The European Proceedings of
Social & Behavioural Sciences
EpSBS

Future Academy

ISSN: 2357-1330

https://dx.doi.org/10.15405/epsbs.2019.03.158

GCPMED 2018
International Scientific Conference "Global Challenges and Prospects of the Modern Economic Development"

SOME ASPECTS OF DESIGN PROCESSES OF THE EFFICIENT USE OF MATERIAL RESOURCES

N.V. Makarova (a)*, R.S. Mukovnin (a), N.I. Kraskova (a), S.V. Videneeva (a)
*Corresponding author

(a) Samara State Technical University, ulitsa Molodogvardeyskaya, 244, Samara, 443090, Russia, iv-kos@mail.ru

Abstract

The efficient use of such factors of production as labor and capital leads not only to the savings of material costs of the company, but also generally has a positive impact on production and financial performance. The scientific approach to materials management is based on a logistics approach to the design of optimal values for the efficient use of material resources in supply chains. The logistics approach to materials management is based on the development of logistics strategies and methods that suggest using material resources most efficiently. In this case, the tools of resource logistics, warehouse logistics and transport logistics can be applied. Currently, the economic literature presents many studies on the development of conceptual foundations of logistics, the practice of applying its forms and methods. It should be noted that there is no sufficiently deep development of the issue of materials management in the supply chain for machine-building enterprises. Within the framework of the logistics approach, many models are developed for operational, tactical, and strategic design of the supply chain, while not focusing on the limited use of such models. The study presents the program of research and design of the efficient use of components. The use of the proposed methodology within the framework of this study and the development of logistics strategies for managing material resources of the machine-building enterprise is not possible, therefore only the main methodological provisions presented will be applied.

Keywords: Material resources, logistics, supply chain, procurement management, procurement.

https://dx.doi.org/10.15405/epsbs.2019.03.158
Corresponding Author: N.V. Makarova
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

The efficient use of such factors of production as labor and capital leads not only to the savings of material costs of the company, but also generally has a positive impact on production and financial performance. The scientific approach to materials management is based on the logistics approach to the design of optimal values for the efficient use of material resources in supply chains (Dobos, Gobsch, Pakhomova, Pishchulov, & Richter, 2013; González-R, Framinan, & Ruiz-Usano, 2013; Bode & Wagner, 2015). The logistics approach to materials management is based on the development of logistics strategies and methods that allow using materials resources mostly efficiently. In this case, the tools of resource logistics, warehouse logistics and transport logistics can be applied.

2. Problem Statement

Currently, the economic literature presents many studies on the development of conceptual foundations of logistics, the practice of applying its forms and methods. It should be noted that there is no sufficiently deep development of the issue of materials management in the supply chain for machine-building enterprises (Korol, 2008; Grzybowska & Kovacs, 2014; Dybskaya & Sergeev, 2018). Within the framework of the logistics approach, many models are developed for operational, tactical, and strategic design of the supply chain, while not focusing on the limited use of such models (Shokin & Sosunova, 2007; Makarova & Sosunova, 2010).

An important problem leading to such a passive use of the model development process is the wrong choice of the method and means that solve the problems of materials optimization. As a rule, the optimization of supply chains does not have an analytical solution in the form of a specific formula, which is why the choice of software for a practical solution seems to be the most relevant (Toluev, 2016). Materials management of the enterprise is a focused activity that rationalizes and optimizes the values of materials in terms of assortment, quality, quantity, time, and place. The process of materials management can be represented by three provisions. The first provision is due to the nature of commodity-money relations. Any process of sale of goods is associated with a change of ownership and transfer of rights to a particular product or service (Wagner & Bode, 2008; Chin, Tat, & Sulaiman, 2015; Lukinsky & Chirukhin, 2017). The second provision is connected with the necessity of moving the acquired good through the channels of commodity circulation. This is due to a time interval between the date of production of the product and its sale on the market. Materials management functions, which are performed in this case, are mainly focused on the determination of specific values of materials. The third provision is to organize materials management processes at the enterprise.

In the management process, the planned materials should be studied not only in terms of assortment, quality, quantity, time and place. It is important to evaluate them by such values as the efficiency of receiving and transporting resources, the availability of service, the price per unit, taking into account the costs of acquisition, etc. A modern scientific approach to materials management of the enterprise, the structuring of materials management functions and their interrelations are their formalization based on a process approach, within which the software products of visual modeling of relevant business processes and their management functions can be used.

