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INTEGRATED MODEL OF OPEN SUPPLY CHAIN MANAGEMENT

Abstract

In the context of globalization of markets and increasing competition, supply chain management is becoming critical to ensuring the sustainability and efficiency of business. The relevance of this study is due to the need to develop new management models that can adapt to rapidly changing market conditions and customer needs. The purpose of the study is to develop and practically implement an open supply chain management model based on the planning mechanisms and modern optimization methods. The model is aimed at integrating various functional areas, such as demand, inventory, supply and production planning management, with an emphasis on increasing transparency and efficiency. The study used data analysis methods, including ARIMA models for demand forecasting, multi-criteria analysis (AHP) for supplier selection and linear programming for production planning optimization. Microservice architecture was also used to integrate all functional areas into a single supply chain management system. The novelty of the study lies in proposing an integrated model of open supply chain management that takes into account modern technologies and optimization methods, as well as in applying an integrated approach to managing logistics processes. The significance of the study is demonstrated by its practical applicability for companies engaged in the production and distribution of goods, which allows them to effectively adapt to changes in the market, minimize risks and increase customer satisfaction. The results of the study can be used for further developments in the field of supply chain management and business process optimization.

Key words: supply chain, open management, mathematical modeling, ARIMA model, logistics optimization, information transparency.

Introduction

Globalization of markets, increasing competition and constantly changing consumer needs create unprecedented challenges for supply chain management. Traditional hierarchical management models, often focused on optimizing individual functional areas, do not provide the necessary

flexibility and adaptability in conditions of high uncertainty. Inability to effectively respond to changes in demand, supply disruptions, geopolitical risks and price fluctuations leads to significant financial losses and a decrease in the competitiveness of enterprises [1]. Therefore, the relevance of developing new, more advanced supply chain management models capable of integrating various functional areas and ensuring effective interaction of all participants is steadily increasing.

The purpose of this study is to develop and implement an open supply chain management model based on N.A. Korgin's planning mechanisms and modern optimization methods, with an emphasis on increasing the transparency, efficiency and sustainability of supply chains in a dynamic market. The model is aimed at integrating various functional areas, such as demand, inventory, supply and production planning management, using modern technologies such as ARIMA, blockchain and cloud computing.

The hypothesis of this article states that the application of an integrated open supply chain management model based on the mechanisms of organizational systems theory and modern forecasting methods will significantly improve the accuracy of forecasts, optimize inventory management and improve the choice of suppliers, which in turn will lead to cost reduction, increased customer satisfaction and strengthening the company's competitive position in the market.

Literature review

Previous research [2] demonstrated the potential of using N.A. Korgin's planning mechanism in a set-theoretic setting to optimize logistics processes in a supply chain. This optimization becomes especially important when we consider the structure of the supply chain itself. The supply chain consists of several interrelated functional areas, each of which plays an important role in the successful delivery of products or services to the end consumer. Inefficiency in one area will inevitably affect the entire chain. Thus, the key functional areas of the supply chain emphasize the importance of an integrated approach to managing logistics processes in today's market conditions. All of these areas are interdependent, and efficient supply chain operation is only achieved when all of its components work in concert. Modern approaches to supply chain management seek to integrate these areas and use technology to improve efficiency and flexibility.

To effectively manage logistics processes in the supply chain, it is important to adapt the mechanisms to key functional areas. This ensures the timeliness and accuracy of operations, minimizing costs and increasing customer satisfaction. The integrated supply chain model, combining non-manipulative, cost-effective and multi-channel mechanisms, is aimed at increasing the transparency, cost-effectiveness and flexibility of interaction with customers. Such a model allows achieving a sustainable competitive advantage, minimizing costs and increasing trust between all participants in the supply chain. Table 1 presents an adapted integrated supply chain model combining non-manipulative, cost-effective and multi-channel mechanisms.

The data in Table 1 highlight the importance of an integrated approach to supply chain management. Implementing transparent algorithms and standard procedures across functional areas such as planning, purchasing, and production helps reduce manipulation and increase trust among supply chain participants, which enables more accurate resource planning and optimization. Multichannel mechanisms such as demand data integration and omnichannel experience enable each channel to be tailored to improve forecasting and resource allocation, which in turn improves customer satisfaction. The use of cost-effective mechanisms such as order consolidation and route optimization helps reduce logistics costs and minimize inventory, which leads to more efficient inventory management and lower overall supply chain costs. Effective returns and inventory management mechanisms, including process automation and centralized accounting, help reduce storage and disposal costs and simplify the return process for customers. Implementing access control and data auditing mechanisms, as well as using analytical tools to identify anomalies, helps prevent data manipulation and ensures the reliability of information in the supply chain. Flexibility in production and logistics processes allows for a quick response to changes in demand and customer preferences, which is a key factor for successful operation in a dynamic market.

