OUTSOURCING OF LOGISTICS SERVICES AS STRATEGIC ADVANTAGE OF SUPPLY CHAIN

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Abstract. Third-party logistics is becoming increasingly popular. Today, many agricultural producers, especially small companies and farms, outsource their logistics operations to 3PL service providers in order to focus on their core strengths. 3PL providers offer optimal solutions for business and contribute to increasing productivity and improving the quality of customer service for companies. Improving the level of service and expanding the range of services, increasing investments in warehouse infrastructure is a general trend in the development of leading 3PL providers, which meets the requirements of logistics in complex agri-food markets. The mathematical model of organization of joint processing of agricultural products considered in the article shows that the strategy of attracting third-party logistics operators allows to reduce the volatility of prices for warehousing services. The results of the study showed that the need to rent warehouse space for an unknown number of goods not only increases the cost of services, but also reduces the size of additional (reserve) warehouse space available on top of the average expected number of goods. In case of a significant excess of the volume of goods, the company is forced to incur additional costs for the organization of extraordinary warehousing. The calculations have shown that the use of the services of 3PL providers can significantly reduce the costs incurred by the company due to insufficient provision of reserve warehouse space.

Keywords: costs, economies of scale, supply chain, logistics providers, warehousing services.

Introduction

Logistics operations play a significant role both in the handling of goods (transportation, storage and distribution) and in the planning of supply chain networks, especially for manufacturing industries. Globalization processes, the expansion of the range of e-commerce, the reduction of the life cycle of products and the increased expectations of customers force manufacturers to focus on their core competencies and outsource others to specialized companies, which makes third-party logistics extremely popular in the world. Thus, according to Statista Market Insights, in 2024, revenues from third-party logistics amounted to 1.35 trillion and in 2029 to cross the mark of 1.5 trillion dollars USA [1].

Even today, 3PL providers offer optimal business solutions at an adequate price, which contribute to increasing productivity and improving the quality of customer service for companies. Improving the level of service and expanding the range of services, increasing investments in warehouse infrastructure is a general trend in the development of leading 3PL providers. On the one hand, this meets the requirements of logistics in complex B2B markets, on the other hand, it forms a barrier to entry and increases the level of capital concentration in logistics.

Therefore, more and more scientists and practitioners are paying attention to the issues of effective interaction between manufacturers and logistics providers and the impact of the latter on the overall efficiency of supply chains. Typically, they use integrated methodologies for multi-criteria MCDM decision-making, namely:

- analytical hierarchical process (AHP) and analytical network process (ANP) [2; 3];
- best worst (BWM) method and weighted aggregate product estimation method (WASPAS) [4; 5];
- method of objective weighing of entropy [6; 7];
- method of step-by-step analysis of weighting coefficients [7];
- method of ordering preferences by similarity with the ideal solution (TOPSIS) [8] and some others.

Most of these studies develop models for evaluating the most appropriate 3PL service provider for a variety of companies and supply chains, but insufficient attention has been paid to the impact of 3PL providers on the supply chain efficiency.

The purpose of the work is to assess the economic efficiency of introducing a third-party logistics system into the supply chains of agricultural products.

Materials and methods

The supply chain is a complex network that combines many business processes to meet customer needs. With the process approach, the supply chains of agricultural products contain all activities related to cultivation and preparation of raw materials, production of the final product and all post-production activities (storage, transportation, sale of finished products, their export or import). All these activities contain a number of specific features, namely: the duration of the production time of finished products, seasonality in production, limited storage periods of products, the need for conditioning at the stages of transportation and storage of products.

In addition, deterioration of agricultural products over time is inevitable, and an increase in production volumes can lead to the availability of goods of imperfect quality. In this regard, increased requirements are put forward to the supply chains of agricultural products related to their safety and, accordingly, the availability of specialized logistics facilities for preservation of products promoted by them.

These problems are especially acute for Ukrainian farmers when, as a result of Russia’s military aggression, a significant number of facilities for storing agricultural products have been lost and there are no resources to restore them. Thus, in Ukraine, as of the beginning of 2024, the total capacity of destroyed granaries reaches 11.4 million tons of manufactured products, and the capacity of damaged granaries reaches 3.3 million tons of simultaneous storage capacities. The cost of restoring destroyed facilities is estimated at 1.8 billion USD [9].

