QUALITY CONTROL IN DAIRY SUPPLY CHAIN MANAGEMENT

Nurakhova B., Ilyashova G., Torekulova U.*

Abstract: The main objective of the article is to study the prospects and opportunities for improving the efficiency of dairy supply chain management through the implementation of the supply chain quality integration (SCQI) model. The study is performed on data collected from three dairy companies: Agroindustrial Company Adal (Kazakhstan), Dean Foods (USA) and Hochwald (Germany). A methodological approach to the evaluation of the vector length is proposed to measure the effectiveness of SCQI model implementation. Three alternative scenarios for the implementation of SCQI are proposed. For Dean Foods, a focus on integration with suppliers is suggested. Hochwald, in turn, should improve its supply chain efficiency via internal integration, while Adal is proposed to improve its value creation effectiveness for consumers. Effectiveness evaluation of the implied supply chain optimization alternatives for Adal, Dean Foods, and Hochwald was carried out by determining the efficiency vector of a supply chain.

Key words: business process, integration, quality, supplier, supply chain, value.

DOI: 10.17512/pjms.2020.21.1.18

Article history:
Received March 2, 2020; *Revised* April 30, 2020*; Accepted* May 16, 2020

Introduction

An important condition for successful development of a modern economy is a production of competitive products and services, which is impossible without improving the quality level. In this regard, systems, methods and tools of quality management have been actively developing recently, the scope of their application is expanding. In conditions of rapid growth in the number of logistics enterprises in the market, the problem of high-quality customer service is of particular relevance. The focus on logistics service in all stages and areas of activity of the enterprises allows the company to achieve high coordination of activities and ensure the availability of materials or goods at the right time, in the right place, amount, and condition. Proper supply chain management (SCM) enables achieving the high quality of the final product, production process, and sales services. Furthermore, effective management ensures successful warehousing, transportation, optimal use of resources, profitability, and superior competitive performance of the enterprise (Kovács and Gubán 2017), The importance of the SCQI concept is growing

* **Botagoz Nurakhova**, MSc. Narxoz University, Almaty, Republic of Kazakhstan; **Guliya Ilyashova**, MSc, Al-Farabi Kazakh National University, Almaty, Republic of Kazakhstan, **Uldana Torekulova**, PhD, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Republic of Kazakhstan.
✉ corresponding author: Botagoz Nurakhova; bota_nzh@mail.ru
✉ July.gk1977@gmail.com; uldana777@mail.ru

steadily. Nowadays this concept is widely implemented to explain how manufacturers integrate with their suppliers and customers for higher-quality services (Huo et al., 2019).

The supply chain is a complex network structure with wide production, storage, and logistics capacities. It consists of a focal firm, suppliers, consumers of different levels, and numerous intermediaries (Pettit et al., 2019).

In the supply chain, time is an important factor in enhancing competitive advantages. Logistic chains that can shorten the interval between order receipt and delivery of goods provide a competitive advantage in the market. Reducing the time of material flow movement within the supply chain reduces also logistics costs (Jiang et al., 2020). Promptness of delivery remains the main criterion on the selection of supplier. Promptness refers to a commitment for the delivery of products and services on time (Liu et al., 2019).

Food products are intensively moving across international borders to meet the growing demand, thereby shifting the focus from managing local agricultural models to optimizing the global food supply chain (Accorsi et al., 2016). These trends increase the relevance of considering the related functions of the food supply chain: not only the cultivation and processing of food products, but also packaging, storage, distribution, as well as control and monitoring of product quality throughout its entire life cycle. These processes complicate the supply chain, which emphasizes the distance between the producer and the consumer and affects consumer awareness of supply chain stages. Multidimensional nature of the problems in supply chain quality management at the enterprise actualizes the application of an integrated approach to management, which should cover all company's processes for ensuring product quality. Considering this, the current paper is aimed at improving the efficiency of dairy product supply management through the introduction of SCQI.

