The Impact of Cost Allocation on Key Decisions of Supply Chain Participants

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Abstract **- Modern business processes are impossible without a logistics system. Logistics costs constitute the lion's share in the total product cost. The purpose of our research is to study the dependence of decision-making on the level of logistics costs. In order to achieve the goal set, questionnaire, mathematical modeling and analysis methods were used in the study. The main problems of cost management in supply chains were highlighted. In the course of our research, we concluded that a universal solution to the problem can be developed for a limited segment of enterprises, since there is no identical solution to increasing cost efficiency for different types of enterprises. According to the results of the questionnaire, managers' decisions on increasing efficiency are dependent on their subjective desires rather than dictated by the economic efficiency. Sixty-seven per cent of the respondents are ready to reject a profitable project due to risks. The questionnaire also showed that only 4% of the managers are ready to quit an already implemented project if it is ineffective. This begs the question: do all projects prove to be really effective after their implementation? A two-factor mathematical model with a dummy variable showed the dependence of increased logistics costs on the period in which they were implemented. The mathematical model obtained during the study will be useful for predicting and budgeting the level of logistics costs. It can also encourage independent enterprises to build advanced mathematical models.**

Keywords— *decision-making process; logistics; cost management; supply chain management; business.*

1. Introduction

Nowadays, the efficiency of supply chain management depends on how its participants are coordinated. At the moment, there are many approaches to managing and increasing the effectiveness of coordination in logistics services (for example, information systems, work groups, a balanced scorecard, information systems, etc.). However, it should be taken into account that the supply chain management system also includes the cost management subsystem of the supply chain participants, which is the object of our research paper.

Enterprises always seek to evaluate the effectiveness of the logistics chain when it is being created. Despite the importance of logistics services for achieving the goals of the enterprise, there are still no effective ways to objectively evaluate their quality. This can be explained by the following features:

1. Intangible service. It is difficult for service providers to explain and specify the types of service; it is also difficult for customers to evaluate them.
2. Direct involvement of the customer in the production of the service.
3. The service is produced and consumed at the same time. That is, it is not stored or transported.
4. In the process of the service consumption, the customer does not become its owner.
5. The service is an activity. Therefore, it can be evaluated only after the purchase. The above-mentioned characteristics of the "service" are important in the logistics process. It should be noted that the quality of the logistics service can be seen when a service provider and a customer meet. The logistics chain quality in the analysis and design of the logistics system should be measured on the basis of the consumer criteria. When evaluating a logistics service, consumers compare some actual values of the quality "measurement parameters" with the expected values. If these indicators coincide, the quality is considered to be satisfactory [1]-[3].

Performance indicators can be applied to infrastructure logistics units of the logistics system as a whole. For example, a general indicator of warehouse performance can be its daily freight turnover rate. In most foreign logistics practices, performance and productivity are not separated. The "logistic productivity" indicator is

similar to the “resource productivity” indicator adopted in our economy [26]. It characterizes the specific consumption of financial, material, energy and labor resources in relation to the volume or other planned indicators [4]-[7].

Scientists distinguish many problems when considering the subsystem of cost management in supply chains. We believe that the main problems are [8]-[11]:

1. The dual nature of logistics chain costs. Costs should be divided into period costs and investment depending on their economic nature.
2. Proper distribution of costs. The costs by participants depend on many factors, including the thoroughness of analytic accounting of the company. In this regard, there may be a situation when the costs of marketing, logistics and advertising samples are referred to as "distribution costs" with no additional analytics. This minimizes the possibility of analyzing and forecasting logistics chain costs.
3. Logistics chain costs should not exceed the optimal level. Resource prices are constantly growing, but logistics must be economical. Despite any increase in logistics chain management, profitability indicators should remain at a fixed high level.

Ghosh D. and Shah J. [12] investigated the dependence of decision-making by supply chain participants depending on the distribution of costs in the “green” market. The authors reviewed cost-sharing contracts in the context of green supply chains. The purpose of the study was to explain why green supply chain participants enter into contractual cost-sharing mechanisms and provide a deeper understanding of the impact of cost-sharing on the key supply chain decisions.

Lee K. H. [13] studied the role of accounting in environmental management and, in particular, the environmental control approach to regulate carbon emissions as part of supply chain management.

A dynamic stochastic optimization model was offered by Agrawal N. [14]. It determines total order quantity and optimal stock distribution among non-identical stores in each period. A generalized Bayesian inference model is used for the needs that partially correlate between stores and time periods. The author also derives optimal approximation to the last period’s excess stock. This makes it easy to solve the formulation of dynamic programming.

