percentage of products made to order
	↓	the number of defective products duration of production percentage of products produced per warehouse
Marketing	↑	the number of orders received the number of orders per sales channel the number of sales channels the number of directions of supply the number of completed orders
	↓	order management costs duration of orders
	↓	the number of complaints and requests for returns share of returned goods
Return	↑	refusal of complaints the effectiveness of drawing up return schedules
	↓	number of returns amount of compensation payments time to establish the reasons for the returns time to identify the guilty parties

It is proposed to set calculation coefficients for each group of indicators. Each enterprise can choose the most important indicators and their calculation.

As a result of the calculations, it is proposed to calculate the integral coefficient of efficiency of supply chains E_{SC}:

$$E_{sc} = \sum_{j=1}^{m} \sum_{i=1}^{n} C_{i^*} k_{ij} \tag{2.8}$$

k_{ij} – the average indicator of efficiency assessment for each group of coefficients of the basic processes of supply chains;

n is the number of basic supply chain processes according to SCOR model (n = 5);

m is the number of coefficients in each group of basic processes.

The specific weight of each group of indicators is established using the method of expert evaluations or the method of hierarchies. The average indicator of efficiency assessment for each group of coefficients of the basic processes of supply chains is calculated according to the established coefficients in each group of indicators, the limits of each coefficient can be calculated or benchmark values can be set to facilitate the analysis of the results of the obtained calculations.

It is also important to distinguish between quantitative and qualitative indicators. To assess the effectiveness of supply chain management in terms of quality indicators, the following factors must be taken into account:

• reliability of the logistics supply chain (which includes its controllability and predictability and provides reliability of delivery terms, availability of the goods at the supplier, reliability of demand);

• fulfillment of conditions by the deadline for the entire supply chain;

• level of service;

• cost control (money, time);

• the relationship between the logistics process and the sales planning process;

• loyalty of suppliers [18].

Having assessed the efficiency of the supply chain, you should always focus on possible ways to increase it. International studies on improving the efficiency of supply chains [19] recommend the following directions (Table 2.12).

Improving supply chain visibility, upskilling, investing in smart technologies, and developing a project plan that will guide every step of the way to improve supply chain efficiency will put the company on a path to achieving and exceeding goals and objectives.

Table 2.12

Directions for improving the efficiency of supply chains

Directions for increasing the efficiency of supply chains	Recommendations on the implementation of directions for increasing the efficiency of supply chains	Responsible departments and managers
Increasing supply chain visibility	Enabling suppliers to check their inventory in real-time so they can better understand your current situation – and plan ahead to meet future needs	Internal service allows key team members to access account information that can help them strategize on their own without risking too much backtracking
Automation	Introduction of automated components into the warehouse with a thorough inspection that ensures that all automated parts are well managed and maintained	Additional training and additional education from suppliers, warehouse managers and planning teams

The end of the Table 2.12

Involvement of own IT department	It is necessary not only to use specialists from the IT department, but to periodically check with them about possible software changes that could streamline supply chain processes. It is the employees who have the most holistic understanding of technology changes in the field of supply chain management that can contribute to the company's advance in the services market	Often, IT consulting management provides direct consultation only when it's time to implement new software or something goes wrong with the current system. It is more effective to involve specialists of one's own IT department on a permanent basis
Evaluation of own training programs	Reviewing all training materials and procedures to ensure they are all up-to-date and performance oriented.	Planned review of training programs with heads of each department, particularly those overseeing the largest workforce
Development of a new project plan	A project plan is a framework that can guide an enterprise in making strategic investments in supply chain capabilities, developing a distribution strategy, establishing communication channels, identifying risks and opportunities, and facilitating cross-functional decision-making and project improvement. The project plan provides a central point of reference for all initiatives	Improving the efficiency of supply chains requires collaboration between teams and departments. This will help align decisions and investments with supply chain goals and the broader corporate vision

The natural functioning of the market mechanism not only establishes a balance between supply and demand in all markets and between the prices of all goods, services and factors of production, but also ensures the optimal functioning of the economic system in general.

The capacity of the logistics system is determined by the maximum volume of material flow that passes through the logistics system at any moment in time.

Optimizing the capacity of the logistics system is due to the need, on the one hand, to match the logistics system to the assigned tasks, and on the other hand, to optimize costs associated with excess or underutilized capacities. In practice, three methods of optimizing the capacity of the logistics system are used:[20]

1st - balance method. It consists of three stages:

- drawing up a balance sheet of logistics system capacities based on the results of product analysis and formalization;

- calculation of the necessary capacities to obtain the required quantity and required quality of the product;

-comparison of the received power values with the actual capabilities.

Based on the available surplus or deficit of the capacity of the logistics system, we obtain the amount of the necessary correction of the product.

2nd - the method of "bottlenecks". Bottlenecks are any resource whose capacity (bandwidth) is less than the need for it. At the same time, we can talk about bottlenecks in logistics systems as a control point that can control the entire system, since such a resource works all the time and gives confidence that as a result of previous operations, no excess volume of products is produced, no excess stocks of unfinished products are created, which this resource unable to overcome

A "bottleneck" may appear in any link of the logistics system, in particular, the appearance of "bottlenecks" in the supply sector is caused by a lack of raw materials for increasing production volumes. On the other hand, the appearance of "bottlenecks" in the technological chain in the case of small production capacities is not excluded. Small capacities of warehouses, packaging shops, and vehicles form "bottlenecks" in the logistics channel, which reduce the throughput of the logistics system with significant volumes of production. Ways to overcome bottlenecks are quite different depending on where they occur: for example, the introduction of additional equipment, the use of outsourcing during peak seasonality, etc.

It is appropriate to note that "bottlenecks" have the following feature: after it is eliminated in one link of the logistics system, it is possible that it will appear in another. Therefore, it is necessary to constantly monitor the main links of the logistics system, studying their capacities.

3rd - the method of detecting excess capacities. In terms of content, it is the opposite of the "bottlenecks" method. All links, where excess capacity is detected, are reduced to optimal limits.

To optimize the capacity of the logistics system at the Grain Alliance enterprise, the "bottleneck" method was used.

The bottleneck of the logistics system arises for two reasons:

1) a specific link in the system received either incomparably high or incomparably low revenues from other units and thus reduced the efficiency of the system as a whole;

2) a specific link of the considered system provided incorrect data to the management, as a result of which there was a "mismatch" of data when planning the activities of the logistics system.

The procedure for identifying bottlenecks in the logistics system is as follows:

1) all links of the logistics system are assigned a serial number in the direction of material flow movement;

2) for each link, the efficiency of the interaction of the links of the logistics system with an amendment to this link j is calculated;

3) indicators of efficiency of links' interaction calculated in 2) are compared among themselves;

4) from all indicators of efficiency of links' interaction the largest is chosen and number of the link corrected during the calculation of the given indicator is fixed;

5) the link under the fixed number is a bottleneck of the macrologistics system.

In the "Farm process" of the supply chain of Grain Alliance we have 5 links of logistics system. There are: 1st- Crop cultivation and harvesting (55%), 2nd- Road transport (10%), 3rd-Elevator (5%), 4th-Rail transport and international transportation (20%), 5th-Elevator abroad (10%) (Table 2.13.).

Table 2.13

Initial data for calculating the coefficients of economic efficiency of the logistics system, thousand UAH (developed by author)

Link number	**1**	**2**	**3**	**4**	**5**
Costs of the link, C_i	23918	4348	2174	8698	4400
Net profit of the link, P_{ni}	7082	1300	645	2576	1287
Gross assets of the link, A_{gi}	127368	23158	11579	46315	24000

1. Determine the efficiency of economic activity of this system.

1.1. Calculate Share of each link in the total costs of the logistics system S_{ci} :

$$S_{ci} = \frac{C_i}{\sum_{i=1}^{n} C_i} \tag{2.8}$$

where n – total number of links in the macrologistics system.

1.2. Calculate Share of each link in the net profit of the logistics system S_{pi} :

$$S_{pi} = \frac{P_{ni}}{\sum_{i=1}^{n} P_{ni}} \tag{2.9}$$

1.3. Calculate Coefficient of economic efficiency for each link of the logistics system E_i:

$$E_i = \frac{S_{pi}}{S_{ci}} \tag{2.10}$$

1.4. Enter calculated indicators in Table 2.14. and rank the links of the logistics system by the value of the Coefficient of economic efficiency.

Table 2.14

The results of calculating the coefficients of economic efficiency of the links in the logistics system (developed by author)

Link number	**1**	**2**	**3**	**4**	**5**
Share of each link in the total costs of the logistics system, S_{ca}	0,54935918	0,09986678	0,04993339	0,1997795	0,10106114
Share of each link in the net profit of the logistics system, S_{pi}	0,54941815	0,10085337	0,05003879	0,19984484	0,09984484
Coefficient of economic efficiency for each link of the logistics system, E_i	1,00010735	1,00987908	1,00211078	1,00032705	0,9879647
Rank of links in the logistics system	**4**	**1**	**2**	**3**	**5**

2. Determine the efficiency of the link as part of an macrologistics system.

2.1. Calculate Profitability of each link in the logistics system P_i :

$$P_i = \frac{P_{ni}}{A_{gi}} \tag{2.11}$$

2.2. Calculate Profitability of the logistics system P_{ls} **:**

$$P_{ls} = \frac{\sum_{i=1}^{n} P_{ni}}{\sum_{i=1}^{n} A_{gi}} \tag{2.12}$$

2.3. Calculate Weighted average profitability of the logistics system P_{aw} **:**

$$P_{aw} = \frac{1}{(n-1)} \left(\frac{P_1}{2} + \sum_{i=1}^{n-1} P_{i+1} + \frac{P_n}{2} \right) \tag{2.13}$$

2.4. Calculate Performance indicator of the links in the logistics system ***PI*** :

$$PI = \frac{P_{ls}}{P_{aw}} \quad (2.14)$$

2.5. Enter calculated indicators in Table 2.15. compare Performance indicator of the links in the logistics system ***PI*** with Coefficients of economic efficiency for each link of the logistics system $\boldsymbol{E_i}$.