Literature Review

In supply chain management, material, information, and financial flows are considered as integrators, enabling the formation of emergent properties of a supply chain (Saengchai, 2019; Zhang et al., 2019b). Successful logistic integration is essential for supply chain efficiency. Thus, three levels of integration can be distinguished. At the first level, separate logistics functions are performed. The internal integration takes place at the second level. Hence, the logistics functions are under control within a single enterprise. The last, third level, covers an integration process between a firm and its external partners (Sahebjamnia et al., 2020). It should be noted that fluctuations in enterprise development must be taken into account in the process of logistic integration (Boichenko et al., 2019).

Successful supply chains that provide enterprises with sustainable competitive advantages are agile, adaptive to developing market, cost-effective, and responsive to trading partners (Ding et al., 2019). The effectiveness of the supply chain largely

depends on the information technology, which ensures the cooperation between partners (Abeysekara et al., 2019; Oláh et al., 2019). The use of Radio Frequency Identification (RFID) technology is among multiple approaches to the information system improvement. Nowadays, RFID is implemented in various fields requiring fast, accurate control, and material flow tracking in the supply chain (Karuppuswami et al., 2018; Song, 2017). Moreover, the fourth industrial revolution (Industry 4.0) significantly improves communication and collaboration within the supply chain. It enables accessing, storing, and processing a large amount of data both, internally and externally (Schniederjans et al., 2020).

Since logistics affects the competitive advantages of cooperating parties, and there is a risk associated with changing working conditions - it is important for parties to know that they both work on mutually beneficial conditions (Malkus, 2018).

Integrated supply chains are characterized by long-term cooperation, exchange of information, coordination of the flow of products and money, joint planning and risk, reduction of chain costs, inventory management, and coordination of procedures and rules for cooperation (Kull et al., 2019). Mass customization improves customer quality integration both directly and indirectly through internal quality integration, and product modularity improves customer quality integration indirectly through mass customization and internal quality integration. Supplier quality integration heightens competitiveness, whereas internal quality integration advances competitive performance through supplier quality integration (Zhang et al., 2019a). At the same time, the impact of supply chain integration (SCI) on financial performance depends on the company's competitive priorities (Wiengarten et al., 2019). Supplier and customer quality integration positively impacts green purchasing and customer green cooperation, which improve environmental performance (Yu et al., 2019). Furthermore, an optimization of natural products' portfolio of a supply chain remains widespread. It includes three interconnected models for describing production, supply chain, and its environmental impact. The models are included in a broader optimization framework whereby the environmental criteria are defined in terms of costs such as the best trade-off between total profit and environmental impact to be achieved (Kirilova and Vaklieva-Bancheva, 2017; Shaharudin et al., 2019). Lean practices have positive associations with supply chain efficiency. Therefore, implementation of lean supply chain practices can influence the electronic company’s operations and performance.

In the field of production, methods of modeling production and logistics processes are increasingly being used. This allows one to create effective methodologies for generating material flows using simulation models and related algorithms. Logistic dependencies detected with these models are ideal for serial production lines (Drastich, 2017).

An analysis of modern scientific approaches to improving process quality management indicates the popularity and relevance of this area among scientists.

However, competitiveness and dynamic response to market requirements, the efficient use of internal resources of dairy enterprises are impossible without the development of a process approach and the use of new methods for managing the quality of supplies.

Materials and methods

The research is conducted on three companies. Agroindustrial Company Adal is among leaders in the Kazakhstan dairy industry, while Dean Foods (USA) and Hochwald (Germany) remain on the top of the world's dairy sector. These enterprises are chosen to review regional characteristics of an efficient supply chain formation and opportunities for SCQI integration in less developed companies. The process and system performance indicators are based on goals, the fulfillment of which the entire system and each process pursue. The study is based on a methodological approach to managing supply chain goals, including the formation of Key Performance Indicators (KPI) (Reynoso, 2018; Tundys and Fernando, 2020).

The supply chain processes are established in the SCOR or GSCF model. The principal difference between the two models is their goal. The SCOR model focuses on transaction efficiency, while GSCF concentrates on partnership management during the implementation of the SCQI concept. The effectiveness of each process is determined through four groups of indicators. Since the SCOR model includes a wide range of indicators that form three levels of process detail, it is used to form the process indicators list for the enterprises under consideration. The research introduces operational data as *level 2 operational indicators*. This information can be gathered regularly to identify key trends of the enterprises. If deviations are noticed in the expected efficiency level, a more detailed examination of the relevant business operations should proceed. More detailed acquisition and analysis of the supply chain data in the SCOR model provides for the calculation of the so-called "Level 3 Diagnostic indicators". Diagnostic indicators can be used to analyze the complexity and configuration of the supply chain, as well as to study particular management practices.