Wanke P. et al. [7] consider the following issues: how much stock should be assigned to orders in the supply chain and where it should be done. The authors emphasize the need to consider the trade-off between cost and level of service. The authors propose a decision support system that uses fuzzy logic for the accounting of stock, transportation costs, short-deliveries and orders. A decision-making system on stock distribution in terms of cost and service levels is proposed in the study.

A lot of research is devoted to supply chain management in a highly specialized industry, taking into account the characteristics of the country. Thus, the authors [15] study the relationship between relational capabilities and the organization of cultural opportunities, which significantly influence supply chain operations. The work [16] is devoted to studying the relationship between supply chains and the agro-industrial cluster, which can increase competitive advantages of stakeholders, who are the key to the survival and development of many businesses and enterprises.

A large number of works [17]-[25] are devoted to the study of risks in the supply chain. Different mathematical approaches were used to address the issue. In our work, we consider “risk” as an economic category and emphasize that cost management in supply chains often depends on the willingness or unwillingness of the company’s management to take the appropriate risks when making management decisions.

The literature analysis showed that there was a lot of research on the topic under consideration. However, it was conducted in highly specialized areas, such as the automotive industry, green technologies, etc. Accordingly, it can be noted that there is no universal approach to managing the distribution of costs between supply chain participants. In our research, we will discuss the existing approaches to cost distribution and analyze its relationship with decision-making in the supply chain.

2. Materials and Methods

2.1. Research design

Our research is based on the questionnaire data. The questionnaire consisted of closed questions with answer options. Since the information on the level of costs is confidential, the answer options to this question were presented by the interval. There were also questions related to the refusal to introduce solutions to increase supply chain cost effectiveness. Such questions could be answered with “yes” or “no”. Based on their results, we compiled a chart of the percentage ratio of various decision-making outcomes.

Based on the interval assessment of the level of supply chain costs, a time series with averaged estimates of the level of costs in thousands of US dollars was constructed. As a result, a mathematical model of supply chain costs for the period 2013-2018 was built.

2.2. Participants

Ten food enterprises with an annual income of more than 500 thousand US dollars were interviewed in order to collect data. When creating a sample of respondents, it was important to choose the enterprises operating in the same industry and having similar income. This ensured that there would not be a striking difference in logistics costs due to a different industry or the scale of the enterprise. Our assumption was confirmed by the data analysis and the enterprises demonstrated a similar level of supply chain costs.

2.3. Intervention

We assume the fact that enterprises could have deliberately provided false answers to keep their commercial confidentiality. In order to obtain the most accurate prognostic model, it would be better to use actual data rather than average indicators of supply chain costs, but the "step value" was 20 thousand US dollars. This means that the statistical error will not be significant when a mathematical model is used for planning.

2.4. Research limitations

To build a "perfect" mathematical model, the risk scores should be calculated. However, to do this, it is necessary to collect additional information on each period of the company's existence (in our research, this is a month; thus, we should perform a risk assessment of each month of work). It is easier to carry out a risk assessment of a year. Since each factor should be evaluated in a six-year period of time to build a model, it is necessary to collect data for 18-25 years for a three- or four-factor model.

3. Results

There is a need to manage supply chains due to common logistics problems of enterprises (Figure 1). The figure below shows the key task of supply chain management. This is the optimal supply chain management aimed at minimizing costs, delivery time of material resources, as well as improving the quality of material resources and service.

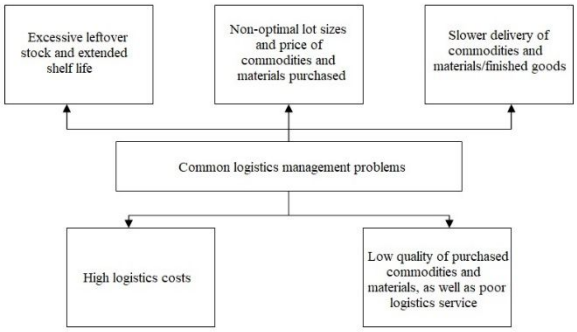

Figure 1. Common problems of the enterprise logistics management

It has already been mentioned that the concepts of "logistics costs" and "investment in logistics" should be separated. On the one hand, supply chain optimization costs reduce profits of the enterprise; but on the other hand, the lack of investment in optimization may result in inefficient operation of the supply chain, which leads to tangible barriers to the efficient performance of the enterprise. The barriers to effective supply chain management can be:

1. Lack of investment in logistics infrastructure.
2. Out-of-date transport and storage infrastructure.
3. Poor development of the logistics services market.
4. Insufficient personnel skill level.
5. Poor informational support.
6. Information policy of companies.

