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A MULTI-THEORETICAL APPROACH TO SUPPLY CHAIN MANAGEMENT

Abstract

The article examines the supply chain as a modeling object. The multi-criteria and contradictory goals in supply chain management are: on the one hand, the maximum level of service, on the other hand, minimizing logistics costs. Solving strategic optimization problems for this class of objects using classical optimization methods is difficult. The theoretical and methodological basis of the supply chain was considered from the perspective of a set-theoretic approach. The purpose of the study is to analyze the behavior of many different agents (suppliers, clients, etc.) with different needs and goals when making decisions. An agent is an active element of the system, possessing a certain autonomy and the ability to make independent decisions, relying on the information it has about the state of the environment and the actions of other agents. In turn, supply chains are a complex organizational (active) system, i.e. associated with human participation. The study of behavioral aspects and interorganizational interaction, the formation of new organizational forms are an extremely important aspect in the management and modeling of supply chains, a factor in the dynamic behavior of the logistics system. The conducted research represents an important contribution to the development of knowledge about the application of the set-theoretic approach in supply chain management. It demonstrates the applicability of this approach in practice through an analysis of a specific company, LLP «Knauf», on the Kazakhstan market.

Key words: supply chain management, companies, set-theoretic modelling, analysis, optimisation, multi-criteria, logistics system.

Introduction

Supply Chain Management (SCM) is a critically important area of modern economics. Effective SCM enhances the competitiveness of enterprises, reduces costs, and improves customer service quality [1].

The m-theoretic approach in supply chain management often involves the use of methods and models based on multi theory and optimization. This approach allows for the consideration of various aspects and constraints inherent in supply chain management, such as uncertainty, multiple optimization criteria, complex relationships among supply chain participants, and dynamic changes in external conditions [2].

In the context of Kazakhstan, multi-theoretic modeling of supply chain management holds significant importance for the development of logistics systems and enhancing the country's competitiveness in the global market. The application of multi theory allows for the analysis of the structure and interconnections between elements of supply chains in various sectors of the economy, such as mining, agriculture, manufacturing, and trade.

Decision modeling plays a crucial role in optimizing logistical processes in Kazakhstan. For instance, in conditions where production and warehouse facilities are distributed across the country, decision-making models help optimize inventory planning and management, reducing time and financial costs associated with transportation and storage of goods.

Supply chain optimization is particularly relevant for Kazakhstan given its geographical location, serving as a bridge between Europe and Asia. Effective supply chain management enables the development of transit and logistics infrastructure, attracts investments, and expands trade partnerships with neighboring and distant countries.

Thus, the implementation of theoretical and mathematical modeling of supply chain management in Kazakhstan contributes to the optimization of logistical processes, the enhancement of business efficiency, and the strengthening of the country's position in the global arena of economy and trade.

In Kazakhstan, there are several companies actively applying supply chain management principles and utilizing theoretical and mathematical modeling to optimize their business processes. Some of these companies may include:

1. JSC NC Kazakhstan Temir Zholy (KTZ) – the national railway company, plays a key role in transporting goods both domestically and in international transit through its territory. JSC NC KTZ can utilize supply chain modeling to optimize train scheduling, route planning, and inventory management at warehouses.
2. Retail chains – companies in the retail sector, such as Magnum Cash & Carry, Ramstore, Spar Kazakhstan, and others, can apply supply chain modeling to optimize inventory management, demand forecasting, and logistics operations.
3. Oil and gas companies – Kazakhstan hosts several major oil and gas companies, such as NCOC (North Caspian Operating Company), Tengizchevroil, JSC NK «KazMunayGas», and others. These companies can use supply chain modeling to optimize logistics in the extraction, transportation, and processing of oil and gas.
4. Manufacturing enterprises – companies engaged in the production of various goods, such as ArcelorMittal Temirtau (steel production), Coca-Cola Almaty Bottlers (beverage production), Kazakhstan Kagazy (paper production), LLP «Knauf» and many others, can also implement supply chain modeling to optimize their manufacturing and logistical processes.

These are just a few examples of companies in various industries that can implement theoretical and mathematical modeling of supply chain management in their operations in Kazakhstan.

Integration of modern supply chain management models, similar to the one successfully utilized by the company LLP «Knauf», which will be described below, holds significant potential for development in Kazakhstan. Implementing this model in the country can bring substantial benefits across various sectors of the economy and enhance the competitiveness of local companies in the global market. Here are several aspects of why a supply chain management model like LLP «Knauf's» should be implemented in Kazakhstan:

1. Efficient inventory management and cost reduction: The LLP «Knauf» model offers optimized inventory management processes, helping to reduce storage and inventory management costs while minimizing losses due to excess or shortage of goods.
2. Improved customer service quality: Applying modern supply chain management methods such as the LLP «Knauf» model enables the optimization of delivery processes and ensures timely order fulfillment, thus enhancing the quality of customer service.
3. Increased efficiency in logistical operations: The LLP «Knauf» model also provides optimized logistical solutions, including selecting optimal delivery routes and managing warehouse stocks, contributing to increased efficiency in logistical operations and reduced delivery times.
4. Development of competitive advantages in the market: Implementing modern supply chain management models like the LLP «Knauf» model will enable Kazakhstani companies to strengthen their positions in the market, develop competitive advantages, and attract more customers both domestically and internationally.