The author's method for evaluating the effectiveness of the SCQI concept is proposed that is based on determining the vector length ($\overline{SCQI_n}$). Thus, the position relative to point *O* for each company n in the supply chain is calculated as follows:

$$SCQI_n = \sqrt{(CE_n)^2 + (SQ_n)^2 + (CQ_n)^2}$$

where CE_n – is the internal efficiency of the ISC formation;

SQ_n – effectiveness of supplier value creation of the enterprise *n*;

CQ_n – effectiveness of customer value creation of the enterprise *n*.

The resultant values allow assessing the effectiveness of a supply chain formation in a company. As part of this evaluation, companies can be compared with each other. Hence the performance criterion represents the value of vector $\overline{SCQI_n}$

compared to other companies.
Accordingly, when conducting a pre-project analysis of the ISC formation process using this model, it is necessary to calculate the changes in three integrated indicators and the vector length:

$$SCQI_n = \sqrt{(CE_n + \Delta CE_n)^2 + SQ_n + \Delta SQ_n)^2 + CQ_n + \Delta CQ_n)^2}$$

where ΔCE_n – variation in the efficiency of the ISC formation;
ΔSQ_n – variation in the value creation effectiveness for suppliers of the enterprise n;
ΔCQ_n – variation in the quality of formation value to customers of the enterprise *n*.
The described methodology is proposed to improve the ISC or evaluate its effectiveness. Thus, the described method can provide support for the adoption of managerial decisions on integrated processes.

Results

Since the examined companies Adal, Dean Foods, and Hochwald operate in different regions of the world, it is necessary to determine common and distinctive features inherent to their SCM system. A schematic illustration of the supply chain model of dairy enterprises is represented in Figure 1.
Hochwald has a unique system of values in selecting suppliers and service providers. The overall goal of the company is to permanently improve productivity and efficiency with regard to health, safety, and environment. Hochwald voluntary standards and processes are certified in accordance with the quality standards and are regularly reviewed, both internally and externally. In 2018, 86 internal and external audits were carried out at all the company's facilities.
Dean Foods' abilities to produce, transport, and sell products are essential for its successful business activity. Dean Foods is subject to federal trucking regulations such as the Federal Haulage Safety Act, which must comply with the extensive Direct to Store Delivery (DSD) system. Failure to comply with the before-mentioned regulations can lead to the inability to promptly deliver goods to customers. It may negatively affect Dean Foods' reputation and performance.
Hochwald and Dean Foods use the services of specialized logistics companies, working with them through 3PL and 4PL models, outsourcing a few logistic functions via 2PL. In Kazakhstan, zero-level and one-level channels are used. Their implementation allows minimizing the price of products and maintaining sales volumes at a relatively stable level (Meimankulova and Umirzakov, 2018). The sale of dairy products through a distribution network provides many advantages. Among them are meeting sanitary-hygienic demands for the storage of dairy products, the possibility of positioning dairy products of one assortment group from different producers, ease of purchase, quality of service, etc. However, the trade through zero-level and one-level distribution channels requires additional expenditures on the consumer side and affects the ability to sell dairy products. As

a result, the distribution network includes only a few small-scale dairy enterprises, oriented at people with low purchasing ability, resulting in a reduction of retail turnover (Kaliyev et al., 2019).

The Adal logistics supply chain provides for the storage of dairy products while maintaining the required temperature and hygiene requirements. The dairy foods may store safely from several hours (unpackaged and perishable goods) to several months (T milk and other non-perishable goods). About 5% of the total time corresponds to the transportation in Adal dairy company, and only 2% to the production.

Thus, the possibilities for product cost reduction and the manufacturing time should be explored through the improvement of supply management, marketing activities, storage, material flows movement, and the interaction between suppliers, consumers, and intermediaries.