Table 2.15

The results of calculating the performance indicators of the link in the logistics system (developed by author)

Link number	**1**	**2**	**3**	**4**	**5**
Profitability of each link in the logistics system, $\boldsymbol{P_i}$	0,05560266	0,05613611	0,05570429	0,05561913	0,053625
Profitability of the logistics system, $\boldsymbol{P_{ls}}$	0,055459943				
Weighted average profitability of the logistics system, $\boldsymbol{P_{aw}}$	0,055518341				
Performance indicator of the links in the logistics system, ***PI***	0,998948143				

3. Identify a bottleneck in the macrologistics system.

3.1. Calculate for each link Performance indicator of the links' interaction in the logistics system $\boldsymbol{PI_j}$, adjusted for link ***j***:

$$PI_j = \frac{P_{lsj}}{P_{awj}} \quad (2.15)$$

where $\boldsymbol{P_{awj}}$ - Weighted average profitability of the logistics system, adjusted for link ***j***;

$\boldsymbol{P_{lsj}}$ - Profitability of the logistics system, adjusted for link $\boldsymbol{j}$:

$$P_{lsj} = \frac{P_{nij}}{A_{gij}} \tag{2.16}$$

where

$$P_{nij} = \sum_{i=1}^{n} P_{ni} - P_{nj} \tag{2.17}$$

$$A_{gij} = \sum_{i=1}^{n} A_{gi} - A_{gj} \tag{2.18}$$

Weighted average profitability of the logistics system (adjusted for link $\boldsymbol{j}$) $\boldsymbol{P_{awj}}$:

for $\boldsymbol{j}$=1:

$$P_{awj} = \frac{1}{(n-2)}\left(\frac{P_2}{2} + \sum_{i=3}^{n-1} P_i + \frac{P_n}{2}\right) \tag{2.19}$$

for $\boldsymbol{j}$=2,3,…., $\boldsymbol{n}$-1:

$$P_{awj} = \frac{1}{(n-2)}\left(\frac{P_1}{2} + \sum_{i=2}^{n-1} P_i + \frac{P_n}{2} - P_j\right) \tag{2.20}$$

for $\boldsymbol{j}$=$\boldsymbol{n}$:

$$P_{awj} = \frac{1}{(n-2)}\left(\frac{P_1}{2} + \sum_{i=2}^{n-2} P_i + \frac{P_{n-1}}{2}\right) \tag{2.21}$$

3.2. Enter calculated indicators in Table 2.16.

Table 2.16

The results of performance indicators of the link' interaction, adjusted for link j (developed by author)

Number of the chain in the logistics system, *j*	**1**	**2**	**3**	**4**	**5**
Net profit of the logistics system as a whole without link ***j***, thousand UAH	5808	11590	12245	10314	11603
Gross assets of the logistics system as a whole without link ***j***, thousand UAH	105052	209262	220841	186105	208420
Profitability of the logistics system without link ***j***	0,0552869	0,0553851	0,0554471	0,0554203	0,05567124
Weighted average profitability of the logistics system without link ***j***	0,0554013	0,0553124	0,0554563	0,0554847	0,0558171
Performance indicator of the link' interaction in the logistics system, PI_j	0,9979347	1,0013143	0,9998336	0,9988390	0,99738685
The bottleneck of the logistics system		The bottleneck of the logistics system			

According to our calculations, we have that the bottleneck of the logistics system is the link "Road transport", the activity of which reduces the efficiency of the logistics system as a whole.

Conclusions to Chapter 2

In conclusion, Baryshivska Grain Company LLC, operating under the umbrella of Grain Alliance, has evolved into a prominent player in Ukraine's agricultural sector since its inception in 1998. Starting with no land but significant equipment, the company has grown to cultivate around 57,000 hectares of arable land in central Ukraine. With a strategic focus on optimizing sown areas, soil conservation, and fostering positive relationships with employees and landlords, the company's ethos extends beyond mere profit-making. The diversified activities of Baryshivska Grain Company encompass crop production, livestock farming, and an extensive elevator network with a total storage capacity of 250 thousand tons. The emphasis on the culture of agriculture, development across the agro-industrial complex, and collaboration with local communities underscores its commitment to holistic growth.

Grain Alliance, specializing in the cultivation and export of grain crops, demonstrates a sophisticated approach to logistics, recognizing its pivotal role in the success of their operations. The detailed exploration of their logistics business processes, from harvesting and transportation to storage, planning, distribution, quality control, and after-sales service, reveals a holistic strategy aimed at ensuring efficient and reliable grain delivery to diverse markets. The detailed overview of Grain Alliance's transport fleet, including trucks, agricultural machinery, wagons, sea and river vessels, and specialized logistics equipment, reflects the company's commitment to utilizing a diverse range of resources for optimal grain transportation and logistics. The incorporation of innovative technologies, such as closed-type hopper cars and advanced combine harvesters like the John Deere S690, exemplifies the company's commitment to efficiency and sustainability in its operations.

Additionally, the challenges faced by the company, particularly the suspension of grain export operations by sea due to hostilities in southern Ukraine, were determine. The strategic move to reorient grain exports through western regions and Europe, along with the acquisition of a transshipment elevator in the Slovak Republic, highlights the company's adaptability and resilience in the face of geopolitical challenges.

In summary, the detailed exploration of Grain Alliance's operations and its integration into the broader agricultural supply chain provides valuable insights into the complexities and strategic considerations inherent in modern agribusiness. The company's multifaceted approach, encompassing logistics, technology, and sustainability, positions it as a dynamic player in the global grain market. A crucial aspect of the chapter involves the introduction of a generalized indicator of system quality, represented as a vector of partial indicators. The normalization of these values is proposed, using an "ideal" value for each indicator. The concept of an ideal system, along with the adequacy region, is introduced to further enhance the understanding of system evaluation. Finally, the chapter touches upon the role of the market mechanism in establishing balance and optimal functioning within the economic system. The optimization of logistics system capacity is explored through three methods: the balance method, the method of bottlenecks, and the method of detecting excess capacities. The application of the bottleneck method is illustrated through a case study of the Green Alliance enterprise, where road transport is identified as the bottleneck affecting the efficiency of the logistics system.

CHAPTER 3
IMPROVEMENT OF "GRAIN ALLIANCE" ACTIVITIES DUE TO OPTIMIZATION OF LOGISTICS SYSTEM

3.1 Ways to develop logistics system of Grain Alliance

Optimizing the transport fleet, routes and warehouse space at Grain Alliance can significantly improve logistics processes and reduce costs. Here are specific recommendations for this:

1. Automation of warehouse management:

- Implementation of warehouse management systems (WMS) to optimize the processes of receiving, storing and issuing goods.

-Using automation technologies such as unmanned vehicles to move goods around the warehouse.

2. Route optimization:

-Using routing algorithms to optimize delivery and pickup of goods.

-Regular route updates based on traffic data, weather conditions and other factors.

3. Use of GPS and IoT technologies:

- Installation of GPS systems on vehicles to track location and detect delays.

-Using IoT sensors to monitor the condition of goods during transportation and in the warehouse.

4. Modernization of the transport fleet:

- Consideration of the possibility of replacing outdated vehicles with more efficient and environmentally friendly models.

-Using vehicles with built-in systems for tracking and monitoring performance indicators.

5. Optimization of warehouse space:

- Analysis of the use of space in the warehouse and optimization of the placement of goods to reduce delivery time.

-Using automated warehouse systems for efficient movement of goods and minimizing errors.

6. Energy efficiency in the warehouse:

- Implementation of energy-efficient technologies and lighting systems to reduce electricity consumption.

- Studying the possibilities of using alternative energy sources for warehouse needs.

7. Cost management system:

-Using a cost management system to monitor and control operating costs.

- Analysis of efficiency indicators and improvement of processes taking into account cost savings.

8. Staff training:

-Provision of personnel with skills for effective use of new technologies and management systems.

- Organization of trainings and seminars on optimization of processes in the warehouse and in logistics.

These recommendations should be taken as a basis and adapted to the specific needs and characteristics of Grain Alliance. It is important to systematically monitor results and make adjustments to achieve maximum efficiency.

A warehouse management system (WMS) can significantly improve warehouse management efficiency for a business like Grain Alliance. Here are some possible benefits and improvements that implementing a WMS can bring:

1. Productivity increase:

A WMS allows you to automate many routine tasks, such as inventory management, product placement, and order picking. This helps to reduce the time of operations and increase the productivity of workers in the warehouse.[33]

2. Minimization of errors:

Automation of warehouse management processes helps to reduce human errors in keeping inventory records, tracking the movement of goods and assembling orders. This contributes to increasing the accuracy and reliability of information.