Therefore, the implementation of a supply chain management model similar to the one successfully operating in LLP LLP «Knauf» in Kazakhstan could be a key factor in the country's economic development and enhancing the competitiveness of local companies in the global market.

When entering a business, a manufacturer is often encountered with questions such as where to locate the plants, what sizes the plants should be, which conversion technology to choose, how much to produce, and how to set the transfer prices. Although there is a large body of literature on the modeling and optimization of supply chain design and operations, most of these works view the supply chain from a centralized perspective and integrate the various components of the supply chain into a monolithic model [3]. Under this approach, it was implicitly assumed that the decision maker has full control over the entire supply chain so that all the strategic and operational decisions can be implemented successfully. However, the management over a supply chain is often decentralized in practice [4].

Supply Chain Management (SCM) represents a complex and vital area of research and practice in modern economics. Effective supply chain management significantly impacts the competitiveness of enterprises, their operational efficiency, and the quality of customer service.

In contemporary research within the field of supply chain management, the theoretical-mathematical approach is actively employed for modeling and optimizing various aspects of logistical systems. Tyapukhin A.P. [5] has proposed theoretical-mathematical models in his works for analyzing complex logistical networks, which enables the consideration of diverse constraints and uncertainties inherent in supply chain management.

Sergeev V.I. [6] has examined the fundamental concepts and theories of supply chain management, placing particular emphasis on the theoretical-mathematical approach and its practical applications. He underscored the significance of this approach for the analysis and optimization of logistical systems, taking into account customs procedures.

In the works of Petrova A.V. [7], the influence of customs procedures on supply chain management is extensively investigated. They have identified the necessity of integrating customs procedures into supply chain management models and explored possible approaches to optimizing this process.

Finally, the work of Liu X., Zhang Y.W., Tang O. [8] presents an innovative approach to optimizing supply chain management considering uncertainty, thus opening new perspectives for the development of this research area and the practical application of the theoretical-mathematical approach in supply chain management.

1. Research, such as the work by Sergeev V.I. and colleagues, analyzes the impact of temporal delays at borders on the efficiency of supply chains. Their study demonstrated that even minor delays can lead to significant issues in the supply chain, resulting in increased logistics costs and reduced overall system performance.
2. Documentation errors and their consequences: Petrov A.V. and colleagues discuss the influence of errors in customs documentation on import and export processes. The research indicates that even minor errors or discrepancies can result in delays in customs clearance and financial losses for companies.
3. Legislative changes and their impact on customs procedures: Liu X. and colleagues investigate the effects of changes in customs legislation on customs control processes. The study reveals that frequent legislative changes can create additional barriers for supply chain participants and necessitate adaptation of risk management strategies.

As seen from table 1, there exist various theoretical approaches to defining the concept of Supply Chain Management (SCM) – a contemporary enterprise management concept. This concept is a result of the evolution of management, marketing, and logistics. It meets the requirements of the modern stage of economic development characterized by the advancement of networked production, which embodies the economy of competencies and interactions.

Based on the literature analysis conducted, the following findings were established:

- There exists a multitude of methods for modeling and optimizing supply chains.
- Theoretical multi approach can be employed for modeling and optimizing supply chains considering customs procedures.
- There is a shortage of research dedicated to the application of the theoretical set approach to modeling and optimizing supply chains with consideration of customs procedures. Within the scope of this study, a system of theoretical multi models for various aspects of supply chain management, taking into account customs procedures, will be developed.

Table 1 – Interpretation of supply chain management by various foreign authors

Author	Definition
Stock and Lambert [9]	Integration of key business processes, originating from end-users and encompassing all suppliers of goods, services, and information, which adds value for consumers as well as other stakeholders.
Cooper M.C., Ellram L.M. [10]	A unified entity, rather than a collection of components, each of which performs its own function.
Monczka R. M., Trent R.J., Handfield R.B. [11]	The concept prioritizes the integration and management of resources, flows, as well as material control.
Copacino W.C. [12]	Supply chain management should integrate all participants involved in transforming raw materials into products and delivering them to consumers at a specific time and place in the most efficient manner possible.
Stein M., Voehl F. [13]	Systematic efforts are directed towards ensuring integrated cost management of the supply chain from raw material suppliers through production to final consumers in accordance with consumer requirements and expectations.
Jones T.C., Riley D.W. [14]	This concept can be represented as a set of principles stating that each company in the supply chain directly or indirectly affects the activities of all other members, and as a result, the supply chain as a whole.
Note: Compiled by the authors based on sources [9, 10, 11, 12, 13, 14].	