Under such conditions, agricultural producers, especially small companies and farms, focus on production functions and outsource logistics to 3PL providers. Economies of scale and the possibility of applying the advantages of the growing experience of the latter in organizing the supply of agricultural products dictate the expediency of such solutions. At the same time, it should be noted that the ability of third-party logistics service providers to learn from their own experience is crucial not only for responding to crises in terms of making significant changes, but also for strategic improvement and planning of supply chains in general.

Thus, E. Gonzalez and colleagues [10] believe that close internal and external cooperation (interaction, administration and common operational processes) of manufacturers and 3PL providers contributes to the growth of profitability and actual leadership in the industry. For this, A. Mittal and colleagues [11] propose to use regional food hubs that provide logistics services to connect small producers and institutional/retail buyers.

In addition to economies of scale and the exploitation of accumulated experience, the advantages of using the services of 3PL companies are determined by many other factors. Among them, we can mention natural cost savings in the case when a company engaged in the transportation of goods also provides other related operations: storage, distribution and information support of goods up to the organization of online ordering systems and tracking the passage of cargo by company customers.

At the same time, economies of scale can be manifested not only in simple opportunities to reduce fixed costs through more complete exploitation of capital resources (including infrastructure), but also in the possibility of more complete smoothing of stochastic elements in the nature of agricultural products. In other words, the possibility of joint processing (transportation, storage and distribution) of products in the supply chains of agricultural producers-clients of a 3PL-level logistics company allows achieve greater stability of cargo flows in general, and therefore leads to lower requirements for reserves for additional capacity (free warehouse space, transport and information resources, etc.).

It should be noted here that due to growing competition and instability of market conditions [12], reduction of time to market entry and life cycle of agricultural products, logistics warehouse operations have become an important component of planning production and distribution of supply chains, the cost of which is constantly growing.

Usually, the total annual costs of warehousing logistics include the costs of logistics processes related to the storage and processing of products, D. Milewski and T. Wiśniewski [13] suggest calculating them according to the following formula:

$$TC_{LC} = \sum_{i=0}^{n} (CI_i + CW_i + CT_i + CLS_i) \tag{1}$$

where TC_{LC} – total annual warehousing logistics costs;
n – number of working days per year;
CI_i – cost of operating equipment per day;
CW_i– warehousing costs per day;
CT_i – transportation costs per day;
CLS_i – cost of lost sales opportunities per day.

However, when it comes to working with multimodal target functions and irregular supplies inherent in agricultural supply chains, it will be more appropriate to use hybrid algorithms that combine probabilistic indicators with classical optimization functions.

Thus, if we consider the supply chain of a company (i) using warehouse services (related to the need to ensure that the product is processed before sending it to the end consumer) in a certain place for a certain time (ti) in which order system applications for the supply of the product according to the Poisson distribution are received with an intensity (λ), then the average quantity of products in storage should be equal to (λ *and* ti).

Considering the fact that the process of receipt of applications is of a random nature, the reserve of the storage capacity is to be determined taking into account the needs for placing not only the average projected quantity of products, but also some additional stock ni. Then the probability that the volume of the company's products that need to be stored will be more than the space allotted for this is calculated according to the following formula:

$$P = 1 - e^{-\lambda_i} \sum_{k=0}^{\overline{n_\iota}-1} \frac{\lambda_i^k}{k!} \tag{2}$$

where λ_i – probability related to the intensity of the flow of applications, %;
$\overline{n_\iota}$ – rental area level, m^2;
$k!$ – factorial k.

And the greater the size of the reserved storage space $\overline{(n_\iota)}$ the lower this probability. Moreover, with a long-term lease of warehouse space in the amount of $\overline{(n_\iota)}$ by price $(s_i\overline{n_\iota)}$ per unit of stored goods, the function $(s_{i(}\overline{n_\iota)})$ usually decreases (as the leased storage space increases, the rental price per unit of space decreases).