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3. Research Questions

Based on the existing problems in optimizing the efficient use of material resources in supply chains, the following issues will be solved:

- Analysis of research methods and design of the efficient use of material resources;
- Drawing up a program for research and design of supplies and the efficient use of material resources for automotive components of the automaker.

4. Purpose of the Study

The purposes of the study are the following:

- Analyse design methods for the efficient use of stocks;
- Develop a research and design program for the supply of material resources.

5. Research Methods

5.1.Analysis of resource efficiency

The research program must include an analysis of the efficient use of automotive components. In this subsection, performance indicators of material intensity of production and the share of material costs in the cost of commercial products are determined. The purpose of the analysis is to calculate the chain and basic growth rates of these indicators.

When consuming material resources by production, they are transformed into material costs, therefore the level of material costs or their share are the main characteristics of their efficient use. The theoretical provisions concerning the evaluation of performance indicators can be formulated as follows:

First, the material intensity of production for the efficient functioning of the enterprise should tend to decrease, which is due to resource saving measures, as well as an increase in the value added in the price of finished products. Secondly, the proportion of material costs in the cost of marketable products may remain unchanged and even increase slightly, due to the action of multidirectional factors. Thus, the growth of labor productivity leads to the replacement of living labor with materialized, and an increase in the proportion of components causes an increase in material costs. These factors determine an increase in the share of material costs in the cost of commercial products of the enterprise. These factors are opposed by the enterprise's activity to save material resources.

The performance of these factors is significantly affected by asynchronous changes in prices of finished products and purchased material resources. The analysis also reveals a trend and provides a comparative evaluation of changes in indicators of the efficient use of material resources, in general, and components, in particular, according to the inter-sectoral balance methodology based on economic, mathematical and graphical modeling of their performance.

It is possible to determine the production efficiency on the basis of inter-branch balance, the main equation of which establishes the relationship between the final and gross product:

$$X = [E - A]^{-1} * Y$$

where X - a column vector of gross products;

Y – a column vector of final products;

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$[E - A]^{-1}$ - a matrix of full costs.

The ratio of final and gross products shows the efficiency of material costs. The larger this ratio, the less gross products are spent on the production of final products. When evaluating the efficiency by this indicator the following circumstances should be taken into account. Firstly, for different economic sectors there is a ratio of final and gross products, which excludes their comparison by this indicator. Secondly, the efficiency of material costs characterizes not only the value of the indicator, but also its performance.

The direct application of the inter-sectoral balance model in evaluating the efficiency is impractical, which is explained by the incomplete set of the inter-sectoral relationships presented.

Methods for identifying the main trends are divided into two main types. The first type is based on identifying individual trend points with the help of groups of neighboring (previous and subsequent) points. This method is known as “mechanical smoothing” in statistical literature. This may include smoothing a number of performance indicators by increasing an interval and using a moving average (simple and weighted).

Another method is based on the assumption that the considered series of performance indicators has some regularity that can be detected by a curve drawn through specific points of this series. This method is called “analytical alignment”. Its essence is in obtaining, using the least squares method, evaluating the deterministic component of performance indicators.

5.2.Economic and mathematical modelling of factors

The next stage in methodological provisions of research and design of supply and efficient use of components is economic and mathematical modeling of factors affecting the efficient use of components: changes in the share of their own production, labor productivity, transport costs in the cost of production, the coefficient of price advance, as well as the evaluation of absolute and relative elasticity of the efficient use of components from the influencing factors.

Theoretical studies, conducted by the authors, allow suggesting a method of multivariate analysis of the cost of components per unit of finished product (capacity).

The method includes the selection of factors based on qualitative analysis, an analytical relationship between the resultant and each factor, determining correlation coefficients, eliminating factors due to multicollinearity, developing a multiple regression model and checking its adequacy, evaluating the absolute and relative elasticity of the profit-and-lost factor from changed factors.

5.3.Economic and mathematical forecasting of resource efficiency

The final stage of the analysis of the efficient use of components is the economic and mathematical forecasting of the efficient use of components, the selection and comparison of forecasting methods, the evaluation of the reliability of the forecast and the determination of its confidence intervals.

The basis of any forecasting method is the idea of extrapolation - the extension of the series beyond the studied periods. Each extrapolation is necessarily based on the assumption that the pattern of development found within the dynamic series is preserved outside this series in further development, i.e. based on the inertia of economic phenomena. Therefore, any prediction should be preceded by a thorough

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study of the time series, which would allow determining the trend of changes in this economic phenomenon. Since the trend of the series, as a rule, is subject to some change, and the data obtained by extrapolation are probabilistic in nature.

The simplest method for predicting one series of dynamics is the use of the average characteristics of this series: the average absolute increase and the average growth rate.