Materials and methods

The formal statement of the problem of logistics systems in the supply chain can be expressed as follows:

X, N – a collective characteristic of suppliers in the supply chain (X) (a set of planned agents),

Ω – the set of transport agents in the supply chain (ω) (a collection of various transportation vehicles used to deliver goods from one point to another),

K – criteria for the efficiency of planning work in a specific supply project or transportation in the supply chain (e.g., transportation cost, supply cost, unit of production, volume, number of agents)

т – a specific logistical task.

A brief statement of the low efficiency of active agents in the planning procedure in the supply chain is as follows:

$$f: K(f) \geq \sup_{f' \in F} K(f') - \varepsilon \quad \text{or} \quad f \in \operatorname{Arg} \max_{f' \in F} K(f') \tag{1}$$

where F is the set of planning processes.

From the point of view of “management” of the logistics process, if the efficiency of planning in the supply chain is optimal according to criterion K, then the target task in logistics should be one, and it belongs to many agents. in some input supply chain problem – X*(т)⊆x, i.e. It is clear that the final task in logistics when planning a supply chain should be provided by only one type of carrier and agents:

The task/first step of the search procedure within the active planning technology presented in the considered article is:

1. Assessing the level of involvement of a specific efficient supply service agent based on the criterion of subordination passivity:

The interest of agents in planning and executing a specific logistics order is formalized by efficiency functions $u^i: \Omega \times X \to \mathbb{R}^1$, where $i \in N$ — index of the agent, X=N – set of agents.

The class of possible efficiency functions is denoted as Ui. The aggregate of agents' efficiency functions (choice profile) is represented by the symbol u, with its cumulative meaning as follows: $U = x_{i=N} U^1$. From the perspective of mechanism theory (more precisely, the theory of efficient mechanisms), the procedure of Pareto efficiency planning tasks plays an important role – $\forall u \in \forall \omega \in \Omega \neg \exists x \in X: \exists i \in N\ u^i(x,\omega) > u^i(f(u,\omega),\omega)$ және $\neg \exists j \in N\ u^j(x,\omega) < u^j(f(u,\omega),\omega)$
.

- If $X = x_{i \in N} X^1$, $\forall i \in N \ u^i : \Omega \times X^i \rightarrow \mathbb{R}^1$ – then it is necessary to split the planned set of parameters into several, and if the agent's objective function depends on each of them, we call the task Individual Planning.
- It will call a set of tasks mixed if $\exists \aleph \subseteq 2^N \backslash \emptyset : X = x_{C \in \aleph} X^C : \forall C \in \aleph, \forall i \in C \ u^i : \Omega \times X^C \rightarrow \mathbb{R}^1$.
- If the efficiency function of each subordinate depends on all the plan outcomes, then $\neg \exists \aleph \subseteq 2^N \backslash \emptyset : X = x_{C \in \aleph} X^C, \forall C \in \aleph, \forall i \in C \ u^i : \Omega \times X^C \rightarrow \mathbb{R}^1$, then we call the set of tasks Collective.

The description of planning in the supply chain using multi theory is based on the following premise: Some agents effectively transmit distorted information based on given ω and u. Consequently, the focal company receives from agents $\tilde{\omega} \neq \omega$ distorted information, which in turn leads to a decrease in efficiency and effectiveness indicators of logistic planning.

The transformation $\omega_f : \Omega \times U \rightarrow \Omega$ describes the distortion of information that agents report to the focal company (in units of activity f) during supply chain management. If $\omega_f = \omega$, then the planning procedure is non-manipulative, i.e. resistant to agents' activity. Determination of transformation ωf in the framework of active planning technology relies on the second stage.

The analysis of the target procedure obtained for controlling resistance to agent activity:

1. If $\omega_f \neq \omega$, then the question arises of finding a way to reduce losses caused by agent activity. To find the answer to this question and address it, it is necessary to introduce a criterion. This criterion determines the losses in the logistics system: $\omega_f \neq \omega$. In this article, we use the concept of proximity of planning results as the criterion, which is formulated as follows: $\Delta_f = \max_{\omega \in \Omega, u \in U} \| f(\omega_f(\omega, u)) \|_L$L – manipulation error – the maximum discrepancy between planning results with and without considering subordinate activity according to some metric L.

The assessment of Δ_f – is the third stage of active planning technology:

2. If the procedure is unstable to activity, the extent to which the planning outcome can be distorted by active subordinates is assessed. The answer to whether the manipulation error can be reduced is proposed to be sought within the ideology proposed in and can be considered in implementation theory.

Through the mechanism $\rho = < S, \pi >$, where S=$x_{i \in N} S^i$, S^i – represents the set of decisions (not just messages) made considering the activity of the subordinate. In general, the sets S and Ω may not be related in any way, but the following transformation represents the function of subordinate agents in the procedure $i \in N, \pi : S \rightarrow X$. During active planning, collective procedures will be denoted as Π, and collective mechanisms as Π.