3. Optimizing the use of space:

WMS allows efficient use of space in the warehouse, optimizing the placement of goods and taking into account their characteristics. This helps increase the amount of goods that can be stored in the warehouse and reduces unproductive spaces.

4. Quick feedback and response:

Thanks to the WMS system, management gets quick access to up-to-date information about stocks and warehouse operations. This allows you to quickly respond to changes in demand, improving planning and reducing reaction time to market changes.

5. Cost reduction:

Using a WMS can help reduce excess inventory, avoid supply delays, and optimize distribution processes. This can lead to significant savings in inventory management costs and optimization of logistics costs.

6. Reporting and analytics system:

WMS provides an integrated reporting and analytics system that allows you to get detailed information about all aspects of warehouse management. This facilitates strategic decision-making and improves the analysis of the efficiency of warehouse operations.

Implementing a WMS can significantly improve warehouse management efficiency for a company like Grain Alliance by streamlining processes, increasing accuracy and optimizing resources.

GPS and Internet of Things (IoT) technologies can significantly improve efficiency and process management in an agribusiness company. Here are a few ways these technologies can be used:[34]

GPS technologies in agribusiness play a key role in improving farm management, increasing production efficiency and reducing costs. Here are some of the ways they are used:

1. Precision farming:

-GPS-hydraulics and self-tracking:

Agricultural machinery can be equipped with GPS-hydraulics, which allows automatic control of the equipment in the field. Auto-tracking ensures the accuracy of machine movement, which allows you to avoid overlapping and gaps in processing.

- Field mapping:

With the help of GPS technologies, you can create detailed field maps that indicate various parameters, such as soil moisture, uniformity of fertilizer application, and other parameters.[35]

-Management of fertilizers and pesticides:

GPS technologies make it possible to precisely determine the places where fertilizers or pesticides need to be applied, which contributes to more efficient use of resources and environmental protection.

2. Machine learning and analytics:

-Harvest monitoring systems:

GPS data can be used to create systems that monitor yields in different areas of the field. This allows agronomists to respond to problems in a timely manner and optimize farm management.

- Prediction of plant development:

The collected data can be used to create models for predicting the development of plants, which allows to optimize the time of watering, application of fertilizers and other aspects of agricultural activity.

3. Accurate location marking (Geotagging):[36]

-Inventory management:

Using GPS to mark the locations of objects on the farm helps in efficient management of inventory such as equipment, vehicles and more.

- Animal care:

In agriculture, GPS can be used to track the movement of animals, which allows monitoring their location, health and safety.

4. Logistics and transportation:

- Transport routing:

GPS helps determine optimal routes for transporting agricultural products, which reduces delivery time and costs.

-Cargo monitoring:

GPS can be used to track cargo and control its location, which facilitates the logistics process.

The use of GPS technologies in agribusiness allows farmers to increase productivity, reduce costs and implement more accurate and efficient farm management.

Internet of Things (sensors, controllers, etc.) that exchange data with each other without human intervention. Based on these data, the software generates understandable reports for the farmer.[37]

Constituent elements of the IoT platform:

1. Electronic field maps;

2. Sensors on the equipment: GPS trackers, seed and fertilizer counters, harvester hopper filling sensors;

3. Fuel level sensors and flow meters;

4. Ultrasonic scanners (depth of field plowing, grain truck body filling, analysis of trace elements in the soil, etc.);

5. Electronic weight controllers on the elevator, hygrometers on the elevator;

6. Electronic gas stations;

7. RFID cards and readers: automatic identification of the driver and vehicle;[38]

8.BLE-tags of trailer equipment;

9. The "own-other" system for the harvester and the grain truck;

10. Weather stations;

11. Drones, satellites.

Sensors and controllers installed on agricultural machinery (seed counters, controllers on sprayers, flow meters and fuel level sensors, combine hopper filling sensors, grain truck filling scanner, plowing depth scanner) and sensors on scales and elevators (moisture meters, grain quality scanners and weight controllers) exchange data and visualize information on your computer screen in the form of clear reports.[39]

All data collection takes place without human intervention, which minimizes the possibility of misuse of goods and material values and embezzlement at the agricultural enterprise.

Data from the IoT platform is easily integrated with 1C, ERP, CRM systems, with Microsoft Power BI, thanks to which the management and the owner see a complete and clear picture of the activity of the agricultural enterprise: from the write-off of goods and calculations of the cost of grain drying in the elevator, based on the actual humidity recorded sensor, before calculating wages for actually cultivated hectares.[40]

The software collects field images and data from satellites, airplanes, drones, and then analyzes them with the help of artificial intelligence and provides information about the condition of fields and crops for agronomists and farmers.

IoT technologies in agro-industry (Fig. 3.1):[41]

1. Plant monitoring systems:

-Using IoT sensors for monitoring the condition of plants, measuring the level of moisture, illumination and other parameters.

-Automated notification of adverse conditions or the need for watering or processing.

2. Tracking the stages of plant development:

-Using IoT technologies to track plant growth stages and determine optimal moments for agrotechnical measures.

-Ensuring an accurate and individual approach to each gender.

3. Crop monitoring systems:

-Using sensors and IoT platforms to collect yield data.

-Data analysis to improve fertilization strategies, plant treatments and optimization of production processes.

4. Monitoring of conditions of warehouses and storage of products:

-Using IoT systems to control temperature, humidity and other conditions in agricultural warehouses.

-Automation of the ventilation system, cooling and other parameters to preserve product quality.

5. Fleet and transport management:

-Using IoT to monitor fleet and equipment status.[42]

-Systems for diagnosis and prediction of technical problems to reduce the risk of breakdowns and increase the uptime of equipment.

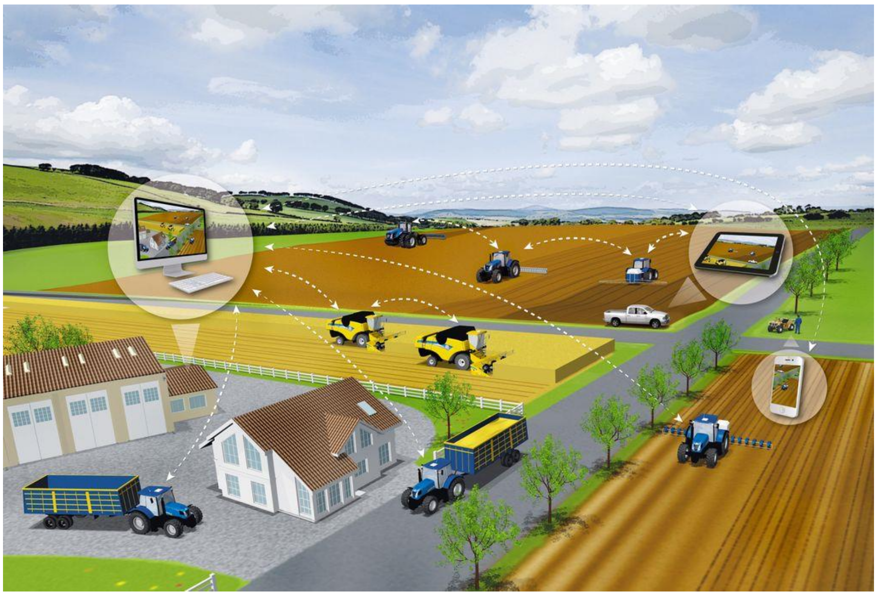

Fig. 3.1 View of the Internet of Things in an agro-industrial company [43]

Implementation of such technologies will help Grain Alliance to optimize production processes, increase efficiency and reduce costs, which is important in the agro-industrial sector.

3.2 Optimization of logistics processes of the company "Grain Alliance" at the stages of harvesting and transporting grain to the elevator

The transport process at an agro-industrial enterprise consists of sequentially executed elements; transport, loading, unloading, auxiliary and downtime for organizational and technical reasons.

Each of the specified elements of the transport process, in turn, consists of a number of operations and works performed during the preparation of the machine and cargo, or during transportation, loading and unloading operations. The specified list establishes the sequence of operations on objects and on the route in general.

At the time of the study, the Grain Alliance enterprise uses the traditional grain transportation algorithm from the field- two-stage grain harvesting "combine John Deere S690 – KamAZ 55102 grain truck" (Fig.3.2)

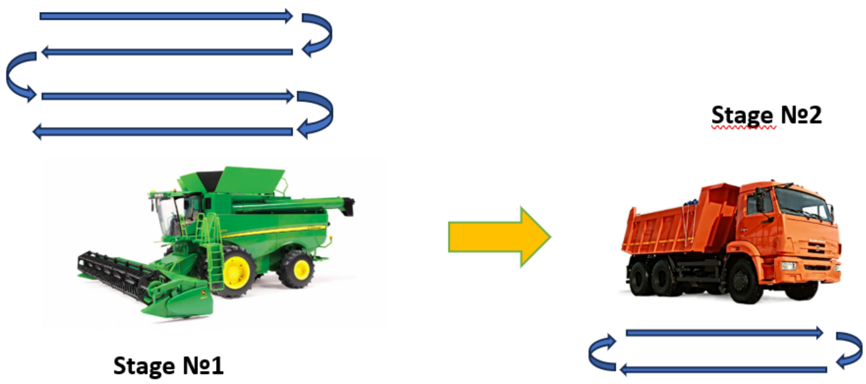

Fig. 3.2 The process of harvesting and transporting grain according to the "combine John Deere S690 – KamAZ 55102 grain truck " algorithm (developed by author)

We will calculate the productivity of the work of harvesting and transport complexes and the costs of transportation of grain crops (corn).