However, this decrease is quite slow, and the total amount of rent payments $(s_i(\overline{n_\iota})\overline{n_\iota})$ increases, because if the amount of goods stored in the warehouse is exceeded, the company will be able to provide an additional volume of goods only for a much higher price ($S_{i,}$).

$$S_i > S_i(-1) > S_i(-2) > S_i(-3) \ldots > S_i(-n) \tag{3}$$

In this case, the optimal choice of the level of long-term leased storage space will be determined by minimizing storage costs, i.e. the task of minimizing the following target function: $\overline{(n_\iota)}$

$$S_i e^{-\lambda_i} \sum_{k=\overline{n_\iota}}^{\infty} \frac{\lambda_i^k (k - \overline{n_\iota})}{k!} + s_i(\overline{n_\iota})\overline{n_\iota} \to \min \tag{4}$$

where S_i – price for additional storage;
$s_i(\overline{n_\iota})$ – cost of renting a unit of space.

With such a strategy, the company(s) will be able to provide itself with the required amount of storage space, but will the cost of storing products be minimal is the question.

Results and discussion

leased areas for storage of agricultural products by an agricultural production company (*i*) at different intensity of the flow of applications λi=85, 90 and 95% for its products under the following conditions:

1. the company has a long-term lease of warehouse space (*ni*)=100m², for which it pays (*si*) = 2 USD·m^{-2}
2. if it is necessary to place additional products, the company must pay (*Si*)= 5 USD·m^{-2}

With a normal distribution of demand, the average value will be μ_X = 120 m², and the standard deviation σ_X = 15 m². Accordingly, according to the intensity of the flow of applications: λ_i = 85% ⟶ μ_X = 120×0.85=102 m²; λ = 90% ⟶ μ_X = 120×0.90=108 m²; λ = 95% ⟶ μ_X = 120×0.95=114 m²

Since function (4) has the first term $e^{-\lambda_i}\sum_{k=\overline{n_\iota}}^{\infty}\frac{\lambda_i^k(k-\overline{n_\iota})}{k!}$ corresponds to the extraordinary costs of storing surplus goods subject to complex Poisson processes, and the second , takes into account the standard costs of renting warehouse space is a linear function, for convenience we will calculate them separately from each other. $s_i(\overline{n_\iota})\overline{n_\iota}$ – the cost of storing surplus goods with an intensity of the flow of applications of 85% is calculated for 10 cases with a step of 1% increase in the leased area and are given in Table 1.

Table 1

Extraordinary expenses of the company with an intensity of the flow of applications of 85%

k	$k!-n_i$	λ_i^k	$k!$	S_i	Extraordinary expenses $e^{-\lambda_i}\sum_{k=\overline{n_\iota}}^{\infty}\frac{\lambda_i^k(k-\overline{n_\iota})}{k!}$
100	0	102^{100}	100!	5	0.00
101	1	102^{101}	101!	5	0.05
102	2	102^{102}	102!	5	0.08
103	3	102^{103}	103!	5	0.10
104	4	102^{104}	104!	5	0.11
105	5	102^{105}	105!	5	0.11
106	6	102^{106}	106!	5	0.11
107	7	102^{107}	107!	5	0.10
108	8	102^{108}	108!	5	0.09
109	9	102^{109}	109!	5	0.08
110	10	102^{110}	110!	5	0.07
$\sum$					0.88

Total costs with an intensity of the flow of applications of 85% are equal to $C = 5 \times 0.88 + 200 = 204.4$ USD.

Similarly, we will perform calculations for intensities λ_i 90 and 95 (Fig. 1.)

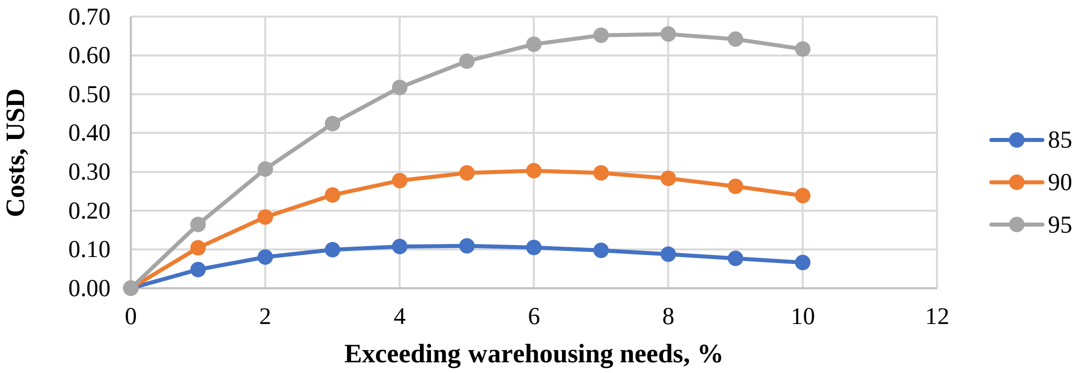

Fig. 1. **Extraordinary costs for storing surplus goods at different intensity of supplies**

And the results of calculating the total costs of an agricultural production company for storage are summarized in Table 2.