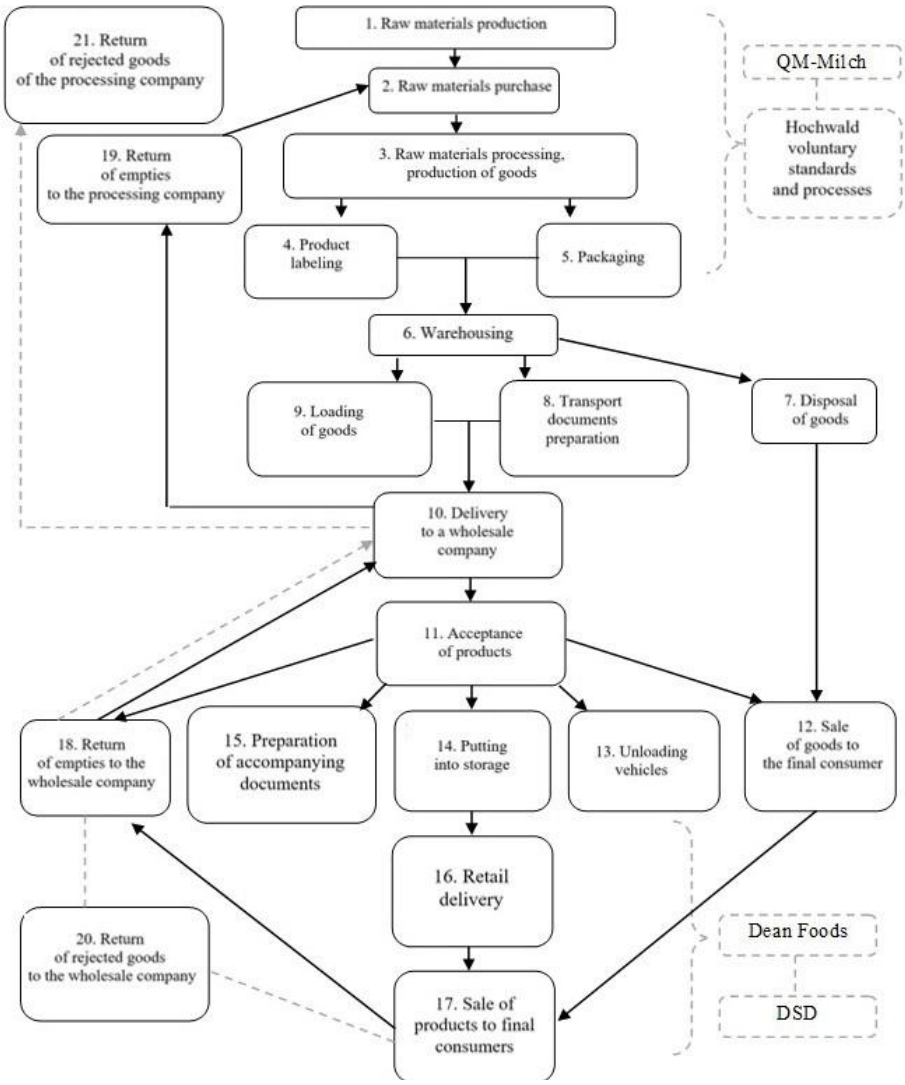


Figure 1: Dairy supply chain (developed by the authors on dairy enterprises' data)

The analysis of the companies' logistics costs has revealed its growth for Adal (14.2%) and Hochwald (4.5%) alongside a decrease for Dean Foods (1.8%) in 2018 compared with 2017. Consequently, Adal and Hochwald use more material resources to manage their logistics systems. At the same time, transportation costs remain high: 46% for Adal, 28% for Hochwald, and 32% for Dean Foods. Such expenditures are associated with perishable products' transportation, route distance, rising fuel prices, and high vehicle maintenance costs. The logistics costs for 2018 are revealed in Figure 2.