It is obvious that an enterprise can only be assessed qualitatively by the "optimal data" appropriate to each particular case. Therefore, this test is subjective, but it is suitable for an internal audit of the enterprise logistics management: the enterprise can see a difference between its own idea of what "optimal management" is and the "subjective ideal".

In order to quantitatively assess the effectiveness of supply chain management, various absolute and relative cost indicators are used.

There are two approaches used for this purpose: minimization of the total supply chain cost and maximization of its total profit. With either approach to cost optimization, the company pursues the same goal: to increase the "gap" between the income and the costs, that is, to maximize profit. Therefore, it is impossible to say which management method is "right".

However, there is another question: what actions should be taken in order to increase the total profit? Perhaps it is necessary to take a new look at logistics management and switch to outsourcing?

Since the research is devoted to cost management, let us consider the examples of enterprise decisions that directly affect costs. Logistics costs can be optimized by:

1. The shift from self-managed logistics to outsourcing. It is much more profitable for small enterprises to use outsourcing services, since the creation of a logistics system from scratch requires regular investments and current costs, which can negatively affect the cost of the main product/service of the enterprise.
2. The introduction of new automatic systems (which is an investment from the economic perspective rather than expenditure). This can lead to labor costs reduction. However, innovative automatic systems may require more qualified service, which may not reduce, but increase labor costs.
3. Modernization of transport and storage infrastructure. Infrastructure modernization costs are also investments. The efficiency of such projects must be calculated separately using financial indicators. For example, modernization of this kind can have an impact on current costs of maintaining a storage facility.
4. Accounting policy of the enterprise.

It is quite natural that for different enterprises different methods for optimizing logistics chain costs will be relevant. Under different initial conditions, the same optimization method can provide both positive and negative financial results.

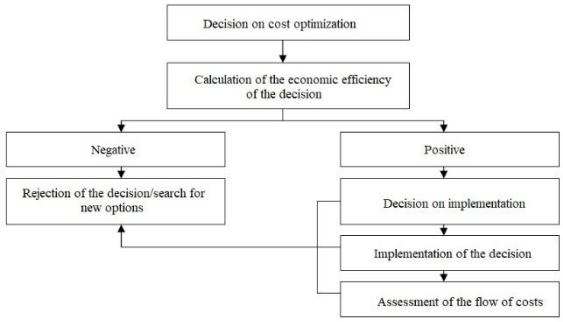

Figure 2. Decision making algorithm for cost optimization

The algorithm clearly shows that obviously disadvantageous decisions will be rejected. But the attention should also be paid to the decisions that are advantageous "on paper". At any stage of the diagram, the decision may prove to be slightly efficient or inefficient at all. Thus, the enterprise management may refuse to implement a decision due to its minor positive impact on the financial result or in favor of another project that may help to better achieve the objectives.

In the second case, the management may reject the decision at the implementation stage if the mid-term assessment of the results showed that there are traps and pitfalls that were not taken into account when writing the project, or there are some unforeseen external or internal factors affecting the final result of cost optimization.

It is also possible that the decision has already been implemented, but according to the additional analysis, it is insufficient/ineffective. In this case, the management returns to the previous activity model.

The performance of the management cannot be considered ineffective if the decisions it made turned out to be unprofitable. It should be noted that performance evaluation is a subjective-qualitative analysis.

Let us consider the management of logistics costs through the enterprise accounting policy. When an accounting system is introduced at an enterprise, an order on the accounting policy is created and adjusted. As a rule, it contains the most complete list of the cost items of the enterprise. However, in practice the analytics of "Distribution costs" is not broken down.

In fact, distribution costs include a large number of costs (Figure 3).