By analogy with the manipulation error, let's define the maximum discrepancy between the target procedure and the planning results of the mechanism ρ:

$$\Delta_f(\rho) = \max_{\omega \in \Omega, u \in U} \| f(\omega) - \pi(s_\pi(\omega, u)) \|_L \tag{2}$$

At the final stage of active planning technology, the active planning task is solved.

Example 1. Let's define as follows, where the set of projects is M, $\#M = m;$; set of agents N, $\#N = n;$; The partitioning of the set of possible orders is as follows:

$$A = \{x = (x_1, \dots, x_m) \in \mathbb{R}_m^+ \mid \sum_{j=1}^m x_j \leq R. \tag{3}$$

Let's take $n = 3, m = 3$. Assuming that the first agent has information about the optimal price that the second and third agents communicate to the focal company: $\tau_{11} + \tau_{21} = R$, the second and third agents have only one target interest. They are to somehow win the order fulfillment project in the supply chain from the focus company: $\tau_{22}, \tau_{33} \leq R$. In addition, the risk of missing the order design in the supply chain from the perspective of the first agent is lower than that of the second agent.

Each agent is allowed to receive a corresponding project, the price of which is approved by the focus company: the first agent – the first project, the second – the second, the third – the third. If another order is received from the focal company, the agent must share the information with the next agent. We call these orders collective as a unique anonymous and symmetric mechanism, if the efficiency function of each subordinate depends on the outcome of the entire plan, then $\neg \exists \aleph \subseteq 2^N \backslash \emptyset : X = x_{C \in \aleph} X^C, \forall C \in \aleph, \forall i \in C \ u^i : \Omega \times X^C \rightarrow \mathbb{R}^1$ [15].

For example, $\tau_{11} \leq \frac{1}{3}$, ал $1/3 < \tau_{21} < \tau_{22} < \tau_{33}$. In this case, the first agent, reporting the task $s_{11} < \tau_{11}$, knows whether the second project is accepted or rejected by the second agent and reports $(\tau_{11} - s_{11})/2$, thereby increasing its efficiency. In this way, agents can prevent falsification of mutual information by working together with each other.

Within this study, a combined methodological approach was applied, based on multi theory and principles of supply chain management optimization. The initial stage of analysis involved examining data on supply chain management processes within LLP «Knauf» company in Kazakhstan, including data on demand, inventory, deliveries, and other key parameters. Based on this data, theoretical supply chain management models were developed, utilizing multi theory methods to describe system elements and their interrelationships. Mathematical modeling methods such as linear programming and stochastic models were employed to formalize these models. After constructing the models and conducting mathematical computations, a quantitative analysis of the results was carried out, including evaluating the effectiveness of proposed supply chain management strategies. The final stage of the research involved a comparative analysis of the results with current management practices and previous studies in the field of supply chain management. Thus, the use of a combined methodological approach enabled the achievement of the research goal and yielded valuable insights into optimizing supply chain management for LLP «Knauf» company in Kazakhstan.

Results and discussion

The efficiency of each agent is characterized by the following type of function:

$$u'(x) = \sqrt{r' + x}, i \in N, \tag{4}$$

Here, r' – i is the agent's private “reserve”, in our example, the agent's reserve cars. The maximum combined efficiency of all agents increases when the order is allocated to all agents,

$$x_{\prime} = (R + \textstyle\sum_{i \in N} r') \ / \ (n - r'), i \in N \tag{5}$$

In order to carry out transports in the supply chain, the agent needs to have accurate and correct information on r^'. If the agent does not personally have a car in his inventory, it will be beneficial for him to convey the distorted information to the focal company, because the effectiveness of the communicated information is likely to decrease. In turn, renting cars and forming it at an inefficient price, reporting to the focal company and allocating cars to transports are inconsistent with agents' incentives to reliably disclose information about their professional activities. Below is a communication diagram of the total number of participants in the supply chain. On the way to the final customer from a foreign country, the goods pass through many posts, transit-transit terminals, customs control posts, and many border transit posts of a foreign country. Active movement of people begins when the goods are exported from a certain country or, on the contrary, enter the import regime. Customs control procedures are carried out at the border checkpoint. Here, vehicles and goods undergo customs inspection and inspection, as well as documents certifying the right of drivers and vehicles to cross the state border. From transitory “inspection – review” at customs posts to the final declaration and storage, participating active employees often exchange information. It is important to use non-manipulative mechanisms to prevent information from being falsified or destroyed. This is because open, transparent corporate and logistical communications effectively coordinate information between participants, ensuring accurate and correct payment of taxes and value-added tax, duties to the state of the customs sector.

The main reasons for using agent-based modeling in supply chain management are: agent-based models are suitable for analyzing interconnected problems, a set of agents with distributed (autonomous) knowledge and a certain structure of relationships between them; Focus on Just-In-Time strategy, cooperation strategies, joint planning; a complex communication system between different links of the chain; high degree of independence of each link in the supply chain, principles of decentralized management.