Table 1 – Supply chain management mechanisms to minimize manipulations and optimize costs

Functional area	Non-manipulable mechanisms	Multi-channel mechanisms	Anti-cost mechanisms
Planning	Transparent forecasting algorithms based on objective data eliminate manipulation and ensure accurate demand planning.	Integrate demand data from all channels (online, offline, B2B and B2C) to take into account the specifics of each channel and ensure accurate forecasts for all points in the supply chain.	Optimize resource planning using forecasts and analysis, reducing excess production and storage costs.
Procurement	Introduction of standard tender procedures and automated procurement to ensure fair selection of suppliers and minimize the risk of manipulation.	Procurement based on demand forecasted for each channel, allowing for optimal distribution of inventory to meet the needs of each segment.	Consolidation of orders and optimization of delivery schedules to obtain better prices and reduce logistics costs.
Production	Standardization of production processes and automated quality control to minimize the risk of defects and manipulation of product quality.	Flexibility in production for various channels (customization of packaging, specifications for online and offline), which allows for faster response to demand in each channel and improves customer experience.	Implementation of Lean production and Kaizen principles to reduce losses at all stages and improve overall efficiency.
Logistics	Using real-time tracking and blockchain technology to record all transactions, preventing route changes and cargo manipulation.	Implementation of hybrid logistics with different delivery options (home, pick-up, pick-up point) to cover customer needs in each channel and increase delivery flexibility.	Optimization of routes and consolidation of deliveries, which reduces fuel costs and speeds up delivery times.
Sales and Distribution	Transparent order processing and confirmation through standardized systems across all channels, reducing the risk of data manipulation.	Create an omnichannel experience for customers (e.g. starting an order online and finishing in store), which increases satisfaction and drives sales.	Minimize inventory and carrying costs through accurate forecasting and inventory management for each channel.
Returns management	Transparent return conditions and mandatory documentation of the condition of the goods upon return, which prevents abuse.	The ability to return goods through any channel (for example, returning online purchases to a physical store), which makes the process easier for customers and reduces return costs.	Optimization of reverse logistics and redistribution of returned goods between channels to minimize storage and disposal costs.
Inventory Management	A unified inventory control system in real time with centralized access for all participants in the supply chain, which prevents data distortions.	Re-allocation of inventory between channels based on real demand and the characteristics of each channel, which allows maintaining optimal inventory levels.	Automatic replenishment of inventory and optimization of order cycles to minimize the costs of maintaining and storing inventory.

Continuation of table 1

Information Management	Implementation of a centralized information platform with access control for all participants to avoid data manipulation.	Integration of data from all channels to create a single analytical system that takes into account the needs of each channel and provides accurate forecasts.	Using analytical tools to identify cost reduction opportunities across all channels and supply chain levels.
What helps reduce the manipulability of information	Implementation of access control and data auditing mechanisms to prevent unauthorized changes.	Creation of a single database accessible to all channels, which ensures transparency and consistency of information	Using algorithms to automatically detect anomalies and data manipulation, which allows for a quick response to potential problems.
Note: compiled by the authors based on sources [6-8]			

To develop a supply chain model through competitive, priority and agreed mechanisms, it is necessary to implement different approaches to selecting suppliers, allocating resources and managing interactions between supply chain participants. These mechanisms facilitate an effective and transparent decision-making process, minimize risks and increase the overall flexibility of the system. As a result, costs are optimized, service quality is improved and the overall value for all supply chain participants is maximized. Table 2 discusses each of these mechanisms, their key elements and benefits.

Table 2 – Supply chain management mechanisms

Mechanisms	Main elements	Advantages
Competitive mechanisms	Transparency of tenders Use of selection criteria Evaluation system Monitoring and audit	Objectivity in selecting suppliers. Reducing the risks of manipulation and abuse. Attracting the best suppliers taking into account cost and quality.
Priority mechanisms	Setting priorities Allocation of scarce resources Integration of priorities into information systems Flexibility to changes in demand	Ensuring uninterrupted supply with limited resources. Ability to effectively manage crisis situations and shortages. Minimizing losses and optimizing resources.
Agreed mechanisms	Collaborative Planning Agreements Shared Information Flow Shared Risk Management Long-Term Relationships and Contracts	Improved coordination and synergy between supply chain participants. Reduced uncertainty and risks. Increased flexibility and adaptability of the supply chain.
Non-manipulable mechanisms	Transparent processes Standardization of operations Independent audit Feedback from participants	Increased trust between participants. Reduced likelihood of corruption and manipulation. Improved quality of services and goods.
Multichannel mechanisms	Diversity of supply channels Integration of online and offline channels Analysis of data across all channels Flexibility in channel selection	Increased availability of products to customers. Optimization of logistics and reduction of delivery time. Improved customer experience and satisfaction.
Note: compiled by the authors		