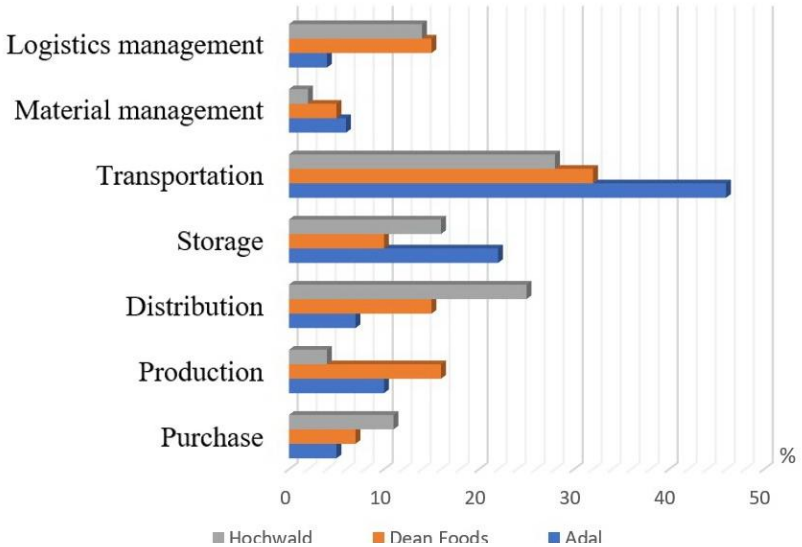
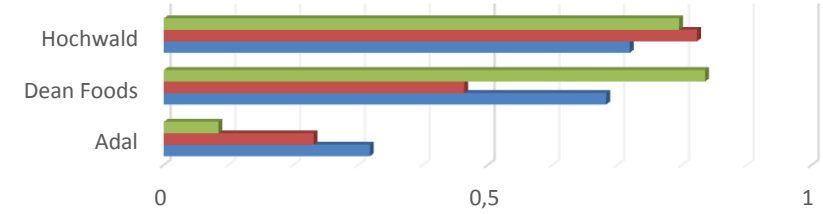


Figure 2: The structure of logistics costs (developed by the authors on dairy enterprises' data for 2018)

Storage costs constitute an important percentage of the total transportation costs due to the requirements for dairy storage and quality. The Adal's production expenditures make up a significant percentage (10%), due to ensuring the production of goods of the best quality at the lowest cost in the shortest possible time.

The effectiveness of Adal, Hochwald, and Dean Foods supply chains is assessed on three integrated indicators: internal efficiency of the ISC formation (CE), quality of value creation in the supply chain for suppliers (SQ), quality of value creation in the supply chain for consumers (CQ)

To compare companies, the results obtained are normalized on a 0–1 scale (Figure 3).

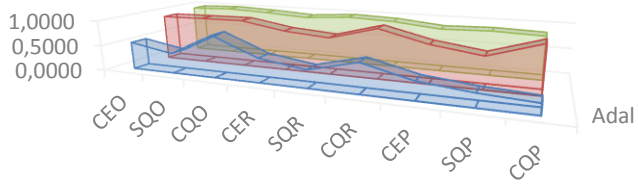


	Adal	Dean Foods	Hochwald
CQ	0,0845	0,8356	0,7953
SQ	0,2312	0,4637	0,8231
CE	0,3182	0,6829	0,7192

Figure 3: Supply chains' effectiveness (developed by the authors on dairy enterprises' data for 2018)

Since the SCQI concept is based on the internal integration of quality, suppliers, and customers, its implementation can improve not only the supply chain effectiveness but also the efficiency of the whole enterprise. In general, key indicators for assessing the supply chain effectiveness can be defined as customer service level, internal performance, demand elasticity and product development.

Three possible scenarios are proposed for Adal, Dean Foods, and Hochwald dairy companies, to implement the SCQI concept effectively. For each of them optimistic, realistic, and pessimistic courses of events are predicted (Figure 5).



	CEO	SQO	CQO	CER	SQR	CQR	CEP	SQP	CQP
Adal	0,5409	0,3930	0,8237	0,4709	0,3422	0,5691	0,3437	0,2497	0,1993
Dean Foods	0,9151	0,9296	0,9416	0,7922	0,7235	0,9693	0,7444	0,6144	0,9108
Hochwald	0,9670	0,9960	0,9623	0,9077	0,9713	0,9385	0,8472	0,8725	0,8430

Figure 5: Possibilities of implementing the SCQI concept (developed by the authors)

According to the data presented, Dean Foods should focus on integration with suppliers, since the highest growth is predicted for SQ. Hochwald needs to improve supply chain efficiency within internal integration due to the higher costs on more effective customer-supplier relationships. Adal should pay particular attention to improving its supply chain since the CE value tends to be extremely low.