For calculations, we will take the John Deere S690 combine harvester (3 combines) and the Kamaz 55102 grain truck (6 trucks). The technical characteristics of these two vehicles are presented in Chapter 2.

The main link in the modeling of transport processes in crop production is the determination of the productivity of an agricultural complex, for example, a harvesting one.

The productivity of a single harvester John Deere S690 can be determined by the formula [30, 31]:

$$w_{Ci} = 0{,}1 \times B \times V_C \times Q \times K_{\text{sh}}\ , \tag{3.1}$$

where B – harvesting width of the combine, m;

V_C - working speed of the combine, km/h;

Q - yield, t/ha;

K_{sh} - coefficient of use of working shift time, $K_{\text{sh}} = 0.75$.

$$w_{Ci} = 0{,}1 \times 10.7 \times 6 \times 5 \times 0.75 = 24.1 \text{ t/hour}$$

The time of filling the hopper of the combine is $t_f = 0.33$ hours.

The distance or length of the run, at which the harvester hopper is filled, is determined from the equation:

$$l_r = \frac{10^4 \times V_h \times \rho_c}{B \times Q} \tag{3.2}$$

where V_h-grain harvester bunker volume, m3;

ρ_c-bulk density of grain of the harvested crop, t/m3.

$$l_r = \frac{10^4 \times 14.1 \times 0.76}{10.7 \times 5} = 2003 \text{ m}$$

When working in a complex group of combines consisting of a number of Nc, the total productivity will be equal to:

$$W_c = Nc \times W_{ci} \tag{3.3}$$

$$W_c = 3 \times 24.1 = 72.3 \text{ t/hour}$$

The time of the working cycle, when the combine hopper will be filled, is determined from the equation:

$$Twc = t_f \times (N_C - 1) \tag{3.4}$$

$$Twc = 0.33 \times (3 - 1) = 0.66 \text{ hours}$$

The productivity of a single vehicle KamAZ that serves the combine is determined from the equation [30, 31]:

$$W_{vi} = \frac{q_n \times \gamma \times \beta \times V_{tv}}{(l_C + V_{tv} \times \gamma \times t_{L-U})} \tag{3.5}$$

where q_n- nominal carrying capacity of the vehicle, t;

γ- load capacity utilization factor;

β-mileage utilization factor;

V_{tv}- technical speed of the vehicle, km/h;

l_C- the distance over which the grain is transported, km;

t_{L-U}- time of loading and unloading the vehicle, hours.

$$W_{vi} = \frac{7 \times 0.86 \times 0.5 \times 60}{(22 + 60 \times 0.5 \times 0.25)} = 6.1 \text{ t/hour}$$

We determine the coefficient of use of the carrying capacity of the vehicle from the equation [30, 31]:

$$\gamma = \frac{q_{act}}{q_n} \tag{3.6}$$

where q_{act}- the actual carrying capacity of the vehicle, t.

$$\gamma = \frac{6}{7} = 0.86$$

The coefficient of use of the vehicle mileage is determined from the equation [30, 31]:

$$\beta = \frac{l_c}{l_G} \tag{3.7}$$

where l_G- total mileage of the vehicle with and without cargo, km.

$$\beta = \frac{22}{44} = 0.5$$

The working cycle of a Kamaz vehicle can be determined by the formula:

$$t_{Cv} = t_f + t_C + t_w + t_{L-U} \tag{3.8}$$

where t_f- the time of filling the hopper of the combine, hour;

t_C- time of movement of the vehicle with cargo, h;

t_w-time of return of the vehicle without cargo (idle run), h.

$$t_{cv} = 0.33 + 0.36 + 0.31 + 0.25 = 1.25 \text{ h}$$

The time of movement of a vehicle with a load is determined from the equation [30, 31]:

$$t_c = \frac{l_C}{V_{tv}} \tag{3.9}$$

$$t_c = \frac{22}{60} = 0.36 \text{ h}$$

The time of movement of a vehicle without a load (idle mileage) is determined from the equation [30, 31]:

$$t_w = \frac{l_w}{V_{tv}} \tag{3.10}$$

$$t_w = \frac{22}{70} = 0.31 \text{ h}$$

The working cycle time of a group of vehicles is determined from the equation [30, 31]:

$$Twc = t_{cv} \times (N_v - 1) \tag{3.11}$$

$$Twc = 1.25 \times (6 - 1) = 6.25 \text{ h}$$

The costs of transporting grain by vehicle from the combine to the elevator are determined from the equation [32]:

$$C_{vi} = \frac{l_G \times K \times G}{\gamma \times q_{act}} + \frac{C_d + A_v + C_t + C_o}{P} \tag{3.12}$$

where K- cost of 1 kg of fuel and lubricants, UAH/t;

G- consumption of fuel and lubricants per 1 km of mileage, kg;

C_d-the driver's salary for the collection period, UAH;

A_v- vehicle depreciation for the collection period, UAH;

C_t- vehicle maintenance costs, UAH;

C_o-other expenses for one vehicle, UAH;

P- the total mass of transported cargo for the entire collection period, t.

$$C_{vi} = \frac{44 \times 100 \times 0.45}{0.86 \times 6} + \frac{12000 + 3333 + 1200 + 500}{6000} = 386.6 \text{ UAH/t}$$

The total costs for the transportation of crops by a group of cars are determined from the equation:

$$C_v = N_v \times C_{vi} \tag{3.13}$$

$$C_v = 6 \times 386.6 = 2319.6 \text{ UAH/t}$$

So, using 3 combines on the field, which will serve 6 KamAZ grain trucks to transport 6000 tons of grain to the elevator, we will spend 2319.6 UAH/t.

Many Ukrainian agro-producers face difficulties during the harvest, not being able to quickly remove the harvested crop from the field.

In turn, because of this, combines are sometimes forced to stop their work, waiting for grain trucks. Ultimately, this has a negative impact on productivity and grain quality.

The technological process is hampered by logistical tasks. The usual harvesting practice in our country is that the harvester, which has filled the hopper, turns on the signal (light indicator on the roof) and stops the harvesting process. After that, a truck that was waiting at the edge of the field approaches him, the grain is reloaded into it, and the work of the combine resumes.

A situation often arises in the field when a combine harvester with a full hopper has to wait for unloading for quite a long time. This is often due to the insufficient number of vehicles: the power characteristics of the combine allow it to fill a full hopper quite quickly, while the machines do not have time to take the grain to the elevator during this time.

A "classic of the genre" can be called a situation when a powerful harvester, having filled a bunker in 10 minutes, waits for unloading for 20-30 minutes with the "blinker" turned on.

It also happens that the delay in the collection campaign is caused by the peculiarities of the terrain. For example, if the combine works behind a hill or in a lowland, its signal about filling the hopper is not easily visible to the tractor (truck) standing at the edge of the field. I can cite many examples of such misunderstandings and uncoordinated actions. And hence - loss of working time, which causes a decrease in the efficiency of the use of equipment.

It is the optimization of logistics that makes it possible to significantly speed up the assembly process and becomes a tangible tool for influencing its productivity.

A hopper-transloader, or a storage unit, is a metal container on a wheeled chassis, designed for intermediate storage of grain. Such bunkers are aggregated with tractors and placed in the field during the harvest. As the hopper of the harvester fills, the accumulator is driven to the grain harvester, which pours the collected grain into it. At the same time, it is desirable that the volume of the grain accumulator is a multiple of the volume of the combine hopper.

In recent years, domestic agricultural producers have been using large grain trucks to transport grain from the field. This is a heavy machine, which is undesirable to drive into the field. Most often, the harvesters themselves are forced to approach the grain truck at the edge of the field, which causes unnecessarily large losses of working time - up to 20-25%. On the other hand, if there is a special bunker on the field, the harvesters practically do not stop their work.

In addition, grain-carrying cars and tractors with trailers do not always keep up with the productivity of combines, so grain-harvesting machines are forced to wait for them with full hoppers. Instead, this problem can be overcome with the help of a storage unit, which will hold the collected grain until the arrival of the grain truck.