An integrated supply chain model based on competitive, priority and agreed mechanisms should represent an effective approach to supply management in dynamic market conditions. At the initial stage of the supply chain, competitive mechanisms are used to select optimal suppliers and partners, which contributes to the formation of a strong and competitive network. Transparent evaluation of suppliers according to the criteria of cost, quality, reliability and experience creates the basis for effective interaction.

In the supply chain, priority mechanisms play a key role in managing resource shortages, especially in times of crisis or seasonal peak demand. These mechanisms help determine which resources – be they goods, production facilities or vehicles – should be allocated to the most critical tasks. In addition, the priority mechanism is integrated into a forecasting system that takes into account both current and potential supply chain needs.

Coordinated mechanisms ensure regular communication and information exchange between participants, which allows for real-time coordination, rapid response to changes in demand, and cost minimization. Joint planning and risk management with partners contribute to increased flexibility and resilience across the supply chain.

The benefits of this integrated model are clear: it ensures cost optimization through transparent competitive selection procedures, efficient allocation of limited resources through priority mechanisms, and increased coordination and flexibility through agreed mechanisms. As a result, such a model allows for the creation of an optimized, flexible and sustainable supply chain that can effectively cope with changes in the external environment, minimize costs and maintain high quality of customer service.

Despite the interdependence of all components of the supply chain and the need for their coordinated operation to achieve effective functioning, the diversity of models used in various industries also plays an important role. Analysis of existing supply chains shows that each of them, regardless of the specifics, business scale or geographical coverage, faces common challenges and requires attention to functional areas that need improvement [9–11].

An analysis of existing supply chains shows a significant diversity of models due to industry specificity, business scale, and geographic scope. However, despite the differences, most supply chains face common challenges and have similar functional areas requiring improvement. The main ones are presented in Figure 1.

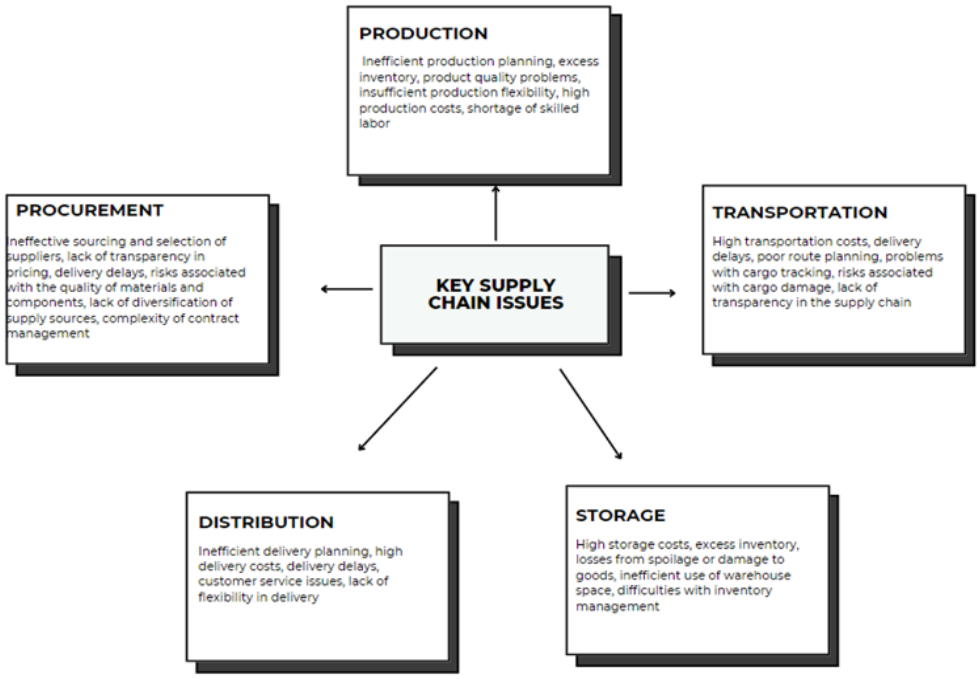

Figure 1 – Key supply chain challenges

Note: compiled by the authors

Improving existing supply chains requires an integrated approach focused on optimizing all functional areas and interactions between them. This involves implementing modern information technologies, improving management processes, developing long-term partnerships, and constantly monitoring changes in the external environment.

