УДК 330.46

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APPLICATION OF MATHEMATICAL METHODS AND MODELS IN MODERN LOGISTICS

Logistics as a science and practical activity allow wide use of mathematical devices for making optimal logistics decisions at the strategic, tactical and operational levels in relatively separate logistics operations, functions, and groups of them and logistics systems. Evolution of logistic concepts, logistics innovation into the practice of enterprises, the current challenges and prospects in the field of logistics management − all this requires the formation and development of adequate mathematical software, which will be able to create a reliable basis for making informed logistics decisions.

The attention towards the use of mathematical models to optimize supply chain has been increasing, mainly because of their lower cost and greater capability. In supply chain management the use of mathematical modeling is not specific to any particular level; those can be used at any level, considering the factors like transportation routing, distribution networks, or warehouse operations. Mathematical modeling approaches that are usually considered in logistic problems include linear programming, mixed-integer/integer linear programming, nonlinear programming, multiobjective programming, fuzzy mathematical programming, stochastic programming, heuristics algorithms, and metaheuristics and hybrid models.

A significant contribution to the development of the mathematical device of modern logistics was made by domestic and foreign scientists [1-7], who have used specific mathematical methods to solve practical problems of logistics management; V. Lukinsky has dedicated his work to the systematization of mathematical methods and models in accordance with the spheres of their application [1]. However, the development of the applied mathematical devices, which occurs with the development of logistics as a science and practical activity, remains not enough investigated and requires further study.

The aim of the study is to analyze the use of mathematical methods and models in modern logistics and identification of the most applied and advanced mathematical models for making effective logistics solutions.

The choice of mathematical devices for the decision making process in the logistics management sphere typically depends on the stated objectives and research methods, among which the scientists [6] allocated:

statistical methods;

methods of mathematical economy and econometrics;

methods of operations research;

methods of economic cybernetics;

expert methods;

method fuzzy sets and fuzzy logic [2-6].

Analysis of professional literature on logistics demonstrates the shift to the priorities regarding the choice of scientists mathematical devices for the solution of logistics tasks from quantitative to qualitative methods. The most applicable methods according to the results of the analysis are heuristic methods, fuzzy sets and fuzzy logic and their combination. A characteristic feature of modern scientific research in logistics is the use of complex hybrid models that are most suitable for the conditions of uncertainty of the macro - and micrologistical environment.

The analysis of the literature of the mathematical devices application for the scientific decision making processes in the field of logistics shows the most common mathematical methods used by scientists [1,5], which are: Multiple-criteria decision-making method (MCDM) or multiple-criteria decision analysis method (MCDA), which are most commonly used in supply chain management (the evaluation and selection of suppliers; management of the green supply chains; the evaluation of the failure effects in uncertain environment). Among these methods the most common are:

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS);

Analytic hierarchy process (AHP);

Weighted Aggregated Sum Product Assessment (WASPAS) method;

VIKOR (Multi-criteria Optimization and Compromise Solution);

Best Worst Method (BWM);

Nonstructural Fuzzy Decision Support System (NSFDSS);

Combinative Distance-based Assessment (CODAS);

Rough Step-Wise Weight Assessment Ratio Analysis Method (R-SWARA), which has received wide application in logistics, especially in transport logistics (estimating an airlines);

Full Consistency Method (FUCOM), a new model for determining weight coefficients of criteria in MCDM models. It is widely used for the study of transport logistics problems (assessing road and rail level crossing; estimating an airlines; the optimal route criteria for the transport of hazardous materials; the ranking dangerous road sections; for selecting automatically guided vehicles), for the evaluation the activities of service companies (process of measuring the quality of express post services), to make decisions in the field of warehouse logistics (to evaluate an adequate forklift) in the city logistics (to decide on the most appropriate location for a bridge), in the supply chain management (the evaluation and selection of suppliers);

Fuzzy Techniques for Decision Making are applied in the field of supply chain management (evaluating and analyzing interactions among criteria, developing supplier selection criteria, rank and select best Logistics Service Provider (LSPs);

Simple Additive Weighting (SAW), Analytic Hierarchy Process (AHP), fuzzy conjuctive/disjunctive methods, fuzzy outranking methods and max-min methods are used to evaluate the weight of criteria during selecting a vehicle type, localization of the logistics center, choosing the optimal service strategy.

Many scientists apply sophisticated combined mathematical methods, which unite different MCDM methods, or combine them with other groups of methods, the main ones being [1-5]:

AHP method, which is used by scientists in combination with the new multi-criteria method – the MABAC (Multi-Attributive Border Approximation area Comparisonfor research in the field of information logistics (evaluating web pages);

MCDM methods with Fuzzy, Pareto analysis with the AHP method which are used to evaluate, rank and select best LSPs;

AHP-VIKOR, DEMATEL (Decision-Making TRAIL And Evaluation Laboratory) and TOPSIS methods integrated with Fuzzy logics are used for the evaluation and selection of suppliers;

Fuzzy DEMATEL is used for the evaluation and analyzing interactions among criteria, developing supplier selection criteria, rank and select best LSPs [5].

The methods described above almost all refer to multicriteria methods, among which are models of multi-attribute decision making and multi-objective decision and as deterministic, stochastic or fuzzy models that use different mathematical algorithms [5].

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Recently, analytical models have become widespread. A feature of analytical models is that the laws of the structure and behavior of the modeling object are described in an acceptable form by precise analytical relationships. These relations can be obtained both theoretically and experimentally. The theoretical approach is applicable only to simple components and systems that allow strong simplification and a high degree of abstraction. In addition, it is difficult to verify the adequacy of the obtained analytical description, since the behavior of the simulated object is not determined, but just needs to be clarified as a result of modeling. To determine this behavior, this analytical description is compiled. An analytical description can also be determined by conducting experiments on the studied object. A more universal approach is imitation model.

Imitation models belong to the class of descriptive models. However, machine imitation is not limited to the development of only one version of the model and its one-time operation on computers. As a rule, the model is modified and adjusted: the source data is varied, different rules of action of objects are analyzed. Model tests are performed in such a way as to test and compare different structural variants of logistics systems. The simulation is completed by checking the results obtained and issuing recommendations for practical implementation.

Simulation models are widely used to predict the behavior of logistics systems, to design and deploy businesses, to train and train staff and so on.

Therefore, it should be noted that the structure of mathematical devices in logistics are dominated by the latest methods of operations research - methods of multicriteria optimization, which in combination with the methods of fuzzy logic, form complex powerful models can provide the effective solution of the scientific problems in uncertainty. The above methods are not an exhaustive list, but point to a clear tendency to adapt the mathematical devices to the need of the modern environment conditions (dynamic conditions of logistics systems and supply chains). The more detailed structuring of the mathematical devices in the logistics field can be seen as a direction for further scientific research.

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