To optimize the collection and transportation of grain to the elevator, I suggest implementing at the Grain Alliance grain transportation algorithm from the field- three-stage grain harvesting "combine John Deere S690- tractor John Deere 8430 with bunker-transloader PBN-30 – MAN TGX with semi-trailer Bodex KIS 3WA" (Fig.3.3)

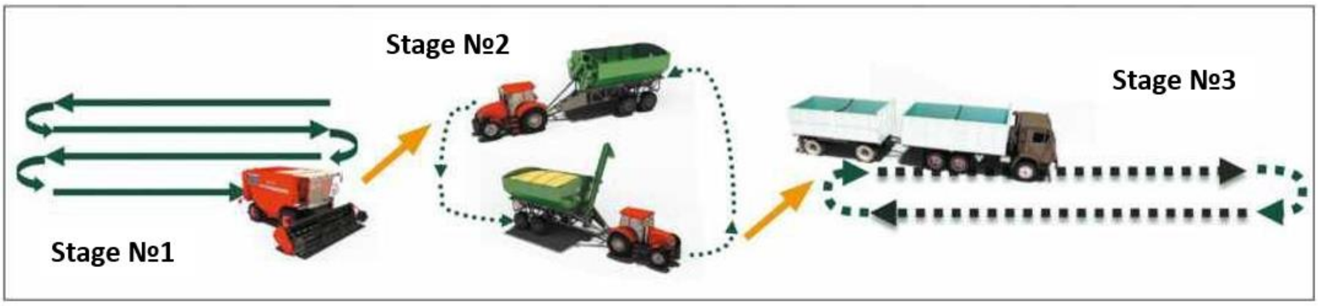

Fig. 3.3 The three-stage grain harvesting "Combine - Bunker-transloader PBN-30 – MAN TGX with semi-trailer Bodex KIS 3WA"

Overloading storage hoppers ensure reliable and trouble-free operation during the busy harvest season, and the special design of the unloading auger allows you to reload grain into machines, load planters, and fill BigBag bags.

The reloading hopper model PBN-30 makes the harvesting process even more efficient and simple. Easily connects to the tractor and works together with the combine in the field (Fig.3.4). The grain harvester's hopper is about 15 m3 and, as it is filled with grain, it is unloaded into the reloader hopper without stopping. A combine harvester in such a chain works non-stop and can process an additional 10-14 hectares per day, increasing farm productivity. In addition, the PBN-30 hopper transfers grain to grain trucks waiting at the edge of the field, reducing delay times and providing a more efficient process.

Fig. 3.4 New hopper-transloader of grain KOBZARENKA PLANT PBN-30

The technical characteristics of hopper-transloader PBN-30 are presented in the Table 3.1.

Table 3.1

The technical characteristics of hopper-transloader PBN-30

1	Weight, kg	6500
2	Carrying capacity, kg	23000
3	Capacity, m^3	30
4	Length, mm	8500

We will calculate the productivity of the work of transport complexes and the costs of transportation of grain crops (corn).

For calculations, we will take the John Deere S690 combine harvester (3 combines), tractor John Deere 8430 with bunker-transloader PBN-30 (2 bunker-transloader) and MAN TGX with semi-trailer Bodex KIS 3WA.

The productivity of a single vehicle tractor John Deere 8430 with bunker-transloader PBN-30 that serves the combine is determined from the equation [30, 31]:

$$W_{vi} = \frac{23 \times 0.96 \times 0.5 \times 25}{(2 + 25 \times 0.5 \times 0.2)} = 61.3 \text{ t/hour}$$

We determine the coefficient of use of the carrying capacity of the vehicle from the equation [23, 24]:

$$\gamma = \frac{22}{23} = 0.96$$

The coefficient of use of the vehicle mileage is determined from the equation [30, 31]:

$$\beta = \frac{2}{4} = 0.5$$

The working cycle of a tractor John Deere 8430 with bunker-transloader PBN-30 vehicle can be determined by the formula:

$$t_{cv} = 0.33 + 0.08 + 0.08 + 0.2 = 0.69 \text{ h}$$

The time of movement of a vehicle with a load is determined from the equation [30, 31]:

$$t_c = \frac{2}{25} = 0.08 \text{ h}$$

The time of movement of a vehicle without a load (idle mileage) is determined from the equation [30, 31]:

$$t_w = \frac{2}{25} = 0.08 \text{ h}$$

The working cycle time of a group of vehicles is determined from the equation [30, 31]:

$$Twc = 0.69 \times (2 - 1) = 0.69 \text{ h}$$

The costs of transporting grain by vehicle from the combine to the MAN TGX with semi-trailer Bodex KIS 3WA are determined from the equation [32]:

$$C_{vi} = \frac{4 \times 125 \times 0.55}{0.96 \times 22} + \frac{14000 + 45000 + 3000 + 1500}{6000} = 23.6 \text{ UAH/t}$$

The total costs for the transportation of crops by a group of vehicles from the combine to the MAN TGX with semi-trailer Bodex KIS 3WA are determined from the equation:

$$C_v = 2 \times 23.6 = 47.2 \text{ UAH/t}$$

The productivity of a single vehicle MAN TGX with semi-trailer Bodex KIS 3WA that serves the combine is determined from the equation [30, 31]:

$$W_{vi} = \frac{36 \times 0.72 \times 0.5 \times 80}{(20 + 80 \times 0.5 \times 0.18)} = 38.1 \text{ t/hour}$$

We determine the coefficient of use of the carrying capacity of the vehicle from the equation [23, 24]:

$$\gamma = \frac{26}{36} = 0.72$$

The coefficient of use of the vehicle mileage is determined from the equation [30, 31]:

$$\beta = \frac{20}{40} = 0.5$$

The working cycle of a MAN TGX with semi-trailer Bodex KIS 3WA vehicle can be determined by the formula:

$$t_{cv} = 0.33 + 0.25 + 0.2 + 0.18 = 0.96 \text{ h}$$

The time of movement of a vehicle with a load is determined from the equation [30, 31]:

$$t_c = \frac{20}{80} = 0.25 \text{ h}$$

The time of movement of a vehicle without a load (idle mileage) is determined from the equation [30, 31]:

$$t_w = \frac{20}{90} = 0.2 \text{ h}$$

The costs of transporting grain by vehicle from the tractor John Deere 8430 with bunker-transloader PBN-30 to elevator are determined from the equation [32]:

$$C_{vi} = \frac{40\times105\times0.4}{0.72\times26} + \frac{25000+18000+2000+1000}{6000} = 97.4 \text{ UAH/t}$$

The total costs for the transportation of crops by a group of vehicles from the combine to the elevator are determined from the equation:

$$C_v = C_{vi\,hopper} + C_{vi\,MAN} \tag{3.14}$$

$$C_v = 47.2 + 97.4 = 144.6 \text{ UAH/t}$$

The total time for the transportation of crops by a group of vehicles from the combine to the elevator are determined from the equation:

$$T_{cv} = t_{cv\,hopper} + t_{cv\,MAN} \tag{3.15}$$

$$T_{cv} = 0.96 + 0.69 = 1.65 \text{ h}$$

We compare the obtained results of transportation algorithm from the field -2-stage grain harvesting and 3-stage grain harvesting.

The total costs for the transportation of crops by a group of vehicles from the combine to the elevator:

- 2-stage grain harvesting: 2319.6 UAH/t
- 3-stage grain harvesting: 144.6 UAH/t.

$$\Delta C = \frac{144.6 - 2319.6}{2319.6} \times 100 = -93.8\%$$

The total time for the transportation of crops by a group of vehicles from the combine to the elevator:

- 2-stage grain harvesting: 6.25 h
- 3-stage grain harvesting: 1.65 h.

$$\Delta T = \frac{1.65 - 6.25}{6.25} \times 100 = -73.6\%$$

According to the obtained results, thanks to the implementation of transportation algorithm from the field- 3-stage grain harvesting, cost optimization will be reduced by 93.8%, and time optimization will occur by 73.6%.

According to the obtained results, thanks to the implementation of transportation algorithm from the field -3-stage grain harvesting, cost optimization will be reduced by 93.8%, and time optimization will occur by 73.6%.

3.3 Assessing efficiency of investment project on optimization of the company's fleet of vehicles

The cost of the new hopper-transloader of grain KOBZARENKA PLANT PBN-30 is 1 680 000 UAH.

To fully meet the needs of cargo transportation at the Baryshivska Grain Company LLC, it is necessary to purchase 2 hoppers-transloaders of grain.

The amount of investment costs is $1\ 680\ 000\ * 2 = 3\ 360\ 000\ UAH$

Assume that the depreciation period is 10 years.

Depreciation is calculated using the straight-line method. The amount of depreciation of both hoppers-transloaders of grain is equal to $\frac{3\ 360\ 000}{10} = 336\ 000\ UAH.$

According to the company's data, as a result of the introduction of 2 units of new hoppers-transloaders, it is expected to receive a net profit in the amount of UAH 848250 with its subsequent annual growth of 5%.

The next step for making a decision on the purchase of new equipment is to perform the following calculations. For example, indicators for the first year of using the new mechanism are calculated:

Cash flows = Net profits + The amount of depreciation

Cash flows (for 1st year) = $848\ 250\ + 336\ 000 = 1\ 184\ 250\ UAH$

Present value of cash flows (net cash flows) = $\frac{Cash\ flow}{(1+discount\ rate)^n}$

The present value of the cash flow (net cash flow) is calculated in several options, when we take the average interest rates on loans of commercial banks of Ukraine as the discount rate, i.e. 25%, and 30%.

With a discount rate of 25%:

Present value of cash flows (for 1st year) =$\frac{1\ 184\ 250}{(1+0.25)^1} = 947\ 400\ UAH$

With a discount rate of 30%:

Present value of cash flows (for 1st year) $=\frac{1\,184\,250}{(1+0.30)^1}=910\,962\ UAH$

Let's calculate all these indicators for each year.