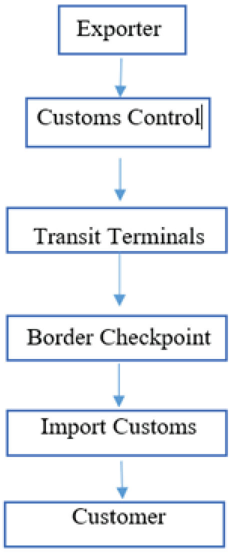

Figure 1 – A collection of industry participants in the supply chain

Note: Compiled by the authors.

Thus, the technology of active management of agents on the distribution of real information includes the following stages:

1. Synthesis of the optimal planning procedure according to the required criterion in the case of passivity of subordinates.
2. Analysis of the received procedure for countering manifestations of agents' activity (for example, manipulation of reported information).
3. If the procedure is not active resistant, active subordinates are evaluated to what extent the planning result can be distorted.
4. This is a synthesis of the planning procedure that eliminates (reduces) the distortion.

This study adopts a combined methodological approach to investigate supply chain management (SCM) practices within LLP «Knauf» company operating in Kazakhstan. The approach integrates principles from multi theory and optimization techniques to develop theoretical SCM models tailored to the specific context of the company. The research methodology comprises several sequential steps aimed at comprehensively analyzing and optimizing SCM processes.

The initial phase involves gathering and analyzing data related to various SCM aspects within LLP «Knauf's» operations in Kazakhstan. This includes examining data on demand patterns, inventory levels, procurement procedures, distribution channels, and other pertinent parameters. Through this data analysis, key insights into the existing SCM practices are obtained, identifying areas for potential improvement.

Subsequently, theoretical SCM models are formulated based on the principles of multi theory, which enables a systematic representation of the interconnected elements within the supply chain network. These models are designed to capture the dynamic nature of SCM processes, considering factors such as demand variability, lead times, transportation constraints, and inventory management policies.

To formalize the theoretical models and facilitate quantitative analysis, mathematical modeling techniques such as linear programming and stochastic modeling are employed. Linear programming enables the optimization of SCM decisions by identifying the most efficient allocation of resources and activities, while stochastic modeling accounts for uncertainty and variability inherent in real-world SCM environments.

Following the construction of the SCM models, extensive mathematical computations are conducted to evaluate the performance of different SCM strategies. This quantitative analysis enables the assessment of various scenarios and the comparison of alternative strategies in terms of their effectiveness, cost-efficiency, and resilience to disruptions.

Finally, the research concludes with a comparative analysis of the proposed SCM strategies against current practices and previous research findings in the field. This comparative evaluation provides valuable insights into the potential benefits and challenges associated with implementing the optimized SCM approaches within LLP «Knauf's» operations in Kazakhstan.

Overall, the combined methodological approach adopted in this study offers a systematic framework for analyzing and optimizing SCM processes, with the aim of enhancing operational efficiency, cost-effectiveness, and competitiveness for Knauf company in the Kazakhstan market.

We divide the main advantages of using agency modeling in supply chain management as follows:

- supports the main function of logistics – coordinates strong relations between the participants of the supply chain;
- connects the internal business processes of the partners as a whole, the multi-agency model affects the development of general business rules and the introduction of a general business process management system, ensuring effective mutual information exchange between the supply chain participants;
- agency modeling like in business games allows business to create a strategy based on trust;
- the model reproduces the ability to act in the emerging chain, new organizational structures based on the rules of interaction of participants, that is, some meso-level properties of the modeled supply chain.

It was found that the agency modeling supply chain has the advantage of coordinating a multi of participants, so we can consider the participants as elements, and the set is formed from those elements.

The multi-theoretic approach in the context of supply chain management represents a powerful tool that allows for modeling and optimizing complex systems considering various characteristics and uncertainties. This approach is based on the utilization of mathematical methods to analyze fuzzy, uncertain, and multiple aspects of the system. In the application of the multi-theoretic approach to supply chain management, the system is considered as a collection of sets, where each set represents a specific aspect or parameter of the supply chain.

The elements of these sets can be either precisely defined or fuzzily specified depending on the degree of uncertainty or variability inherent in the given parameter. For example, the set of suppliers may include both fixed suppliers with clearly defined characteristics and fuzzily defined categories of suppliers, which may vary in terms of delivery reliability or product quality.

The utilization of multi-theoretic approach enables consideration not only of precise parameter values within a system, but also their potential variations and uncertainties. This facilitates a more accurate modeling of real-life supply chain conditions, which are often characterized by instability and uncertainty. Furthermore, such an approach allows for sensitivity analysis and optimization of supply chain management strategies, considering various scenarios and potential changes in the environment.

Let's consider an example of applying multi-theoretic modeling to supply chain management using the case of LLP «Knauf» company in Kazakhstan.