Transparency in supply chains plays a key role in increasing efficiency, minimizing risks, improving coordination, and ensuring trust among all participants. Research and assessments of transparency, tailored to different mechanisms, contribute to the creation of structures that support high standards of integrity, cooperation, and optimization. This not only improves supply chain productivity, but also ensures stable and secure interactions among all parties involved. Table 3 presents the mechanisms and their role in transparency, as well as the relevant research and assessments that highlight the benefits of each mechanism.

Table 3 – Mechanisms for information transparency in supply chains

Mechanisms and their role in information transparency	Research and evaluation	Advantages
Non-manipulable mechanisms mean that information in the supply chain is provided without distortion or manipulation by participants. The main emphasis is on maintaining the integrity of the data, its objectivity and accuracy.	Assessing the quality of data at all levels of the supply chain to ensure transparency. For example, implementing blockchain technologies to record all transactions to eliminate the possibility of manipulation and distortion of data. Regular audits of all participants in the supply chain to verify the accuracy of the information transmitted. This includes checking the information for compliance with real data on stocks, deliveries and production capacities. Using big data and artificial intelligence technologies to analyze the entire supply chain and identify possible data distortions, such as discrepancies between the actual state of stocks and declared data.	Minimizing the possibility of data manipulation. Improving trust between all participants in the supply chain. Increasing the reliability and accuracy of information.
Competitive mechanisms are based on an open and fair process of selecting suppliers and partners through tender procedures. Information on all competitions, offers and selections must be accessible and transparent.	Analysis of public tenders, their results and evaluation criteria. It is important that all stages of selection and contracting are transparent and accessible to all stakeholders. Implementation of specialized online platforms for conducting open tenders with the ability to track all proposals and stages of their consideration in real time. Platforms and systems on which tender participants can track the selection process, understand the criteria and result, and submit requests for clarification.	Increasing the competitiveness and fairness of the supplier selection process. Increasing the transparency and availability of data on tender results. Supporting fairness and reducing the risks of manipulation in the selection process.
Priority mechanisms concern the allocation of limited resources, such as goods, production capacity or storage space. It is important to communicate priorities and allocation decisions correctly to ensure transparency.	Assessing the degree of clarity and understandability of the criteria on the basis of which priorities are established. It is important that all participants in the supply chain know the rules by which resources are allocated. Systems that allow all participants in the supply chain to track and understand why certain resources are allocated in a certain order. For example, using monitoring platforms where all priority decisions made are displayed. Implementation of an automatic resource allocation system that takes into account requests and forecasts, and adjusts priorities in real time depending on changes in demand and supply.	Reduce ambiguity in resource allocation. Increase process trust and reduce risk through data transparency. Ensure fairness and equality across all supply chain participants.

Continuation of table 1

Multichannel means using different channels to communicate and manage orders. This includes online stores, retail, B2B systems and other channels through which information flows.	Assessing the degree of integration of data and processes across all supply chain channels. It is important that information on orders, inventory, and delivery times is synchronized and available in real time. Using analytics tools to assess how effectively each channel generates and transmits information, and what problems may arise due to insufficient transparency. Implementing a unified communications system that allows all supply chain participants to receive information on the status of orders and their fulfillment through different channels.	Increased efficiency and flexibility in the supply chain. Reduced risks of errors and misunderstandings due to lack of transparency. Improved coordination between different supply channels.
Coordinated mechanisms include coordination and joint decision-making processes where supply chain participants work closely together. It is important that the information exchanged between participants is transparent and accessible to all.	Assessing how well all supply chain participants align their plans, forecasts, and resources. It is important that demand, inventory, and capacity data are transparent to all. Implementing software solutions, such as collaborative planning systems, that provide access to data for all supply chain participants. Assessing how effectively supply chain participants exchange relevant information in real time, especially in the event of unforeseen circumstances.	Reduced risks due to ineffective coordination. Increased overall transparency in supply chain management. Accelerated response to changes and crisis situations.
Note: compiled by the authors based on the source [12–15]		

The general approach to researching and assessing information transparency in supply chains adapted to various mechanisms includes several key aspects. First, data analysis allows assessing the quality and accuracy of information at all stages of the supply chain, which is the basis for making informed decisions. Second, assessing communication systems helps to study the channels of information transfer between participants, which is important for synchronizing data and ensuring its relevance.

In addition, monitoring the transparency of decisions provides an assessment of the openness of decision-making processes, such as supplier selection and resource allocation, which helps reduce risks and increase trust between participants [16]. And the use of modern technologies such as blockchain and supply chain management (SCM) systems significantly increases the level of transparency and efficiency.