The assessment of the effectiveness of proposed optimization alternatives for Adal, Dean Foods, and Hochwald is carried out through the vector efficiency evaluation according to the CE, SQ, and CQ integrated indicators (Figure 6).

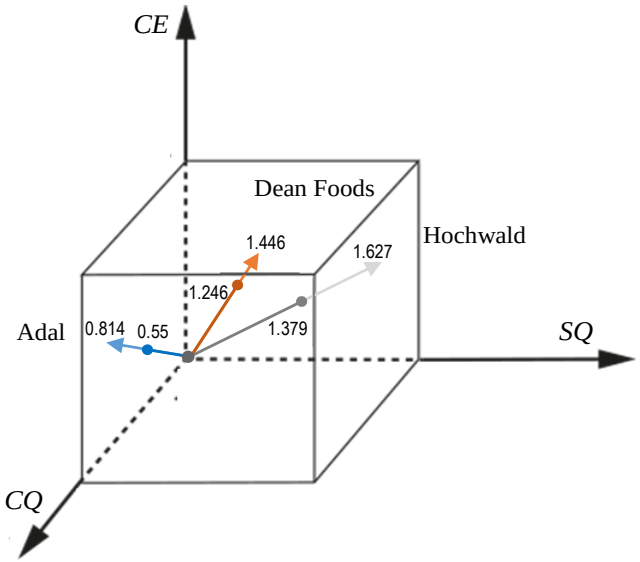


Figure 6: Efficiency vectors of SCQI implementation (developed by the authors according to companies' data for 2018)

The comparative projections of efficiency vector length for each company before and after the SCQI concept implementation revealed an upward trend. For the Adal dairy company, a vector length of 0.264 offers great opportunities for further development. With the introduction of the SCQI concept, Adal can significantly improve its competitive position not only in the Kazakhstan market but also internationally. According to data, the expected vector length for Dean Foods corresponds to 0.199 and 0.248 for Hochwald. Even a slight rise in values contributes to significant efficiency improvement. Thus, it can be argued that the implementation of the SCQI concept enhances supply chain efficiency for all dairy enterprises under study. Together with partners, enterprises can manage internal and interorganizational processes to achieve efficient flows of products, services, information, and money. Consequently, joint management in the company will provide maximum customer value of the product at low cost and high adaptability to changes in the external business environment.

Discussion

The orientation of enterprises towards the integration is primarily related to the growing volatility of the external environment and the desire to more efficiently

adapt to customer requirements, growing competition, and accelerated development of information technologies (Huo et al., 2019).

The purchase of goods by final consumers causes a sequence of events in the supply chain (Jermsittiparsert et al., 2019). An order receipt from a retail store entails transportation from distribution centers, order picking, loading, and final delivery to the shop. In turn, replenishment at the distributor includes deliveries from the manufacturer, the production process itself, and requests for the supply of necessary materials.

Another important aspect is the identification of business processes within a supply chain (Leukel and Sugumaran, 2018). As for logistics, all business processes can be combined into three groups: the movement of materials, the movement of information, and the movement of financial resources (Ali et al., 2018).

The main difference between SCOR and GSCF models lies in the purpose they pursue (Lestari et al., 2020). The GSCF framework is more strategic and focuses on increasing long-term shareholder value through closer cross-functional relationships with the key members of the supply chain (dos Santos and Leite, 2018). Therefore, depending on the stage of development, the SCOR or GSCF models can be respectively beneficial for the newly created or mature supply chain.

The presence of integration levels complicates the achievement of SCI since the supply chain combines various objects, business philosophies, and systems with complex structures (Sahebjamnia et al., 2020).

The main objective of the partnership between logistics companies is the transformation of long-term relationships (B. Rakic and M. Rakic, 2018). Coordination of partners' actions within the supply chain is achieved when each participant acts rationally and recognizes all the needs and capabilities of a supply chain. Given the interdependence between participants, effective coordination is essential for overall and individual success.