LLP «Knauf» is one of the leading global manufacturers of building materials, including gypsum board, gypsum panels, insulation materials, etc. In Kazakhstan, LLP «Knauf» also has its presence, offering its products both for the construction market and industrial needs.

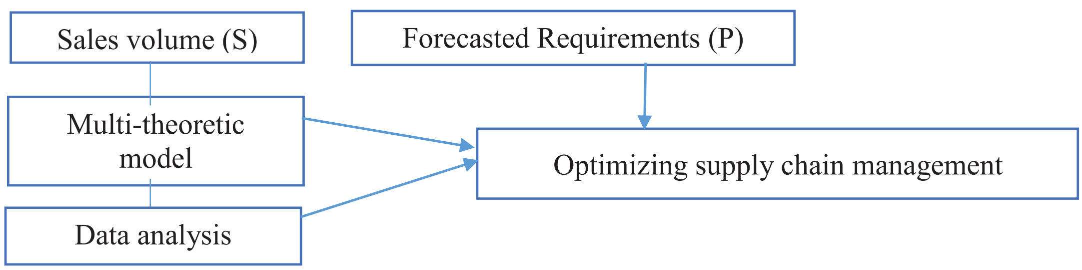

Figure 2 – Simulation scheme

Note: Compiled by the authors.

Figure 2 illustrates the key components of the supply chain management model of company, including demand forecasting, inventory management, production processes, logistics and transportation, risk management, as well as monitoring and performance analysis.

The depicted figure represents a general outline of the supply chain management model that can be utilized within the framework of multi-theoretic modeling. Multi-theoretic modeling involves the analysis of systems using multi theory to describe the elements of the system and their relationships. In the context of supply chain management, multi-theoretic modeling can be employed to optimize decision-making processes, planning, and resource management within the supply chain. This supply chain management framework comprises a set of suppliers, a set of central warehouses, and a set of consumers. Each set represents the collection of all relevant elements (e.g., suppliers, central warehouses, and consumers).

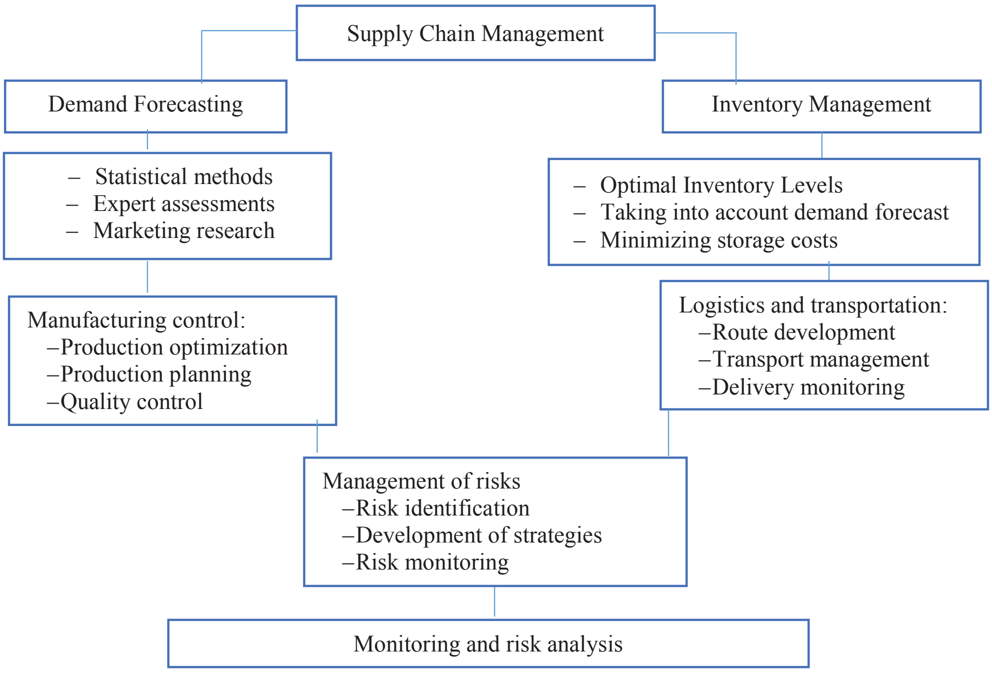

Figure 3 – The Supply Chain Management Model of LLP «Knauf» Company

Note: Compiled by the authors.

The present article examines the application of multi-theoretic modeling to optimize supply chain management using the example of Knauf company. To achieve this, we analyze the actual sales volumes of the company over the past year and forecasted demands for the next year. Subsequently, a model is constructed and quantitative analysis is conducted to determine the effectiveness of supply chain management.

Supply chain management plays a pivotal role in modern business, particularly in the manufacturing industry of construction materials. Knauf, being one of the leaders in this field, faces challenges in optimizing its supply chain to meet demand and minimize costs.