The forecast of the analytical trend has one major drawback, which leads to large errors in this method of forecasting. In this case only the deterministic component of the dynamic series is predicted and the random component is not taken into account. To avoid this error and make the forecast more accurate, it is necessary to find the pattern of change over time of the random component. To do this, it is customary to find deviations from the trend and determine the pattern of their change over time. Then the forecast of the random component is made. The results of both forecasts are combined.

In general, the analysis of the efficient use of components is carried out according to the following source data and design indicators of the material intensity of commercial products and its capacity:

- Commercial products;
- Cost of commercial products;
- Material costs (without depreciation),

including:

- Cost of purchased components in material costs;
- Cost of components of own production;
- Average number of workers;
- Average cost of the active part of production assets;
- Cost of components (for 1 car on the model with the highest sales).

5.4.Evaluation of business performance

Methodical provisions of this subsection of the program include:

- Analyze the efficient procurement and warehouse business processes of the enterprise;
- Determine performance values for ensuring the production of components, evaluation of their impact on the material intensity of products, material levels, costs of logistics;
- Select the method of economic and mathematical modelling of performance value impact of providing components on indicators of commercial activity (neural network model, DEA method, analysis of variance, etc.), evaluation of their significant influence.

The system of direct and indirect indicators of business performance:

1. Values of efficient logistics:

- Steady supply of material and technical resources;
- Quality of supplied products;
- Supply set of material and technical resources;
- Timely payment of received products;
- Product availability for industrial consumption.

2. Indicators of business performance:

- Duration of the turnover of stocks;

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- Material intensity of products;
- Costs of logistics.

3. Production figures:

- Production time per unit of production;
- Level of unfinished production;
- Costs of production.

4. Indicators of production and business performance:

- Profit of the enterprise;
- Profitability of production.

The next step in evaluating business performance is the study of stocks of components, their compliance with the concepts of "just in time" and "exactly in sequence." The used norm setting methods of reserve stocks of components (1-2 product groups), and the mathematical and statistical characteristics of random variables (the statistical law) are analyzed.

The study of reserve stocks is carried out according to the extended method based on the following data over time:

a) Stocks (without household inventory) for the first day of the quarter;

including:

- Purchased components, of which:
- Wiring in the assembly of the same type (for the largest purchases);
- Batteries of the same type (for the largest purchases).

b) Area of the warehouse, taking into account the areas for the wiring in the assembly of the selected type.

c) Area of the warehouse, taking into account the areas for batteries of the selected type.

d) Initial cost and storage area of the wiring in the assembly of all kinds.

e) Initial cost and storage area of all types of batteries.

e) Storage costs for the wiring in the assembly of all types in the warehouse and areas of the wiring (without depreciation).

g) Storage costs for all types of batteries in the warehouse and areas of batteries (without depreciation).

In the analysis of the methods used, the statistical law of random variables is of particular importance.

The sequence of "just in time" design includes the following steps and corresponding calculations:

- The duration of the logistics cycle with a given confidence level is determined. From a practical point of view, in designing of the "just in time" system, it is not the overall logistics cycle that matters, all its components are unknown to the consumer, but the period for delivery of components, and even more precisely, the deviation of the actual delivery intervals from those agreed delivery plans with the supplier. However, it is impossible to talk about the presence of any statistical law by the type of dependence of the statistical frequency of a random variable on its values. A more reasonable evaluation is given by the mathematical testing according to Pearson criterion;

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- Mathematical-statistical values of deviations of the actual supply of components from the planned one are calculated: the average value of deviations and the standard deviation;
- Total duration of deliveries of components on the "just in time" system on condition of daily delivery is established;
- Strategy of matching the intervals of delivery of components with a calendar schedule of production is determined.

The final stage of the evaluation is the analysis of channels, schemes and distribution of components, the development of a scheme for the existing distribution of components, the definition of information interrelations of procurement and storage business processes, information technologies used.

In this regard, a methodology for analyzing and optimizing the transport of components based on the following source data has been developed:

Transport costs for the delivery of material resources (both paid separately and included in the prices by the supplier):

- Transport costs for the delivery of components, of which:
- Transport costs for the delivery of the wiring in the assembly of one type of car / railway (specify the type of transport);
- Transport costs for the delivery of batteries of one type by car / railway (specify the type of transport).

The average volume of the delivery lot of the wiring in the assembly.

The amount of markups and discounts from the purchase price of the wiring in the assembly provided by the supplier (indicate all discounts and markups):

- Delivery lot;
- Discount;
- Markup.