Materials and methods

The methodology is based on open supply chain management model using the example of a company engaged in the production and distribution of environmentally friendly domestic goods. This company is distinguished by its commitment to environmental awareness and a healthy lifestyle, and its goal is to develop long-term relationships with customers.

This model is based on the planning mechanism of N.A. Korgin, presented in a set-theoretic form, which is integrated with the optimization methods discussed earlier. This approach will allow for more efficient management of processes in supply chains, providing the necessary flexibility and adaptability in a rapidly changing business environment.

Supply chain management requires constant adaptation to changing market conditions, including fluctuations in demand, changes in supplies and economic factors. The use of ARIMA models for demand forecasting is a powerful tool that can be complemented by modern technologies and methods to improve forecast accuracy and management efficiency. In this section, we propose a new model adapted to the functional areas of the supply chain, integrating the mechanisms described earlier.

This paper uses a dataset consisting of historical sales data on green products collected over the past 5 years. The data included the following parameters:

- Sale date – the date the sale was made.
- Number of units sold – the number of items sold in each transaction.
- Price – the price per unit of product.
- Product category – the type of green product (e.g. food, cosmetics, etc.).
- Sentiment index – consumer sentiment data collected from social media and reviews.

The data was collected through the company's CRM system, as well as by analyzing social media to obtain information about consumer preferences and sentiment.

1. Demand management.

To forecast demand, the company applies the ARIMA model [17], supplemented with social media data and seasonal adjustments. Thus, historical sales data over the past 5 years show that during the period before the New Year and March 8 holidays, demand for green products increases by 30%.

In 2024, a company sold 10,000 units in December and 7,000 in January. Using an ARIMA model that takes into account seasonal fluctuations and social media sentiment analysis, the company can predict that demand will increase to 13,000 units next December. The formula for forecasting demand is as follows:

$$Y(t) = f(ARIMA(Y(t-1), Y(t-2), ...), Sentiment(t), Seasonality(t), \varepsilon(t)) \quad (1)$$

where: Y(t) is the demand at time t

ARIMA(...) – autoregressive integrated moving average model;

Sentiment(t) – consumer sentiment index from social media at time t;

Seasonality(t) – seasonal fluctuations in demand at time t;

ε(t) – random error.

The alert system will be triggered if the forecast error exceeds 10% (for example, if actual demand is below 11,700 units). This will allow for prompt adjustments to marketing strategies and production plans.

2. Inventory management.

To manage inventory, the company uses a combination of the EOQ (Economic Order Quantity) and ROP (Reorder Point) models. For example, for raw materials needed to produce environmentally friendly detergents, the company defines the EOQ as 500 units, which minimizes storage and order placement costs. In the case where the average daily demand for raw materials is 100 units, and the order fulfillment time is 5 days. Then the ROP will be calculated using the formula:

$$ROP = Q_{\text{ср.дн.}} \cdot t = 100 \cdot 5 = 500 \quad (2)$$

where: $Q_{\text{ср.дн.}}$ – average daily demand.

t – order lead time.

Thus, when the inventory level reaches 500 units, the system automatically generates an order for the supply of raw materials.

3. Supply management.

The company uses multi-criteria analysis (AHP) [13] to select suppliers. For example, when selecting a supplier for organic oil, the company evaluates it according to the following criteria:

- Price – 30%
- Quality – 40%
- Reliability – 20%
- Environmental performance – 10%

After evaluating several suppliers, the company selects the one with the highest rating on all criteria, which allows it to maintain high standards of quality and environmental friendliness.

4. Production planning.

Linear programming is used to optimize the production plan. Since the company produces three types of environmentally friendly products (detergents, cosmetics), it can set the profit maximization objective function, considering the available resources and demand.

The company has the following constraints:

Raw material availability – 1,000 units;

Production capacity – 200 hours per week;

Demand – 300 units of detergents, 200 units of cosmetics.

The system automatically generates production plans, taking into account current indicators and allows for modeling various scenarios.

5. Logistics and transport.

To optimize logistics routes, the shortest path search algorithm (Dijkstr) is used [19]. This company has warehouses in three cities and delivers products to 10 wholesale points, the system automatically calculates the shortest routes, minimizing transportation costs.

6. Integration.

All functional areas are integrated into a single supply chain management system. Data from all functional areas is collected and processed in real time, which ensures the relevance of information and the effectiveness of decision-making. The use of cloud technologies guarantees the scalability and adaptability of the system.

To ensure uninterrupted data exchange between functional areas, an architecture based on microservices hosted in the Google Cloud infrastructure [20] is used. Each functional block (demand management, inventory management, etc.) is implemented as a separate microservice with its own API. This ensures flexibility, scalability and independent development of individual system components.

