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Original scientific paper

EVALUATION OF LOGISTIC FLOWS IN GREEN SUPPLY CHAINS BASED ON THE COMBINED DEMATEL-ANP METHOD

Nikita Osintsev[1], Aleksandr Rakhmangulov[1], Vera Baginova[2]

[1]Nosov Magnitogorsk State Technical University, Magnitogorsk, Russia
[2]Russian University of Transport, Moscow, Russia

Abstract. *Supply chains and transport corridors have a significant impact on the socio-economic and environmental situation in the regions where the elements of the logistics infrastructure are located. The achievement of the goals of the concept of sustainable development in these regions is ensured, among other things, as a result of the formation of green supply chain management (GSCM), that is, as a result of changes in existing approaches to supply chain management. Analysis of the practice of supply chain management showed a wide variety of parameters and indicators of logistics flows used in decision-making at different stages of managing these flows. The authors propose a universal system of the logistic flows parameters and indicators for the GSCM, corresponding to the principles of the concept of sustainable development. A methodology for ranking indicators of logistics flows based on a combined DEMATEL-ANP method has been developed. The results of a case study on the evaluation of logistics flows for the GSCM are presented. The ranks of logistics flow indicators obtained in the study are proposed to be used in GSCM to adjust of the logistics flows actual parameters to achieve the goals of the concept of sustainable development.*

Key words: *Green Supply Chains, Logistic Flows, MCDM, DEMATEL, ANP, Sustainable Development, GSCM*

1. INTRODUCTION

Supply chains, transport and logistics systems have become the determining factors in the development of the global economic system. Companies around the world are striving to build sustainable supply chains that deliver products to market more efficiently and more environmentally than their competitors.

The volume of trade flows in the world economic system since 2000 shows a positive trend [1]. The expansion of the global market for logistics services since 2016 is 3.48% and, according to estimates [2], by 2022 it will amount to about 12.25 trillion US dollars.

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Corresponding author: Aleksandr Rakhmangulov,
Nosov Magnitogorsk State Technical University,Lenin Street, 38, 455000 Magnitogorsk, Russia
E-mail: ran@magtu.ru

The requirements for reliability, environmental friendliness, and social responsibility of organizations - elements of supply chains are constantly growing [3]. In such conditions, the authors were motivated by the need to improve the existing Supply Chain Management (SCM) methods [4, 5] for assessing logistics flows to select green technologies and ensure sustainable development of supply chains.

Sustainable development of supply chains requires the use of methods for making management decisions to change the parameters of logistics flows based on the measurement and evaluation of their indicators. The complexity of green supply chain management (GSCM) stems from the lack of research on the relationship between various parameters and indicators of logistics flows [6]. Moreover, there is no comprehensive approach to evaluating these parameters and indicators [7] against the background of an increase in the number of criteria and alternatives due to the need to achieve sustainable development goals [8].

Multi-criteria decision-making methods (MCDM) are an effective tool for solving these problems. The scientific area for improving MCDM is actively developing currently. A literature review [9] showed an increase in the number of MCDM-related publications over the past ten years. MCDMs are actively used to solve various problems in the field of climate change [10], sustainable engineering [9], green logistics [11], GSCM [12, 13], reverse logistics [14]. However, the selection of the appropriate MCDM method for a specific situation requires additional research [15]. The most used MCDMs are AHP, ANP, DEMATEL, TOPSIS, ELECTRI, PROMRETHEE, and combinations of these methods.

The lack of a comprehensive and systematic evaluation of all types of logistics flows, as well as the relationship between indicators and parameters of flows from the point of view of the concept of sustainable development, is the main drawback of most of the existing GSCM methods and models [6].

This study aims to develop a methodology for evaluating logistics flows for systemic supply chains management in accordance with the goals of the concept of sustainable development.

The main contribution of this study is a new universal system of parameters and indicators of logistics flows in green supply chains. A feature of the proposed system is the ability to comprehensively assess all logistics flows for compliance with aspects of the concept of sustainable development and the quality of green supply chain management.

The combined DEMATEL-ANP method used in the study considers the relationship between parameters and indicators of logistics flows. The authors hypothesize that this approach contributes to improving the quality of managerial decision-making to adjust the actual parameters of logistics flows in accordance with the goals of the concept of sustainable development.

The remainder of this paper is organized as follows. Section 2 contains a literature review of research of the GSCM based on the evaluation of the logistics flows parameters and indicators using the DEMATEL and ANP methods. Section 3 presents the original system of parameters and indicators of logistics flows in the GSCM, as well as the methodology and algorithm of the hybrid DEMATEL-ANP. Section 4 contains the results of a case study on the application of the hybrid DEMATEL-ANP method to evaluate flows in green supply chains. In the conclusion, the main results of the study are presented, and the directions of its development are discussed.