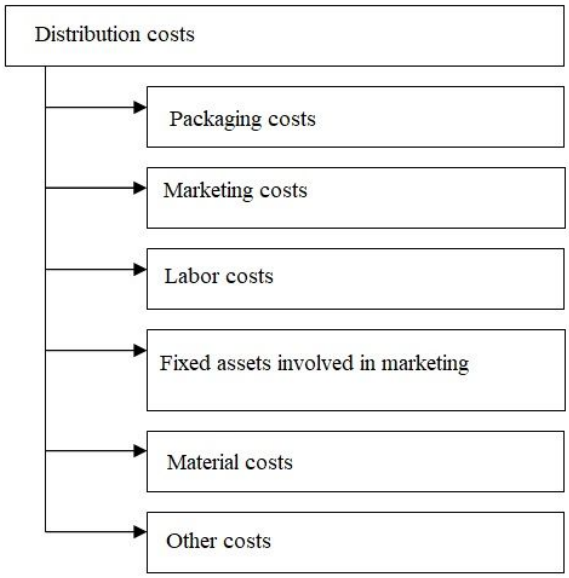

Figure 3. Distribution costs structure

The structure of distribution costs shows that logistics costs may be "hidden" in material costs (costs of maintenance warehouses, machinery, etc.), labor costs and in fixed assets. In order to analyze and reflect logistics costs, it is important to introduce additional analytics, which will show a reliable picture of logistics costs and evaluate their effectiveness according to the subjective criteria of the enterprise.

Let us consider the results of the survey of companies on management decisions on improving the efficiency of supply chain management.

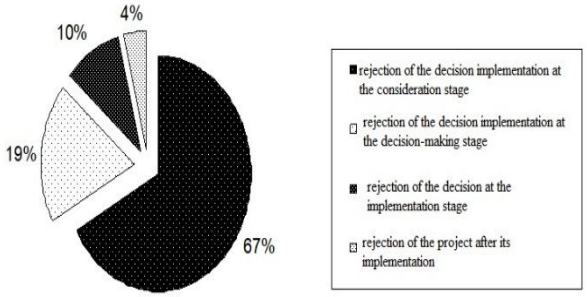

Figure 4. The results of the survey on decision-making on improving the cost-effectiveness of supply chains

According to the survey results, the majority of the enterprises refuse to implement the project at the stage of its consideration and only 4% of the respondents are ready to give up the project if it turns out to be ineffective.

The chart shows that the decisions on improving the efficiency of logistics costs are made and the enterprises are willing to accept all the risks associated with the project. Sixty-seven per cent of the respondents are ready to reject a profitable project because they are not ready to accept all the risks associated with it.

There are also some interesting conclusions about the respondents who are ready to give up the project if it

turns out to be ineffective. What is the percentage of the enterprises that continue to use the implemented "improvements" after they have proved to be inefficient? Unfortunately, the answers to such questions have not been found.

Let us consider the prognostic model of the supply chain costs.

The overall distribution of the supply chain costs is presented in Figure 5.

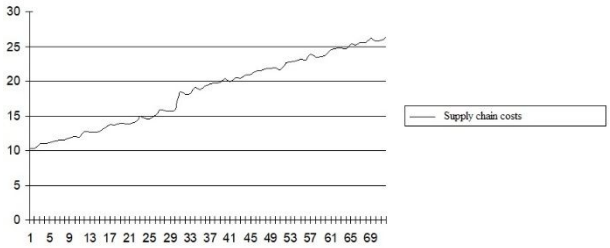

Figure 5. Supply chain costs for the period of 2013-2018

Using the MS Excel LINEST function, we built the usual **1**. As a result, we got a single-factor model of the dependence of supply chain costs on the period (Table 1).

Table 1. The result of the MS Excel LINEST function for a single-factor model

a_1	a_0
0,24052	9,70609
S_1	S_0
0,00331	0,13904
R^2	Se_V
0,98691	0,58376

The table shows that the model has a high correlation coefficient. Let us consider whether the expected value of the supply chain costs coincides with their actual value (Figure 6.)

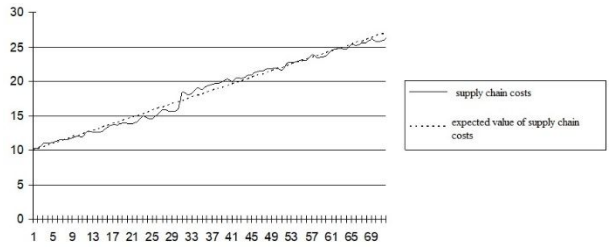

Figure 6. Expected and actual values of supply chain costs for the period of 2013-2018 (single-factor model)

As it can be seen, the expected values are close to the actual ones. However, there was a sharp spike between the 29th and the 33rd period (May-September 2015). As it is not taken into account in our model, we should introduce a dummy variable to consider a slight increase in supply chain costs until May 2015, as well as the spike. The expected value should also be recalculated (Table 2).