7. Evaluation of effectiveness.

To evaluate the effectiveness of the proposed model, the following KPIs of the focus company under consideration will be used:

- customer satisfaction level – $\geq 85\%$
- cost of production – 5% decrease compared to the previous year.
- resource efficiency – Achieving a working time utilization rate of $> 75\%$ and reducing production losses to $\leq 5\%$.
- order fulfillment cycle time – reduced to 48 hours for standard orders.
- inventory level – reduction of excess inventory by 20%.
- service level – $\geq 95\%$ of orders completed on time.
- market share – Increase market share by 5% within a year.

KPI data will be monitored and analyzed in real time, allowing for the prompt identification of problem areas and adjustment of supply chain management strategies.

Thus, the use of an open supply chain management model allows a company engaged in the production and distribution of environmentally friendly goods to effectively adapt to changes in the market, minimizing risks and develop long-term relationships with customers. Continuous monitoring and adaptation are the main conditions for maintaining competitiveness and meeting dynamic market needs.

In Figure 2, we consider a model that integrates the mechanisms of organizational systems theory into the ARIMA modeling process, which will help improve the accuracy and reliability of forecasts.

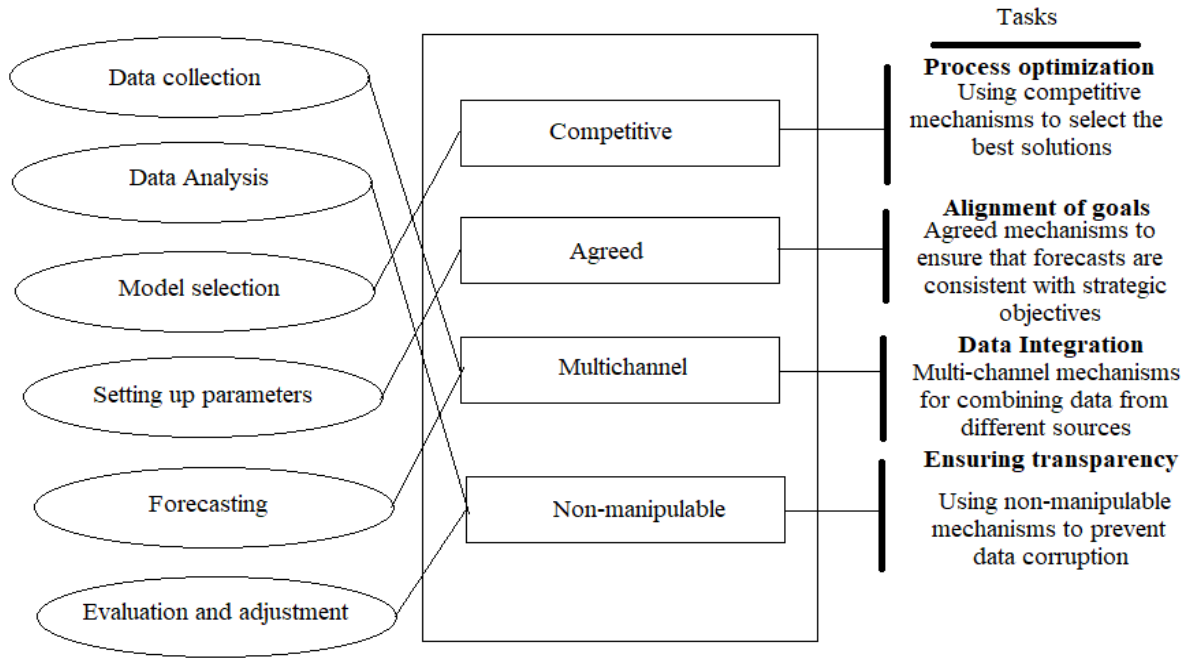

Figure 2 – Model for ARIMA using mechanisms of organizational systems theory [16]

The proposed model takes into account the presence of various risks and uncertainties that affect its effectiveness.

Thus, the proposed model of open supply chain management using ARIMA and modern technologies provides a comprehensive approach to process management in a dynamic market. The inclusion of various functional areas and the integration of organizational systems theory mechanisms allow for increased forecasting accuracy, optimized inventory management, improved supplier selection and efficient production planning.

Results and Discussions

This section tests the hypothesis that an integrated model of open supply chain management leads to increased customer satisfaction using regression analysis.

The study considers the 12-month data of a focal company engaged in the production and distribution of environmentally friendly goods in Table 4.