The amount of markups and discounts from the purchase price of the wiring in the assembly provided by the carrier:

- Delivery lot;
- Discount;
- Markup.

The average volume of the delivery lot of batteries.

The amount of markups and discounts from the purchase price of batteries provided by the supplier (indicate all discounts and markups):

- Delivery lot;
- Discount;
- Markup.

The amount of markups and discounts from the purchase price of batteries provided by the carrier:

- Delivery lot;
- Discount;
- Markup.

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5.5.Goal setting for logistics of components

Determine possible logistics strategies with respect to components by the objects of management: supply, location, stocks, transportation, information.

The methodological provisions of this subsection of the program imply the development of mapping goals.

The strategic goals of the company are distributed in five areas: financial goals, goals for customers, goals of internal business processes, goals of training and development, logistics goals. For example, typical logistics goals might be:

- Optimization of logistics processes in terms of cost / income;
- Reduction of total costs;
- Improving the quality of supply;
- Reduction of stocks in warehouses;
- Increased supply flexibility;
- Service improvement, etc.

5.6.Development of methods for the selection of logistics strategies

Analyze and evaluate the feasibility of the strategy on reduction in stocks of components based on their deliveries in the “just in time” system. Present the preliminary expert evaluation of its economic efficiency.

In this subsection of methodological provisions of the program, the most responsible is the evaluation of the economic efficiency of the supply of components according to the “just in time” system. The theoretical studies established the following factors and sources of economic efficiency of “just in time” deliveries:

- Improve the accuracy and timely planning and operational regulation of the logistics of production due to the redistribution (transfer) of a significant part of control actions from the external to the internal environment, which is more defined, structured and determined. This indirect effect of “just in time” deliveries leads to a reduction in transport costs for maintaining and regulating economic relations with suppliers of material resources. As a result, the cost of production is reduced, which can be calculated as the product of cost, share of transaction costs in cost and share of their reduction.
- Increase the accuracy of planning the volumes of material resources purchased from suppliers. This kind of indirect economic effect leads to more reasonable calculations of stocks and a decrease in their normative part.
- Reduce the storage area of material resources in proportion to the reduction in stocks, respectively, the reduction in capital costs.
- Reduce the time of production of a unit of production due to the reduced production and commercial cycle. Cost savings for this source is formed by reducing the business cycle due to the reduction in stocks of material resources in days of storing.

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5.7.Feasibility of outsourcing

The feasibility of the outsourcing logistics strategy of procurement and warehouse business processes for 1-2 commodity groups of components is analyzed and evaluated. The preliminary expert evaluation of the economic efficiency of outsourcing logistics is needed.

5.8.Supply of components

Compare the "just in time" system and traditional materials management. Present the features of its use in the supply of components. Formalize the logistics cycle to ensure the production of components.

Present the stages of designing the delivery of "just in time" components. Determine the duration of the logistics cycle with a given confidence level. Establish the statistical law of deviations from the agreed interval of the supply of components. Calculate the mathematical-statistical features of "just in time" delivery. Determine the total duration of the supply of components.

Evaluate the efficiency of the supply of "just in time" components. Determine the factors and sources of the economic efficiency: improving the accuracy and timely planning of the supply of components, reducing current and insurance stocks, reducing storage space, etc.

5.9.Making decisions on outsourcing production

Consider the state and development of outsourcing components; logistics indicators of components (number of types, distance to the warehouse, number of floor equipment, number of assembly lines per day, area of the warehouse, etc.). Select and rank components for outsourcing production by economic and mathematical methods.

Consider advantages and disadvantages of outsourcing production of components based on the industrial park and terminal complexes. Evaluate and compare the options for the interaction of the logistics chain, including the industrial park and receiving and unloading terminals.

The methodology for evaluating the feasibility of industrial outsourcing of components is based on the baseline indicators presented in Table 01.

Table 01. Characteristics of components of own production

Name	Number of types	Distance to the warehouse	Number of floor equipment	Number of assembly lines per day	Area of the warehouse, m^2	Number of warehouses	Stock ratio in the warehouse, days	Number of platforms with inclined movement	Load ratio of platforms with inclined movement
	Assembly line	Assembly line	Assembly line	Assembly line					
	1, 2 and so on	1, 2 and so on	1, 2 and so on	1, 2 and so on					

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Decision on outsourcing production of components is based on the evaluated strategic feasibility of the economic efficiency. The impact of the development of industrial outsourcing on the logistics of the automotive industry is analyzed.