The relationship between multi-theoretic modeling and the calculation of supply chain management efficiency metrics in Knauf lies in the fact that the supply chain management model utilizes multi theory principles to analyze sales, demand, and inventory data. Multi-theoretic modeling enables the optimization of supply chain management by considering various factors such as demand variability, seasonality, and others, and assists in decision-making based on mathematical models.

For analysis, we utilized real sales data from Knauf company for the past year and forecasted data on demand for the next year.

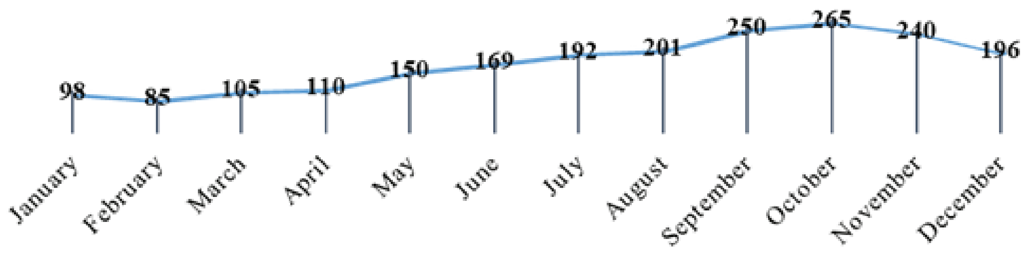

Figure 4 – LLP «Knauf» sales volume for 2023 (thousand tons)

Note: Compiled by the authors based on source [16].

The supply chain management model utilized by Knauf company is based on the concept of demand forecasting and inventory optimization. It comprises the following key components:

Model Criteria:

- Cost Minimization: The model aims to reduce expenses related to warehousing, transportation, and production.
- Customer Satisfaction Maximization: Supply chain management at Knauf focuses on providing a high level of service and meeting customer needs.
- Optimal Resource Allocation: The model strives for the optimal utilization of company resources, including labor and materials.

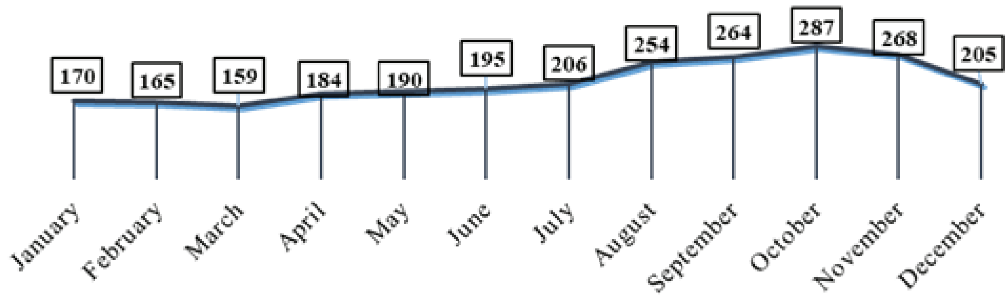

Figure 5 – Forecasted needs of the company LLP «Knauf» for the upcoming year

Note: Compiled by the authors based on source [16].

Based on the conducted analysis and calculations, the following conclusions can be drawn:

1. Supply chain management effectiveness: Calculations have shown that the service level of LLP «Knauf» company is approximately 83.33%, indicating a high level of order fulfillment on time. This demonstrates the efficiency of supply chain management and the company's ability to meet customer needs.
2. Optimization of delivery times: The average delivery time is approximately 4.17 days, interpreted as a relatively fast delivery time, which can contribute to improved customer service and reduced inventory holding costs.
3. Inventory management: LLP «Knauf» company's inventory turnover is approximately 1.82 times per year, indicating its ability to efficiently manage inventory, minimizing excess stock and optimizing its utilization.
4. Recommendations for further improvement: Based on the analysis results, it is recommended for LLP «Knauf» company to consider opportunities for further improvement in supply chain management, such as logistics optimization, implementation of new inventory management technologies, and enhancing collaboration with suppliers.

Thus, the analysis of supply chain management efficiency indicators based on theoretical-mathematical modeling provides valuable information for strategic decision-making by LLP «Knauf» company and can serve as a basis for further research in the field of supply chain management.

Conclusion

This paper describes the open delivery of information based on relationships among multiple supply chain participants using a multi-theoretic method for supply chain management. By dividing tasks and communicating the right information, a decision is made that benefits everyone involved.

Through the joint planning of the activities of the participants of the supply chain planning, it is possible to form an integrated function that allows to control all logistics activities in the chain, material flows and the work of employees, and through their optimal organization, increases the strength of the chain and the reliability of information, as well as increases the level of profit from service provision.