To make an informed management decision on the feasibility of the project, we use other indicators of investment project efficiency.

a) The Net Present Value (NPV) represents the sum total of discounted annual differences between real (net of tax, interest expense etc.) cash outflows and inflows over the project life.

$$NPV = -CAPEX + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} \tag{3.16}$$

where, $CAPEX -$ capital expenditures (or initial investment) at the year zero of the project;

$CF_t -$ cash flow in the year, t;

n – economic life, years;

t – each year of economic life;

r – the required rate of return for the project.

If, $NPV < 0$ – a project shall be rejected;

$NPV = 0$ – the return is equal to the discount rate, and the income earned will be just sufficient to cover obligations to creditors;

$NPV > 0$ – the return on investment is above the discount rate and the investment project can be considered acceptable.

b) The Profitability Index (PI) represents the generation of cash, reported at the present, per unit of investment.

$$PI = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} / CAPEX \tag{3.17}$$

If, $PI < 1$ – a project shall be rejected;

$PI \geq 1$ – a project shall be accepted;

$PI = 1 - Profit = CAPEX$

c) The Internal Rate of Return (IRR) the average annual rate generated by the project and is the discount rate which makes NPV=0.

$$IRR = r_1 + \frac{NPV(r_1)}{NPV(r_1) - NPV(r_2)} * (r_2 - r_1) \tag{3.18}$$

where, $r_1 -$ required rate of return for the project, when NPV $(r_1) < 0$ (or NPV $(r_1) > 0$;

$r_2 -$ required rate of return for the project, when NPV $(r_2) > 0$ (or NPV $(r_2) < 0$.

d) The Payback Period (P) tells how much time it will take to recover the initial investment made in the project.

$$P = A + \frac{B}{C} \tag{3.19}$$

where, A – the last period with a negative cumulative net cash flow;

B – the absolute value of cumulative net cash flow at the end of the period A;

C – the net cash flow during the period after A.

Let's calculate all these indicators for different discount rates.

With a discount rate of 25%:

$$NPV = \left(\frac{947\ 400}{(1+0.25)^1} + \frac{785\ 064}{(1+0.25)^2} + \frac{650\ 852}{(1+0.25)^3} + \frac{539\ 835}{(1+0.25)^4} + \frac{447\ 956}{(1+0.25)^5} + \frac{371\ 879}{(1+0.25)^6} + \frac{308\ 855}{(1+0.25)^7} + \frac{256\ 620}{(1+0.25)^8} + \frac{213\ 306}{(1+0.25)^9} + \frac{177\ 373}{(1+0.25)^{10}}\right) - 3\ 360\ 000 = 1\ 339\ 139\ UAH$$

$$PI = \left(\frac{947\ 400}{(1+0.25)^1} + \frac{785\ 064}{(1+0.25)^2} + \frac{650\ 852}{(1+0.25)^3} + \frac{539\ 835}{(1+0.25)^4} + \frac{447\ 956}{(1+0.25)^5} + \frac{371\ 879}{(1+0.25)^6} + \frac{308\ 855}{(1+0.25)^7} + \frac{256\ 620}{(1+0.25)^8} + \frac{213\ 306}{(1+0.25)^9} + \frac{177\ 373}{(1+0.25)^{10}}\right) / \ 3\ 360\ 000 = 1.40$$

$$IRR = 25 + \left(\frac{1\ 339\ 139}{1\ 339\ 139 + 1\ 815\ 336} * (80 - 25)\right) = 48.35\ \%$$

$$P = 4 + \frac{3\ 360\ 000 - 2\ 923\ 151}{447\ 956} = 4.98\ years$$

The total results of the calculations of the feasibility of implementing an investment project for the purchase of new hoppers-transloaders, when the discount rate is equal to 25% are presented in the Table 3.2.

Table 3.2

Calculations of the feasibility of implementing an investment project for the purchase of new hoppers-transloaders (discount rate 25%)

Indicators	Years									
	1	2	3	4	5	6	7	8	9	10
The amount of depreciation, UAH	336000	336000	336000	336000	336000	336000	336000	336000	336000	336000
The amount of net profit, UAH	848250	890663	935196	981955	1031053	1082606	1136736	1193573	1253252	1315914
The amount of cash flow, UAH	1184250	1226663	1271196	1317955	1367053	1418606	1472736	1529573	1589252	1651914
Discounted Cash Flows, UAH	947400	785064	650852	539835	447956	371879	308855	256620	213306	177373
The amount of investment costs, UAH	3360000	-	-	-	-	-	-	-	-	
Net present income of the investment project, UAH	1 339 139									
Profitability Index	1.40									

The end of the Table 3.2

Internal Rate of Return, %	48.35
Payback Period, years	4.98

Sourse: developed by author

With a discount rate of 30%:

$$NPV = \left(\frac{910\,962}{(1+0.30)^1} + \frac{725\,836}{(1+0.30)^2} + \frac{578\,605}{(1+0.30)^3} + \frac{461\,453}{(1+0.30)^4} + \frac{368\,187}{(1+0.30)^5} + \frac{293\,901}{(1+0.30)^6} + \frac{234\,705}{(1+0.30)^7} + \frac{187\,510}{(1+0.30)^8} + \frac{149\,866}{(1+0.30)^9} + \frac{119\,827}{(1+0.30)^{10}}\right) - 3\,360\,000 = 670\,851\ UAH$$

$$PI = \left(\frac{910\,962}{(1+0.30)^1} + \frac{725\,836}{(1+0.30)^2} + \frac{578\,605}{(1+0.30)^3} + \frac{461\,453}{(1+0.30)^4} + \frac{368\,187}{(1+0.30)^5} + \frac{293\,901}{(1+0.30)^6} + \frac{234\,705}{(1+0.30)^7} + \frac{187\,510}{(1+0.30)^8} + \frac{149\,866}{(1+0.30)^9} + \frac{119\,827}{(1+0.30)^{10}}\right) / \ 3\,360\,000 = 1.20$$

$$IRR = 30 + \left(\frac{670\,851}{670\,851 + 1\,815\,336} * (80-30)\right) = 43.49\ \%$$

$$P = 5 + \frac{3\,360\,000 - 3\,338\,944}{293\,901} = 5.07\ years$$

The total results of the calculations when the discount rate is equal to 30% are presented in the Table 3.3.

Table 3.3.

Calculations of the feasibility of implementing an investment project for the purchase of new hoppers-transloaders (discount rate 30%)

№	Indicators	Years									
		1	2	3	4	5	6	7	8	9	10
1	The amount of depreciation, UAH	336000	336000	336000	336000	336000	336000	336000	336000	336000	336000
2	The amount of net profit, UAH	848250	890663	935196	981955	1031053	1082606	1136736	1193573	1253252	1315914
3	The amount of cash flow, UAH	1184250	1226663	1271196	1317955	1367053	1418606	1472736	1529573	1589252	1651914
4	Discounted Cash Flows, UAH	910962	725836	578605	461453	368187	293901	234705	187510	149866	119827
5	The amount of investment costs, UAH	3360000	-	-	-	-	-	-	-	-	
6	Net present income of the investment project, UAH	670 851									
7	Profitability Index	1.20									
8	Internal Rate of Return, %	43.49									
9	Payback Period, years	5.07									

Sourse: developed by author

Taking into account performed calculation of investment project, it can be concluded that the project is appropriate for implementation, as net present value is positive, i.e. the project is profitable and the payback period of this project is 4.98 years at discount rate 25%, and 5.07 years at discount rate 30%. Implementation of this project makes it possible to quickly and economically collect and transport grain to the elevator. Using a hopper-transloader of grain KOBZARENKA PLANT PBN-30 will save costs, be reliable and efficient.

Conclusions to Chapter 3

In conclusion, the potential for significant improvements in logistics processes and cost reduction at Grain Alliance through the optimization of the transport fleet, routes, and warehouse space, is underlined. Specific recommendations have been provided, covering various aspects of warehouse management, route optimization, GPS and IoT technologies, modernization of the transport fleet, warehouse space optimization, energy efficiency, cost management, and staff training. It is emphasized that the recommendations provided should serve as a foundation and be adapted to the specific needs and characteristics of Grain Alliance. Additionally, the importance of systematic monitoring of results and continuous adjustments to achieve maximum efficiency is underscored. The integration of these technologies holds the promise of optimizing operations, reducing costs, and enhancing overall efficiency for Grain Alliance in the agro-industrial sector. In conclusion, the chapter presents a detailed analysis of the transport processes at the Grain Alliance agro-industrial enterprise, focusing on the traditional two-stage grain harvesting algorithm involving the "combine John Deere S690 – KamAZ 55102 grain truck." The study calculates the productivity and costs associated with this approach, emphasizing the challenges faced during the harvest due to delays in unloading, logistical constraints, and the impact on overall efficiency.

An optimized three-stage grain harvesting algorithm, introducing a hopper-transloader as an intermediary storage unit to streamline the process is propozed. This new approach involves the "combine John Deere S690 – tractor John Deere 8430 with bunker-transloader PBN-30 – MAN TGX with semi-trailer Bodex KIS 3WA." The productivity and costs of this optimized algorithm are thoroughly calculated to assess its feasibility.