2. Literature Review

2.1. Evaluation of logistic flows

The complexity of decision-making in GSCM is associated with insufficient knowledge of the system of indicators and parameters of logistics flows. Moreover, there are practically no methods of comprehensive evaluation of green supply chains for compliance with the principles of the concept of sustainable development [7]. The system of logistics flows is an object of management in supply chains and includes material (product) flows, information flows, financial flows, and value (services) flows. [16] Currently, a universal system of parameters and indicators of logistics flows is not presented in scientific publications. However, this system is necessary to evaluate the compliance of supply chains with the goals of the concept of sustainable development.

Different researchers suggest using a variety of sets and systems of parameters and indicators for all or for specific logistics flows. Transport mass, transport route and transport time are the main indicators of material flow in the SCM according to [17, 18]. Additional parameters include the flow map (set of points, path, length), flow speed and time, flow intensity [19]. Tyapukhin and coworkers proposed four groups of the logistics flows parameters: quantity, quality, costs, and time [20]. The authors [19] combine the logistics flows parameters into two groups. The first group includes physical parameters that reflect the spatio-temporal properties of logistic flows. The second group unites the statistical parameters that characterize the patterns of change in physical parameters. Kozlov proposed to evaluate logistics flows using their average values and the indicator of their disorganization [21]. The vector (direction of movement) and scalar (number of resources) values of logistic flows are studied in [22]. Material use indicators and beneficial output indicators are proposed in [23]. These indicators can be used to calculate various material productivity or material intensity indicators. The relationships between the quantitative parameters of flows and stocks in SCM are established in [24], and in [25] – the relations between the parameters of various logistics flows. Turki and coworkers proposed a discrete flow model for optimizing the closed-loop supply chain based on the criterion of minimum total costs. The model optimizes capacities of manufacturing stock, purchasing warehouse and the vehicle, the value of returned used end-of-life products [26].

Several researchers have focused on examining specific logistics flows. For example, material flow theory principles applied to logistics and SCM in the context of sustainable development are used in [27, 28]. It is shown that material flow management should be carried out considering the development of a particular country (region). “Owner”, “region”, “time”, as well as “flow rate”, “flow chart”, “flow direction”, “flow capacity” are proposed to be used as the main attributes of material flows [28]. “Cooperation” indicators for information flow, “costs” for financial flow, and “delivery times” for material flow are proposed to evaluate the performance of the supply chain in [29].

Bröcker and coworkers [30] proposed an estimate of trade and transportation flows considering economic growth, globalization, and changing commodity composition of trade flows, along with the evolution of value-to-weight ratios for commodity groups. Gerini and Sciomachen consider the performance indices of the system as the main indicator of the evaluation of the cargo flow at a warehouse logistic [31]. A performance indicator for material flow effectiveness in production systems is proposed in [32]. Martinico-Perez and coworkers have proposed two groups of indicators for evaluating material flow to achieve sustainable development goals. The extensive indicators group includes domestic extraction, direct material input, domestic material consumption, physical trade balance, net addition to stock, and the intensive indicators group consists of resource efficiency or resource intensity, resource productivity, material flow with respect to size of territory [33]. Jong and coworkers point to a lack of research on impact of changes in transport costs and times (by mode) on the trade flows and suggest a new model for trade flows in Europe that is integrated with a logistics model for transport chain choice through Logsum variables [34]. Porkar and coworkers propose two groups of indicators for evaluating material flows in the green supply chain with the aim of increasing total profit, depending on the direction of these flows: forward (quality and green design indicators) and backward (green scrap score indicators) [35]. A system of twenty-six universal indicators of logistics flows for evaluating and forming a “resource balance” in green supply chains are proposed in [7].

A complex of thirty-five indicators for evaluating the total costs (financial flows) arising from the formation of innovation flows in the logistics system is proposed in [36]. The “metric” of information flow in logistics is studied in [37].

Kolinski and coworkers studied integration of information flow for greening supply chain management. A set of indicators is proposed to evaluate the effectiveness of distribution processes, considering operational and economic aspects, as well as information flow. Information flow is evaluated by the following indicators: reliability of information flow, return of delivery rate due to erroneous data, average time for analysis of data on delivery plans [38].

A literature review of research in the field of logistics flows evaluation allows to conclude that at present, a universal system of parameters and indicators of logistics flows is not presented in scientific publications. However, this system is necessary to evaluate the compliance of supply chains with the goals of the concept of sustainable development.

2.2. Logistic Flows in Green Supply Chains

Scientific research over the past 15-20 years has increasingly focused on the GSCM. This is because, on the one hand, the impact of elements of the supply chains on the environment is objectively increasing, and on the other hand, environmental legislation is being tightened in almost all countries. Against this background, there is an increase in the number of publications devoted to the theory and practice of green supply chain management.

We have identified six main subject areas in the field of GSCM as a result of the analysis of current scientific publications: Policy, Synthesis, Purchasing, Manufacturing, Green logistics, and Reverse logistics (Table 1).