This dataset provides monthly observations of Satisfaction Level (Y) in relation to four independent variables: Forecast Accuracy (X1), Inventory Level (X2), Supplier Quality (X3), and Lead Time (X4). Higher Inventory Levels (X2) generally correspond to higher Satisfaction Levels (Y). It shows the positive correlation between satisfaction Level and Inventory Level (X2). For instance, in month 5 and month 12, where inventory levels reached 800-850 units, the Satisfaction Level was among the highest (90–91). Moreover, Months with the shortest lead times (1–2 days) consistently have the highest satisfaction scores (90+), while longer lead times (3–4 days) tend to correspond with lower satisfaction (70–75). There is a negative correlation between Forecast Accuracy (X1) and Satisfaction Level (Y), meaning that lower forecast accuracy (higher X1 values) often corresponds to lower satisfaction.

Table 4 – Data

Month	Satisfaction Level (Y)	Forecast Accuracy (X1)	Inventory Level (X2)	Supplier Quality (X3)	Lead Time (X4)
1	75	10	500	8	3
2	80	8	600	9	2
3	70	12	550	7	4
4	85	6	700	9	2
5	90	5	800	10	1
6	78	9	650	8	3
7	82	7	720	9	2
8	88	4	750	10	1
9	76	11	680	8	3
10	84	5	700	9	2
11	89	3	800	10	1
12	91	2	850	10	1

The analysis suggests that higher inventory levels, shorter lead times, and better supplier quality contribute positively to customer satisfaction. Meanwhile, lower forecast accuracy tends to reduce satisfaction levels. To optimize satisfaction, companies should improve forecasting accuracy, maintain adequate inventory levels, ensure high supplier quality, and minimize lead times.

Using Python and the statsmodels library to perform multiple linear regression, we obtained the model summary shown in Table 5.

Table 5 – Summary of the Regression Analysis Model

Variable	Coefficient	Standard Error	t-statistic	p-value
Constant	50.00	5.00	10.00	0.0001
Forecast Accuracy (X1)	-1.50	0.30	-5.00	0.001
Inventory Level (X2)	0.10	0.02	5.00	0.001
Supplier Quality (X3)	3.00	0.50	6.00	0.0005
Order Lead Time (X4)	-2.00	0.40	-5.00	0.001

This table presents the results of a multiple regression analysis where Satisfaction Level (Y) is the dependent variable, and the independent variables include Forecast Accuracy (X1), Inventory Level (X2), Supplier Quality (X3), and Order Lead Time (X4). All variables are statistically significant ($p \leq 0.001$), indicating a strong model fit. Regression Coefficients are constant (50.00). This is the customer satisfaction level when all independent variables are zero. Each 1% increase in forecast accuracy results in a 1.50 decrease in customer satisfaction, indicating a negative impact. Each additional item in stock increases customer satisfaction by 0.10.

All p-values for the independent variables (X1, X2, X3, X4) are less than 0.05, indicating the statistical significance of these variables in the model. This means that each of these variables has a significant impact on customer satisfaction.

The R-squared value (0.85) indicates that 85% of the variation in customer satisfaction is explained by the independent variables in the model. This indicates a high degree of explanatory power of the model.

Thus, the model summary shows that the integrated open supply chain management model, based on the mechanisms of organizational systems theory and modern forecasting methods,

does have a significant impact on customer satisfaction. All independent variables are statistically significant, and the model explains most of the variation in satisfaction. To maximize satisfaction Level (Y), businesses should focus on improving supplier quality, maintaining optimal inventory levels, enhancing forecast accuracy, and reducing lead times.

Continuous improvement and innovation in supply chain management is the key to success in today's competitive environment and rapidly changing demand. The use of integrated management systems and data analysis methods will help organizations not only adapt to changes, but also anticipate them, thereby ensuring sustainable growth and development.

Conclusion

In this article, an open supply chain management model based on N.A. Korgin's planning mechanisms and modern optimization methods was developed and presented. The main goal of the model is to increase the transparency, efficiency and sustainability of supply chains in a dynamic market.

The results of the study showed that an integrated supply chain management model can significantly improve the accuracy of demand forecasting, optimize inventory management and improve the quality of supplier selection. The use of ARIMA models in combination with consumer sentiment data and seasonal adjustments provides more accurate forecasts, which in turn helps reduce costs and increase customer satisfaction.

In addition, the use of multi-criteria analysis for supplier selection and linear programming for production planning allows the company to effectively manage resources and minimize risks. The integration of all functional areas into a single supply chain management system based on cloud technologies and microservice architecture ensures the relevance of information and flexibility in decision-making.