The key findings reveal that the proposed three-stage grain harvesting algorithm significantly outperforms the traditional two-stage approach in terms of cost and time optimization. The cost reduction is impressive, amounting to 93.8%, and the time optimization reaches 73.6%. These results highlight the potential benefits of incorporating advanced logistics strategies in grain transportation.

The utilization of hopper-transloaders, illustrated by the PBN-30 model, emerges as a crucial component in enhancing efficiency. The hopper-transloader not only facilitates continuous harvesting by accommodating the combine's output but also minimizes waiting times for grain trucks, leading to increased overall productivity. In conclusion, the chapter provides a comprehensive analysis of the investment project involving the purchase of new hoppers-transloaders of grain, specifically the KOBZARENKA PLANT PBN-30 model, for Baryshivska Grain Company LLC. The total investment cost for acquiring two units of the hopper-transloader is determined to be 3,360,000 UAH. The depreciation period is set at 10 years, with an annual depreciation of 336,000 UAH. The results indicate that the investment project is economically justified and financially sound. The positive NPV values, PI greater than 1, and favorable IRR suggest that the project is acceptable and has the potential to generate returns above the required discount rates. Furthermore, the calculated payback period falls within a reasonable timeframe.

Thus, the implementation of the hopper-transloader project is recommended, as it promises economic efficiency, cost savings, and improved grain collection and transportation to the elevator. The use of financial metrics supports the conclusion that the investment is financially feasible and aligns with the company's objectives. The acquisition of new hoppers-transloaders is expected to contribute positively to the overall operational efficiency of Baryshivska Grain Company LLC.

CONCLUSIONS

1. Studying logistic criteria as diagnostic indicators of the level of efficiency of transport processes shows, that the transport logistics is recognized as integral to overall logistics systems, addressing tasks related to service market areas, transport process organization, and stock management. Costs and delivery time are highlighted as pivotal factors in choosing transportation methods, and a multi-criteria approach is advocated for transportation planning. Criteria such as "just-in-time" delivery, duration of cargo delivery, transportation costs, vehicle performance, and energy consumption are deemed essential for evaluating transport efficiency.

A comprehensive analysis of cargo transportation made it possible to determine the participants - the consignor, the carrier and the consignee. The criteria for the efficiency of product delivery were determined, taking into account the efficiency of the national economy and the complexity of determining optimality.

2.Optimization principles as mechanisms for ensuring the efficiency of technologies in transport processes include linear programming methods (the simplex method, dual simplex method, and others), integer programming methods (segmentation, branched search, combinatorial, heuristic, and random search), nonlinear programming methods (direct, indirect, design, linearization, etc.).

The optimization of logistics solutions is a cyclical process involving stages such as problem awareness, goal formulation, model development, method selection, data preparation, solution analysis, plan adoption, implementation control, result evaluation, and final analysis. Various logistics tasks can be addressed through optimization, including transportation planning, determining transport network capacity, finding the cheapest transport route, selecting the optimal location for distribution centers, and devising strategies for supply management and investment planning.

Various cost optimization methods are discussed, including functional cost analysis, "just-in-time" production organization, target costing, kaizen-costing, life cycle cost analysis, economic value added (EVA), ABC analysis, XYZ analysis, and the balance method. Each method has its advantages and disadvantages, and their applicability depends on specific conditions. The choice of methods depends on the nature of the optimization problem being addressed.

3. The detailed overview of the Baryshivska Grain Company LLC evolution into a prominent player in Ukraine's agricultural sector was provided. The company's commitment to holistic growth, encompassing crop production, livestock farming, and a substantial elevator network, is underlined. Grain Alliance's sophisticated approach to logistics, including its diverse transport fleet and strategic use of technology, reflects its commitment to efficient and reliable grain delivery. The calibration facility, equipped with Japanese technology, situated in Baryshivka, ensures the production of high-quality sowing material and meets global standards for soybean grain. As the company continues to expand its geographical footprint and contribute to the development of the agricultural sector, it remains steadfast in its commitment to sustainable practices, employee welfare, and community engagement. The journey of Baryshivska Grain Company LLC exemplifies a successful integration of strategic investments, technological advancements, and a comprehensive approach to agricultural management.

Logistics play a crucial role in company`s operations, as efficient grain delivery and storage are essential for the success of their business. The main goal of the logistics business processes at Grain Alliance is to ensure efficient and reliable grain delivery to the markets and to maintain product quality throughout the entire supply chain.

During analysis the challenges faced by the company, particularly geopolitical disruptions affecting grain exports, were determined. Grain Alliance's adaptability and resilience are highlighted through strategic reorientation and the acquisition of a transshipment elevator in the Slovak Republic.

Furthermore, the EU's proposed plan to support Ukraine's grain export, addressing urgent measures, increasing transport capacity, simplifying customs operations, and organizing temporary storage, underscores the broader international context in which Grain Alliance operates.

4. Optimizing the capacity of the logistics system of the Grain Alliance is due to the need, on the one hand, to match the logistics system to the assigned tasks, and on the other hand, to optimize costs associated with excess or underutilized capacities.

To optimize the capacity of the logistics system at the Grain Alliance enterprise, the "bottleneck" method was used. The bottleneck method, as applied in the case of the Grain Alliance enterprise, focuses on identifying specific links with reduced efficiency, leading to an overall decrease in the system's effectiveness. It involves assigning serial numbers to all links, calculating the efficiency of their interactions, and pinpointing bottlenecks for corrective measures. Overcoming bottlenecks requires careful monitoring, and their elimination in one link may lead to their appearance in another. The case study at Grain Alliance highlighted "Road transport" as the bottleneck due to either excessively high or low revenues and incorrect data provision, resulting in a mismatch during planning.

5. Analysis of the optimization of logistics processes at Grain Alliance, emphasized the potential for significant improvements in cost reduction and efficiency through recommendations covering warehouse management, route optimization, technology integration, energy efficiency, and staff training. The proposed changes are positioned as adaptable foundations tailored to the specific needs of Grain Alliance, with an emphasis on continuous monitoring and adjustment for optimal results. Specific recommendations have been provided, covering various aspects of warehouse management, route optimization, GPS and IoT technologies, modernization of the transport fleet, warehouse space optimization, energy efficiency, cost management, and staff training.

The implementation of a Warehouse Management System (WMS) is highlighted as a crucial step, offering benefits such as increased productivity, minimization of errors, optimized space utilization, quick feedback and response, cost reduction, and an integrated reporting and analytics system. The potential advantages of WMS for Grain Alliance are aligned with streamlining processes, increasing accuracy, and optimizing resources.

6. Based on the results of assessing performance indicators of the Grain Alliance logistics system, detailed analysis of transport processes within Grain Alliance, comparing a traditional two-stage grain harvesting algorithm with a proposed optimized three-stage approach was provided. The results reveal the substantial cost and time advantages of the optimized algorithm, showcasing the potential benefits of incorporating advanced logistics strategies, including the utilization of hopper-transloaders.

Research concludes with a comprehensive analysis of an investment project involving the purchase of new hoppers-transloaders for Baryshivska Grain Company. The financial evaluation, considering indicators such as Net Present Value (NPV), Profitability Index (PI), Internal Rate of Return (IRR), and Payback Period, supports the conclusion that the project is economically justified and aligns with the company's objectives. The acquisition of new hoppers-transloaders is anticipated to enhance operational efficiency, contribute to cost savings, and improve grain transportation for Baryshivska Grain Company.

REFERENCES

1. Wang, X., Chen, Y., and Zhang, L. (2013). Construction of a system for evaluating the efficiency of transport of logistics companies. Journal of Industrial Engineering and Management, 2013. Issue. 6. № 4, art. 1084-1104.
2. Vorkut T.A. Trends in the development of the road freight transportation market in Ukraine. // System control methods, technology and organization of production and operation of cars: Collection. of science pr. – K.: NTU, TAU. – 1999. – Issue 7. - P.110-114.
3. S. Stokolyas. The efficiency of transport logistics as a component of the logistics system. Electronic magazine "Effective Economy", 2014. Issue No. 7.
4. E.V. Nagornyi, N.Yu. Shramenko. Analysis of the criteria for the efficiency of logistics systems in the delivery of goods. Interuniversity collection "Scientific Notes". Lutsk, 2010. Issue #28, articles 353-357.
5. Pravdin N.V., Negrei V.Ya., Podkopaev V.A. Interaction of different types of transport: - (examples and calculations) / Sub. Ed. N.V. the truth - M.: Transport, 1989 - 208 p.
6. N.A. Voloshyna Justification of the criteria for the efficiency of road transport in the logistics system/ N.A. Voloshina// Bulletin of the Kharkiv National Automobile and Road University/ Ministry of Education and Science of Ukraine; editor: V.A. Bogomolov (chief editor) and others. - Kharkiv: Khnadu, 2005. – Issue 28 - pp. 60-62.
7. Rossolov O.V. To the question of the criterion for choosing a rational cargo delivery scheme/ Rossolov O.V., Lyubiy E.V.// Bulletin of the Kremenchug State Polytechnic University/ Ministry of Education and Science of Ukraine; editor: M.V. Zahirnyak (chief editor) and others. – Kremenchuk: KDPU, 2006. – Vol. 2/2006 (37) part 1. – P. 101 – 102.