5.10. Making decisions on logistics outsourcing

Consider the main development pathways for relations with suppliers of logistics services, the basic functions of logistics companies for the supply of components (accumulation and concentration of wholesale supplies of components, their fragmentation into small wholesale deliveries, assembly of structural modules, the formation of their cargo units, etc.).

Consider the evaluation and selection of options for the development (investment) of logistics companies for the supply of components. Justify the location of logistics companies. Choose the carriers of cargo units of constructive modules based on economic and mathematical methods.

The method for evaluating the feasibility of industrial outsourcing of components is based on the baseline indicators presented in Table 02.

Table 02. Indicators to calculate the feasibility of industrial outsourcing components

Name of components of own production	Volume of production, thousand units / month	Production cost (without depreciation), mln. rubles / month	Production stocks of materials for components on the first day of the month, mln. rubles	Stock of the work in progress on the first day of the month, mln. rub.	Fixed assets associated with the content of materials and production of components for the first day of the month, mln. rub.	Average purchasing price of components or their analogues on the market, thousand rubles / units

The evaluation of production outsourcing efficiency is based on the method developed by the authors, which as a criterion of the efficient application involves the comparison of the enterprise's reduced costs for the options of their own production and production by the outsourcing manufacturer.

Set goals and develop the economic-mathematical model optimizing the logistics chain: a logistics operator — a carrier of components — an assembly company. Evaluate the economic efficiency of the logistics chain. Goal setting is carried out in the following sequence:

- Regression dependence of the quarterly income of a wholesale intermediary company, derived from component supplies from the volume of a one-time delivery lot (q), is determined as follows:

$$D = \frac{a}{q^b}$$

The basis for the change in gross revenues is the variation in the markup of a wholesale intermediary company depending on the change in the volume of a delivery lot.

Reducing the volume of a delivery lot increases the distribution costs of the wholesale intermediary company for one set of components and requires an increase in the markup. An increase in

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the volume of a delivery lot leads to a decrease in distribution costs for one set of components and requires a decrease in the margin.

- Revenues of the motor transport company (T), which transports components as agreed, are also its reduced costs. Their analytical dependence on the volume of a one-time delivery lot of components is expressed by the following regression equation:

$T=a/q^b$

- For the conditions of acceptance, storage and delivery of components, the regression dependence of the quarterly current costs of the enterprise (Cx) on the volume of their delivery lot:

$C_x=a*q - b*q^c$

- Analytical dependence of the reduced costs of the enterprise related to the immobilized working capital in stocks, taking into account the quarterly amount of bank interest, on the volume of a delivery lot of electrical equipment (Cc):

$C_c= a*q + b*q^c + d*q^k$

- One-time investments in fixed assets for the warehouse and administrative purposes of the enterprise (Cк) depend linearly and proportionally on the size of the production stock of components:

$C_k= a*q$

Thus, the total value of the total reduced costs (C) is the sum of the following components:

$C = D + T + C_x + C_c + C_к \rightarrow \min$

Differentiated costs in terms of the volume of the supply of components allow determining their optimal value, as well as the optimal value of the markup of the wholesale intermediary company (provider of logistics services) and tariffs of the motor transport enterprise.

6. Findings

The program of research and design includes the following sections and subsections:

1. Study the efficiency ensuring the production of components.

1.1. Analyze the efficient use of components

1.2. Evaluate business performance to ensure automotive production of components.

2. Select logistics strategies to improve the efficiency ensuring the production of components.

2.1. Set logistics goals of stockpiling and warehouse business processes of components, their alignment with corporate, functional goals, mapping goals.

2.2 Develop methods for the selection of logistics strategies in relation to components according to the most complete implementation of the goals set: expert evaluation methods, economic and mathematical, structural and functional methods, etc. Select and rank logistics strategies and measures ensuring their implementation.

2.3. Analyze and evaluate the feasibility of the strategy implementation of outsourcing production based on the expansion of the production of components by third parties. Carry out preliminary expert evaluation of the economic efficiency of outsourcing production.

3. Develop logistics systems for providing automotive production of components.

3.1. Develop methods for the supply of “just in time” components.

3.2. Develop methodology for making decisions on outsourcing production of components.

3.3. Develop methodology for making decisions on outsourcing logistics of components.

4. Evaluate the economic efficiency of the developed logistics strategies and measures implementing them on the basis of changes in the indicators of material intensity and reserve capacity of commercial products, as well as indicators of the indirect effect of resource saving.

7. Conclusion

Thus, the use of the proposed methodology within the framework of this research and the development of logistics strategies for managing material resources of the automaker is not possible, therefore only the main methodological provisions presented will be applied.

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