Table 2. The result of the MS Excel LINEST function for a two-factor model with a dummy variable.

a_2	a_1	a_0
0,1989638	2,0512763	10,0263
S_2	S_1	S_0
0,0025985	0,1095376	0,0593024
R^2	Se_V	
0,9978485	0,2384078	

The correlation coefficient increase indicates a closer relationship between the indicators of the model; let us check it on the graph (Figure 7).

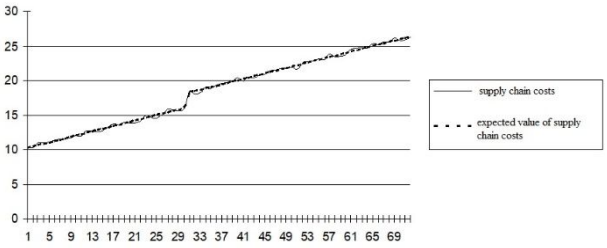

Figure 7. Expected and actual supply chain costs for the period of 2013-2018 (two-factor model with a dummy variable)

As it can be seen, the line graph of expected costs is practically imposed upon the line graph of actual costs. It means this model can be accepted.

Based on the questionnaire results, we concluded that supply chain costs are significantly affected by management decisions, which are highly dependent on the willingness or unwillingness of management to take risks. Unfortunately, we cannot evaluate the desire of companies to take risks. Due to this factor, the model would definitely lose its objectivity and prognostic value.

The model we obtained is:

$$\hat{y} = 10.0263 + 2.051x_1 + 0.1989x_2 \quad (1)$$

where

$\hat{y}$ – expected value of supply chain costs;

x_1 – period (month);

x_2 – dummy variable that takes into account a sharp spike.

In mathematical terms, the costs will certainly go up over time due to constantly growing resource prices; and a_2 is the coefficient by which the costs started to increase after the spike in May-September 2015.

4. Discussion

Having studied cost management in supply chains, we can conclude that enterprises dealing with supply chains, regardless of their activity type and size face similar cost management problems. However, it should be noticed that there is no universal solution to one problem for small and large businesses or food and military industries. It is always necessary to remember a number of key characteristics of different business categories:

1. What is the critical cost for the enterprise? It is not appropriate to offer a large enterprise a cost optimization plan for a small enterprise that will save it $ 500 a month while its monthly cost is estimated at 50 thousand US dollars.
2. How is supply chain management affected by the industry specifics? For example, the difference between the logistics for daily consumer goods and luxury goods, or perishable goods and goods that have no expiration date.

Risk assessment is a very complex issue as it significantly depends on the approach used. There is no common "right" approach to measuring it; and it is not going to be developed due to the fact that risk is a qualitative category . Unfortunately, there is a heterogeneous idea of what exactly supply chain risk is, what information should be collected and how risk management and mitigation can be developed based on this information. Risk factors have already been introduced in other areas and are partially used in supply chain management [18]-[22].

In modern research, scientists often use mathematical modeling. In econometrics textbooks, whole sections are devoted to optimization and logistics problems. Although such tasks are aimed at the optimal distribution of material resources, which are part of the logistics costs, they do not fully reflect them.

Unfortunately, to build a mathematical model that would take into account all the factors influencing the external and internal environment, the enterprises have to provide more information, which is confidential and should not be disclosed [27]. Therefore, one of the goals of our research was to guide analytical departments of the companies. First of all, the integral risk indicator should be calculated for each year of the sample; supply chain costs should be referred to as the total for the year. Due to the fact that the number of factors affecting the performance indicator will increase in the model, it is necessary to increase the number of observation periods. Thus, we concluded that the younger the enterprise is, the fewer factors can be taken into account so that this mathematical model and its parameters remain statistically significant.

5. Conclusion

In our research, we investigated the problems related to cost management in supply chains and concluded that there is no universal solution to similar problems. We also highlighted that for the analysis and accurate study of cost distribution, it is necessary to introduce additional analytics of the "Distribution costs", since they include packaging costs, marketing costs, etc. This problem can easily be solved by programming the automatic programs used in enterprises. According to the questionnaire results, the management of 67% of the surveyed enterprises is not ready to take risks associated with the project implementation, even if it seems effective "on paper". The two-factor mathematical model with a dummy variable indicates that the value of supply chain costs depends on the period of project implementation and their constant growth is accompanied by increasing resource prices. Costs will continue to increase over time due to the structure of the mathematical relationship. The presented mathematical model can be used by enterprises to budget supply chain costs in the future.

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