8. Nefedov N.A. Determination of the optimality criterion of consumer goods delivery schemes./ Nefedov N.A., Cherepaha O.S.// Avtomobilny transport/ Coll.scient.p.- Kharkiv: KHADU. – 2006. – Issue 19. - P.62-65.

9. Ponomaryova N.V. Forecasting cargo flows on land modes of transport in international traffic: Author's Ref. thesis Ph.D. technical Sciences: Special. 05.22.01 - transport systems. Kh. national automobile - road University of Kh., 2007. - 20 p.

10. Nagorny E.V. Rationalization of technological and logistical parameters of transport service for truck owners in transport hubs / Nagornyi E.V., Stolyar T.V.// Automobile transport/ Collection of scientific papers - Kharkiv: KhGADU. – 2006. – Issue 18. - P.54-56.

11. Analysis of international transport corridors as a means of economic integration of Ukraine [Electronic resource] / N. M. Naish, M. V. Aksyonov, Zh. M. Ivchenko // Bulletin of the East Ukrainian National University named after Volodymyr Dahl. - 2015. - No. 1. - P. 293-296. - Access mode: http://nbuv.gov.ua/UJRN/VSUNU_2015_1_65

12. Goryainov A.N. Diagnostics in transport and logistics systems / Collection of materials of the International scientific and practical conference "Strategies of innovative economic development: business, science, education" April 7-10, 2010. Kharkiv NTU "KhPI", 2010. - P.328-330.

13. Pavlov V.I., Bortnik S.M. Transport and logistics complex of the region: integration processes: Monograph. // Editor-in-chief M.I. Dolishniy. - Lutsk: Nadstryya, 2005. - 256 p.

14. Kigel V.R. Optimization of logistics solutions: Study guide for students majoring in "Logistics". - Kyiv: "KROK" University of Economics and Law, 2007. - 136 p.

15. Yarovenko T. S. Ways and methods of optimizing enterprise costs in market conditions / T. S. Yarovenko, A. O. Dovga, V. E. Ostryanina. Bulletin of Dnipropetrovsk University. "Economy" series. – 2013. [Electronic resource]. Access mode: http://vestnikdnu.com.ua/archive/201372/yarovenko-dovga.html#sdfootnote1anc.

16. Savchenko L. V. Optimization of decisions in logistics: theory and practice. – Kyiv: RIO NTU, 2007. – 248 p.

17. Olkhova M. V. Spheres of rational use of road and rail modes of transport in trunk transportation of packaged goods: abstract of candidate technical science, special.: 05.22.01 - transport systems / Olkhova Maria Volodymyrivna; Kharkiv. National University named after O. M. Beketova. - Kharkiv, 2015. - 22 p.

18. Lysa S.S. Evaluation of economic efficiency of logistics chains of trade networks. Bulletin of the Chernivtsi Trade and Economic Institute. 2011. Issue 2(1). P. 266-271.

19. Glynn F. 5 tips to improve supply chain efficiency 6 River System.2019.URL: https://6river.com/how-to-increase-supply-chain-efficiency/ (дата звернення: 06.10.2019).

20. R. Skrynkovsky, N. Kostyuk, NM Koval, MM Diagnostics of transport activity as a component of the logistics system of the enterprise. Problems of economy. 2016. № 2. P. 123–128.

21. Official Grain Alliance site // [Electronic resource]. – Access mode: http://www.grainalliance.com/ua/.

22. The experience of BZK Grain Alliance, or About the features of elevator operation in the European market [Electronic mode]. – Access mode: https://elevatorist.com/blog/read/803-dosvid-bzk-grain-alliance-abo-pro-osoblivosti-roboti-elevatora-na-yevropeyskomu-rinku

23. Official site of the DMZ-Karpaty // [Electronic resource]. – Access mode: https://dmz-karpaty.com/en/services/car-building/19-6869

24. Baryshivska Grain Company plans to maintain production profitability by optimizing logistics [Electronic mode]. – Access mode: https://agrotimes.ua/interview/dorozhnya-karta-baryshivskoyi-zernovoyi-kompaniyi-grain-alliance/

25. Agrologistics in Ukraine [Electronic mode]. – Access mode: https://www.apk-inform.com/uk/exclusive/topic/1521330

26. Grain Alliance upgrades machinery to increase grain exports [Electronic mode]. – Access mode: https://agroportal.ua/ru/news/novosti-kompanii/grain-alliance-onovlyuye-tehniku-shchob-zbilshiti-eksport-zerna

27. Official site of the State Statistics Service of Ukraine. URL: http://www.ukrstat.gov.ua/

28. Statistical Collection "Activity of Entities", 2019/ State Statistics Service - Kyiv, 2019. - 154 pages.

29. Klymenko V.V., Lozova H.M., Evaluation of efficiency and competitiveness of transport and logistics enterprises // Theoretical and applied issues of economics: collection of scientific works. -K., KNU named after Taras Shevchenko - 2021. Issue 1 (42). - P. 142 -155.

30. Osetskyi V., Klymenko V., Lozova G., Umantsiv Yu. 2023. Ensuring the competitiveness and financial stability of transport and logistics companies in the conditions of russian-Ukrainian war. Academic review. №2. P. 25–47. doi.10.32342/2074-5354-2023-2-59-2

31. Andrzej Szymonik. Ekonomika transportu dla logistyki i logistyki. Teoria i praktyka. Łódź, 2013, 231 ul.

32. Malovichko A.S. Ukraine's integration into transport and logistics systems of the European Union. Black Sea Economic Studies. 2016. Issue 7. p. 55–58.

33. Trushkina N. Improvement of the organizational and economic mechanism of managing the logistics activities of the enterprise. International scientific electronic journal. 2019. Issue 5. No. 4. p. 156–172.

34. Skrynkovskyi R. M., Kostyuk N. R., Koval N. M., Galelyuk M. M. Diagnostics of transport activity as a component of the logistics system of the enterprise. Problems of the economy. 2016. No. 2. p. 123–128.

35. Statistical collection "Activity of business entities", 2019 / State Statistics Service - Kyiv, 2019. - 154 pages.

36. Vovk L. V. Logistics as a strategy of innovative development agricultural enterprises / L. V. Vovk // AGROSVIT. – 2016. – No. 1-2. - pp. 8-15

37. Herelytsia R.O. Peculiarities of transport logistics of agribusiness enterprises /R.O. Herelytsia // Formation of the regional agricultural development strategy: materials of the 4th interfaculty of science and practice. conf. of young scientists, May 30, 2008. Zhytomyr, 2008. p. 187–189.

38. Hryhorak M.Yu. Logistics of supply, production and distribution: Study guide / M.Yu. Hryhorak, O.V. Karpun, O.V. Katerna, K.M. Molchanova - K.: NAU, 2017. - 382 p.

39. Gutorov O.I. The concept of logistics in economic activity agricultural enterprises / O. I. Gutorov // Institutional foundations of transformations in the agricultural sphere: a collection of materials of the Thirteenth Annual Meeting of the All-Ukrainian Congress of Agricultural Economists, Kyiv, June 20-21, 2011 - Kyiv: NNC "IAE", 2011. - pp. 585-590.

40. Zhaldak H.P. Demyan A.L. Ways to improve the logistics activity of the enterprise. Business, innovations, management: problems and prospects: Materials of the 1st international scientific and practical conference. Kyiv, April 23, 2020 Kyiv. 2020. pp. 208–209

41. O. P. Karasyov. Formation of the competitiveness of the agricultural sector of Ukraine / O. P. Karasyov // Ensuring sustainable development of the agricultural sector of the economy: problems, priorities, prospects: materials of the 6th International Scientific and Practical Internet Conference, October 29-30, 2015 - Dnipropetrovsk: Typography " Standart" (PP Boyko V.V.), 2015. - pp. 13-15.

42. N. V. Kovalchuk Theoretical aspects of logistics activity of agrarian enterprises / N. V. Kovalchuk // Effective economy. – 2011. – No. 12.

43. Kornietskyi O.V. The importance of logistics for the agro-industrial complex approach [Electronic resource] / O.V. Kornietskyi //Effective economy. – 2015. – No. 8. – Access mode: http://www.economy.nayka.com.ua/?op=1&z=4240

APPENDIX A

Голові реорганізаційної комісії
Національного авіаційного університету
в.о. ректора
Володимиру ШУЛЬЗІ

ДОВІДКА ПРО ВПРОВАДЖЕННЯ РЕЗУЛЬТАТІВ КВАЛІФІКАЦІЙНОЇ РОБОТИ

Виконана здобувачем вищої освіти факультету транспорту, менеджменту і логістики Національного авіаційного університету ОС «Магістр» за спеціальністю 275 «Транспортні технології (на повітряному транспорті)» освітньої програми «Мультимодальний транспорт і логістика» Нестеренко Катериною Дмитрівною кваліфікаційна робота на тему «Оптимізація технологій транспортних процесів у межах логістичних систем» має практичну значущість і рекомендована до впровадження у практику діяльності ТОВ «БЗК». Зокрема, заслуговують на увагу наведені автором рекомендації з оптимізації логістичних процесів на етапах збирання та транспортування зерна до елеватору, а також оптимізація парку транспортних засобів підприємства.

Заступник генерального директора
по елеваторам Олександр Гавриленко