Integration of modern supply chain management models, similar to the one successfully implemented in the company LLP «Knauf», presents a high potential for development in Kazakhstan. Implementing this model in the country could bring significant benefits across various sectors of the economy and enhance the competitiveness of local companies in the global market. Here are several aspects explaining why a supply chain management model akin to the LLP «Knauf» model should be adopted in Kazakhstan:

1. Efficient Inventory Management and Cost Reduction: The LLP «Knauf» model offers optimized inventory management processes, which help reduce storage and inventory management costs, as well as minimize losses due to excess or shortage of goods.
2. Improved Customer Service Quality: Applying modern supply chain management methods, such as the LLP «Knauf» model, allows for the optimization of delivery processes and ensures timely order fulfillment, contributing to improved customer service quality.
3. Increased Efficiency of Logistic Operations: The LLP «Knauf» model also offers optimized logistical solutions, including selecting optimal delivery routes and managing warehouse inventories, which enhances the efficiency of logistic operations and reduces delivery times.
4. Development of Competitive Advantages in the Market: Implementing modern supply chain management models, similar to the LLP «Knauf» model, will enable Kazakhstani companies to strengthen their market positions, develop competitive advantages, and attract more customers both domestically and internationally.

Therefore, the implementation of a supply chain management model similar to the successful one employed by LLP «Knauf» in Kazakhstan could be a key factor in the country's economic development and in enhancing the competitiveness of local companies in the global market.

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ЖЕТКІЗУ ТІЗБЕГІН БАСҚАРУДЫҢ ТЕОРИЯЛЫҚ-ЖИЫНДЫҚ ТӘСІЛІ

Аңдатпа

Мақалада жеткізу тізбегі модельдеу нысаны ретінде қарастырылады. Жеткізу тізбегін басқарудағы көп өлшемді және қарама-қайшы мақсаттар: бір жағынан, қызмет көрсетудің максималды деңгейі, екінші жағынан, логистикалық шығындарды азайту. Классикалық оңтайландыру әдістерін қолдана отырып, осы қатардағы объектілер үшін стратегиялық оңтайландыру мәселелерін шешу қиын. Жеткізу тізбегінің теориялық және әдістемелік негізі теориялық-жиындық көзқарас тұрғысынан қарастырылды. Зерттеудің мақсаты – шешім қабылдау кезінде әртүрлі қажеттіліктері мен мақсаттары бар көптеген әртүрлі агенттердің (жеткізушілер, клиенттер және т.б.) мінез-құлқын талдау. Агент – белгілі бір дербестікке ие және қоршаған ортаның жай-күйі және басқа агенттердің іс-әрекеттері туралы өзінде бар ақпаратқа сүйене отырып, дербес шешім қабылдау мүмкіндігіне ие жүйенің белсенді элементі. Өз кезегінде, жеткізу тізбегі адамның қатысуымен байланысты күрделі ұйымдастырушылық (белсенді) жүйе. Мінез-құлық аспектілері мен ұйымаралық өзара әрекеттесуді зерттеу, жаңа ұйымдық формаларды қалыптастыру жеткізу тізбегін басқару мен модельдеудегі аса маңызды аспект, логистикалық жүйенің динамикалық мінез-құлқының факторы. Жүргізілген зерттеу жеткізу тізбегін басқаруда теориялық және көп тәсілдерді қолдану туралы білімді дамытуға маңызды үлес қосады. Ол Қазақстан нарығындағы нақты «Кнауф» ЖШС компаниясын талдау арқылы бұл тәсілдің тәжірибеде қолданылуын көрсетеді.

Тірек сөздер: жеткізу тізбегін басқару, теориялық-жиындық модельдеу, талдау, оңтайландыру, көп критерийлік, логистикалық жүйе.

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ТЕОРЕТИКО-МНОЖЕСТВЕННЫЙ ПОДХОД К УПРАВЛЕНИЮ ЦЕПЯМИ ПОСТАВОК

Аннотация

В статье рассматривается цепь поставок как объект моделирования. Многокритериальность и противоречивость целей в управлении цепью поставок являются, с одной стороны, максимальный уровень сервиса, с другой стороны, минимизация логистических издержек. Решение стратегических задач оптимизации для такого класса объектов с помощью классических методов оптимизации затруднительно. Теоретико-методологическую основу цепи поставок рассмотрели с позиции теоретико-множественного подхода. Целью исследования является анализ поведения множества различных агентов (поставщиков, клиентов и т.д.) с различными потребностями и целями при принятии решений. Агент – активный элемент системы, обладающий известной автономностью и способностью осуществлять самостоятельное принятие решения, опираясь на имеющуюся у него информацию о состоянии среды и действиях других агентов. В свою очередь, цепи поставок являются сложной организационной (активной) системой, связанной с участием человека. Исследование поведенческих аспектов и межорганизационного взаимодействия, формирование новых организационных форм являются исключительно важным аспектом в управлении и моделировании цепей поставок, фактором динамического поведения логистической системы. Проведенное исследование представляет собой важный вклад в развитие знаний о применении теоретико-множественного подхода в управлении цепями поставок. Оно демонстрирует применимость данного подхода на практике через анализ конкретной компании ТОО «Кнауф» на рынке Казахстана.

Ключевые слова: управление цепочками поставок, компании, теоретико-множественное моделирование, анализ, оптим.

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