The major role in the supply chain is given to the implementation of standardized operations and management processes (Ding et al., 2019). Therefore, to create a responsible supply chain, it is necessary to outline the essential characteristics of standardization, which will not be too rigid and allow obtaining a responsible supply chain link.

Conclusions

Hochwald and Dean Foods dairy companies work with the specialized logistics providers through the 3PL and 4PL models, outsourcing only a few functions via 2PL. The prevalence of zero-level and one-level channels for dairy product distribution in Kazakhstan enables minimizing product value for the final consumer and maintaining stable sales volumes. In 2018, the companies' logistics costs increased for Adal (14.2%) and Hochwald (4.5%) and decreased for Dean Foods (1.8%) compared with the previous year. It confirms that Adal and Hochwald use more material resources to manage their logistics systems.

The study revealed the importance for Dean Foods to focus on integration with suppliers since the highest growth is predicted for the level of value creation effectiveness for suppliers. Hochwald should improve supply chain efficiency within internal integration due to the increased expenses for better customer-supplier relationships. Adal must pay particular attention to improving its supply chains since the internal efficiency of the ISC formation tends to be extremely poor. Effectiveness evaluation of the proposed supply chain optimization alternatives for Adal, Dean Foods, and Hochwald is performed by determining the efficiency vector of a supply chain. The greatest prospects are opening up for the Adal dairy company (vector increased by 0.264), while the predicted rise for Dean Foods is 0.199 and 0.248 for Hochwald. Even a slight rise in the vector length for Hochwald and Dean Foods contributes to a significant improvement in their efficiency. At the same time, Adal can enhance its competitive position not only on the Kazakhstan market but also internationally.

As a consequence, the implementation of SCQI is necessary to improve supply chain efficiency at all dairy enterprises under study. Future research can apply the results achieved to identify the relationships and features of supply chain quality management in other sectors.

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KONTROLA JAKOŚCI W ZARZĄDZANIU ŁAŃCUCHA DOSTAW

Streszczenie: Głównym celem tego artykułu jest zbadanie perspektyw i możliwości poprawy wydajności zarządzania łańcuchem dostaw mleka poprzez wdrożenie modelu integracji jakości łańcucha dostaw (SCQI). Badanie zostało przeprowadzone na danych zebranych od trzech firm mleczarskich: Agroindustrial Company Adal (Kazachstan), Dean Foods (USA) i Hochwald (Niemcy). Proponowane jest metodologiczne podejście do oceny długości wektora do pomiaru skuteczności wdrożenia modelu SCQI. Zaproponowano trzy alternatywne scenariusze wdrożenia SCQI. W przypadku Dean Foods sugerowane jest skupienie się na integracji z dostawcami. Z kolei Hochwald powinien poprawić efektywność łańcucha dostaw poprzez integrację wewnętrzną, podczas gdy Adal proponuje poprawę efektywności tworzenia wartości dla konsumentów. Ocena skuteczności sugerowanych alternatyw optymalizacji łańcucha dostaw dla Adal, Dean Foods i Hochwald została przeprowadzona poprzez określenie wektora wydajności łańcucha dostaw.

Słowa kluczowe: proces biznesowy, integracja, jakość, dostawca, łańcuch dostaw, wartość.

乳品供應鏈管理中的質量控制

摘要：作者必須按照文檔中給出的說明進行論文發表。本文的主要目的是研究通過實施供應鏈質量整合（SCQI）模型來提高乳製品供應鏈管理效率的前景和機遇。這項研究是基於從三個乳製品公司收集的數據進行的：農業工業公司Adal（哈薩克斯坦），DeanFoods（美國）和Hochwald（德國）。提出了一種評估矢量長度的方法，以衡量SCQI模型實施的有效性。提出了用於SCQI實施的三種替代方案。對於Dean Foods，建議將重點放在與供應商的集成上。反過來，霍赫瓦爾德（Hochwald）應該通過內部整合來提高其供應鏈效率，而阿達（Adal）則被提議來提高其為消費者創造的價值。通過確定供應鏈的效率向量，對隱含的Adal，Dean Foods和Hochwald的供應鏈優化備選方案進行了有效性評估。

關鍵詞：業務流程，整合，質量，供應商，供應鏈，價值。