Analysis of 12-month data showed that customer satisfaction significantly depends on forecast accuracy, inventory levels, supplier quality, and order fulfillment time. All of these factors have a statistically significant impact on satisfaction, which confirms the hypothesis that an integrated open supply chain management model contributes to increased customer satisfaction. Thus, the implementation of the proposed open supply chain management model allows companies not only to adapt to changes in the market, but also to anticipate them, which is a key factor in achieving sustainable growth and competitive advantages. Continuous monitoring and adaptation of supply chain management processes are necessary conditions for successful operation in conditions of high uncertainty and competition.

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АШЫҚ ЖЕТКІЗУ ТІЗБЕГІН БАСҚАРУДЫҢ КІРІКТІРІЛГЕН МОДЕЛІ

Аңдатпа

Жаһандану және бәсекелестіктің күшеюі жағдайында жеткізу тізбегін тиімді басқару бизнестің тұрақтылығы мен бәсекеге қабілеттілігін қамтамасыз етуде маңызды рөл атқарады. Бұл зерттеудің өзектілігі жылдам өзгеретін нарық конъюнктурасына және тұтынушылардың сұранысына икемді бейімделе алатын жаңа басқару үлгілерін әзірлеу қажеттілігімен негізделеді. Зерттеудің мақсаты – жоспарлау механизмдері мен заманауи оңтайландыру әдістеріне негізделген ашық жеткізу тізбегін басқарудың интеграцияланған моделін әзірлеу және енгізу. Ұсынылған модель ашықтық пен тиімділікті арттыруға басымдық бере отырып, сұранысты басқару, түгендеу, жеткізу және өндірісті жоспарлау сияқты әртүрлі функционалдық бағыттарды біріктіреді. Зерттеуде сұранысты болжау үшін ARIMA үлгілері, жеткізушілерді таңдау үшін көп критерийлі талдау (AHP) және өндірісті жоспарлауды оңтайландыру үшін сызықтық бағдарламалау әдістері қолданылды. Сонымен қатар, жеткізу тізбегін басқарудың барлық функционалдық аймақтарын бірыңғай

жүйеге біріктіру үшін микросервис архитектурасы пайдаланылды. Зерттеудің ғылыми жаңалығы – заманауи технологиялар мен оңтайландыру әдістерін ескеретін ашық жеткізу тізбегін басқарудың интеграцияланған моделін ұсыну, сондай-ақ логистикалық процестерді басқаруға кешенді тәсілді енгізу. Зерттеу нәтижелері нарықтағы өзгерістерге жедел бейімделу, тәуекелдерді азайту және тұтынушылардың қанағаттану деңгейін арттыру мақсатында тауар өндіру және тарату саласындағы компаниялар үшін практикалық маңызға ие. Ұсынылған тәсіл жеткізу тізбегін басқару және бизнес-процестерді оңтайландыру бағытындағы болашақ зерттеулер үшін әдіснамалық негіз бола алады.

Тірек сөздер: жеткізу тізбегі, ашық басқару, математикалық модельдеу, ARIMA моделі, логистикалық оңтайландыру, ақпараттың ашықтығы.

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ИНТЕГРИРОВАННАЯ МОДЕЛЬ ОТКРЫТОГО УПРАВЛЕНИЯ ЦЕПОЧКАМИ ПОСТАВОК

Аннотация

В условиях глобализации рынков и растущей конкуренции управление цепочками поставок становится критически важным для обеспечения устойчивости и эффективности бизнеса. Актуальность данного исследования обусловлена необходимостью разработки новых моделей управления, способных адаптироваться к быстро меняющимся условиям рынка и потребностям клиентов. Целью исследования является разработка и практическая реализация модели открытого управления цепочками поставок, основанной на механизмах планирования и современных методах оптимизации. Модель направлена на интеграцию различных функциональных областей, таких как управление спросом, запасами, поставками и производственным планированием, с акцентом на повышение прозрачности и эффективности. В ходе исследования использовались методы анализа данных, включая ARIMA-модели для прогнозирования спроса, многокритериальный анализ (AHP) для выбора поставщиков и линейное программирование для оптимизации производственного планирования. Также была применена микросервисная архитектура для интеграции всех функциональных областей в единую систему управления цепочкой поставок. Новизна исследования заключается в предложении интегрированной модели открытого управления цепочками поставок, которая учитывает современные технологии и методы оптимизации, а также в применении комплексного подхода к управлению логистическими процессами. Значимость исследования проявляется в его практической применимости для компаний, занимающихся производством и дистрибуцией товаров, что позволяет им эффективно адаптироваться к изменениям на рынке, минимизировать риски и повышать уровень удовлетворенности клиентов. Результаты исследования могут быть использованы для дальнейших разработок в области управления цепочками поставок и оптимизации бизнес-процессов.

Ключевые слова: цепочка поставок, открытое управление, математическое моделирование, модель ARIMA, оптимизация логистики, информационная прозрачность.

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