Table 2

Storage costs of the company with different intensity of product supplies

Storage costs	**Supply intensity**		
	85	90	95
Extraordinary expenses, USD	0.88	2.49	5.19
Ordinary expenses, USD	200	200	200
Total costs, USD	204.4	212.45	225.95

As can be seen from Table 2, with an intensity of the flow of applications of 85% (and, accordingly, the availability of free warehouse space), the total costs practically correspond to ordinary costs. However, with the increase in the intensity of the flow of applications to 90% and then to 95% (and, accordingly, a decrease in free space), they increase due to extraordinary costs, which, with the intensity of the flow of applications of 95%, reach 2% of ordinary costs. In such a course of events, the company either pays larger amounts for unscheduled storage of products or increases the size of long-term lease of warehouse space, which in turn affects the growth of ordinary costs.

In the case of outsourcing its logistics operations, the company (i) turns to the services of a 3PL-level logistics company, which is able to provide it with appropriate warehouse services with costs lower than those incurred by the company itself. After all, 3PL operators usually work with more than one company and have a larger number of warehouse space. Extraordinary costs for storage services of a 3PL provider are calculated according to expression 5 and are reflected in Table 3.

$$\mathrm{F}(M) = \min S\, e^{-\lambda M} \sum_{k=\bar{0}}^{n} \frac{\lambda_k M^k (k-\bar{n})}{k!\, M} + S(\bar{n})\bar{n} \tag{5}$$

where M – number of warehouses in the 3PL provider

Table 3

Extraordinary expenses of the company for the storage services of a 3PL provider with an intensity of the flow of applications of 95%

M	k	$k! - n_i$	M^k	$k!$	S	**Extraordinary expenses (eq. 5)**
1	100	0	1^{100}	100!	5	0.0000033
2	101	1	2^{101}	101!	5	0.0000025
3	102	2	3^{102}	102!	5	0.00
4	103	3	4^{103}	103!	5	0.00
5	104	4	5^{104}	104!	5	0.00
6	105	5	6^{105}	105!	5	0.00
7	106	6	7^{106}	106!	5	0.00

The results of the calculations show that even at the highest intensity of 95%, with the presence of three warehouses, the 3PL operator's extraordinary costs are reduced to zero, which means that the total cost of storing products, regardless of the intensity of the flow of applications, will be equal only to the usual costs of renting warehouse space. Thus, we can state that even in the absence of additional benefits from using a 3PL provider the fact that a logistics company has the ability to provide services to many companies at the same time allows to achieve significant savings in the costs of these services.

Conclusions

1. The need to rent warehouse space for an unknown amount of goods not only increases the cost of services, but also reduces the size of additional (reserve) warehouse space available on top of the average expected number of goods. In case of a significant excess of the volume of goods, the company is forced to incur additional costs for organization of extraordinary warehousing.

2. The paper considers a mathematical model of organizing joint processing (transportation, storage and distribution) of agricultural products in supply chains through the involvement of 3PL-level logistics operators. With their interaction, optimization of logistics costs occurs due to economies of scale, which is manifested in the possibility of reducing fixed costs through a more complete exploitation of capital resources and in smoothing out the stochastic features of agricultural products.
3. The calculations have shown that the use of the services of a 3PL provider can significantly reduce the volatility of prices for warehousing services and, accordingly, reduce the costs incurred by the company due to insufficient provision of backup warehouses.

Author contributions

Conceptualization, formal analysis and writing – Zagurskiy O., original draft preparation methodology and project administration –Savchenko L., data curation and visualization – Demin O., funding acquisition – Opalko V.

All authors have read and agreed to the published version of the manuscript.

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