The authors reached the following conclusions from a review of GSCM research:

- at present, the conceptual and terminological apparatus of the GSCM, the principles of sustainable development and green logistics have been formed. Various GSCM indicator systems have been developed and used,
- the factors of sustainable development of supply chains were identified and systematized. Various solutions are proposed for the implementation of green technologies in logistics. The MCDM apparatus is actively used in the GSCM,
- the complexity of managing green supply chains lies in the insufficiently studied interconnections of indicators and parameters of logistics flows. There is no universally accepted universal system for assessing logistics flows in green supply

chains. Assessing the sustainability of supply chains and making decisions on the selection and implementation of green technologies is carried out, as a rule, relating to individual functional elements or areas of the logistics system: purchases, production, warehousing, transport, and marketing. This approach reduces the productivity of green technologies and does not effectively achieve sustainable development goals.

Table 1 Research in GSCM

Field of study	Characteristic	References
Policy	Issues of business ethics and corporate social responsibility, environmental audits, as well as solving problems related to environmental protection, compliance with the requirements of legislation and the state in the field of ecology	[39-43]
Synthesis	GSCM literature reviews, research, and tutorials	[16], [44-56]
Purchasing	Environmental issues related to supplier-buyer relationships, environmental decisions, certification, and environmental quality standards	[13], [57–65]
Manufacturing	Problems of design, development, and production of ecological products to reduce harmful emissions and waste	[66–70]
Green logistics	Environmental issues related to the sustainable transportation, handling and storage of hazardous materials, inventory management, warehousing, the choice of locations for transport and logistics infrastructure, the use of packaging	[11], [70–76]
Reverse logistics	Problems of separation of reverse flows (material flows from consumers to sources) into recyclable and waste	[14], [77–79]

2.3. DEMATEL and ANP methods in green supply chain management

Multi-Criteria Decision Making (MCDM) is widely used today to solve complex multifactorial design and green supply chain management problems. MCDMs can be used to quantify trade-offs between economic, social, and environmental goals for sustainable supply chain development [6].

The authors chose a combination of Decision Making Trial and Evaluation Laboratory Method (DEMATEL) [80] and Analytic Network Process (ANP) [81, 82] in this study. DEMATEL is used to identify the interdependencies between the criteria under study and to develop a map of the network relationships between the criteria. The ANP method [83] is a generalization of the AHP (Analytic Hierarchy Process). ANP is used to define dependencies and feedbacks between criteria, structuring these relationships between criteria in the form of a network.

The combination of DEMATEL with ANP is widely used today to solve various problems. Gölcük and Baykasoğlu propose to distinguish the following four groups of such combinations: Network Relationship Map of ANP; Inner Dependency in ANP; Cluster-Weighted ANP and DEMATEL-Based ANP (DANP) [84]. The merit of integrating DEMATEL and ANP is the ability to determine the degree of dependence between the DEMATEL criteria and use them to normalize the unweighted supermatrix in ANP.

The performed analysis shows that the DEMATEL method in GSCM was applied to solve various problems. For example, to evaluate the factors of sustainable development of SCM, to select environmental suppliers, to implement green initiatives or best green practices, to choose a development strategy and in other fields (Table 2).

Table 2 Research and practice of the DEMATEL and ANP methods application in GSCM

Field of study	References
DEMATEL	
Evaluation of factors influencing the implementation of initiatives in GSCM	[85]
Evaluations of factors for choosing environmentally friendly logistics companies	[86]
Evaluation and selecting sustainable suppliers	[87–89], [90]
Identifying critical factors in GSCM	[91]
Selecting suppliers with competencies in supply chain carbon management	[92]
Greenfield analysis	[93]
Evaluation of the municipal logistics sustainability within the framework of the concepts of Industry 4.0 and Logistics 4.0	[94]
Prioritizing green supply chains implementation within the technology-organization-environment (TOE) approach	[95]
Green corporate social responsibility evaluation	[96]
Evaluation of the GSCM practices	[97]
Evaluation of the Key Success Factors (KSFs) for implementing networked SCM	[98]
Predicting and measuring the likelihood of success of the GSCM implementing	[53]
DEMATEL-ANP	
Green project management in supply chains	[99]
Renewable energy selection	[100]
Assessment of the risk and reliability of the implementation of oil and gas construction projects	[101]
Financial statement supply chain assessment	[102]
Evaluation of the effectiveness of the flight safety management system	[103]
Choosing a company strategy	[104]
Assessing the competitiveness of a green supply chain	[99]
Analysis of consumer demand when choosing a supplier in green supply chains	[105]
Assessment of sustainable development of small and medium-sized enterprises	[106]

The main identified disadvantages of using the DEMATEL and ANP methods in the GSCM are:

- the generally accepted universal system of parameters and indicators of logistics flows has not been developed,
- the methods of complex evaluation of the set of logistics flows indicators are underdeveloped,
- the relationship of indicators and parameters of logistics flows from the standpoint of the concept of sustainable development is insufficiently studied,
- the evaluation of logistics flows is considered in relation to specific (isolated) elements of the GSCM,
- the evaluation of all logistics flows in GSCM to achieve sustainable development goals is carried out insufficiently comprehensively and systematically.

The use of the combined DEMATEL – ANP method in the GSCM has the following advantages.

First, the method makes it possible to identify relationships both between groups of parameters of logistics flows (see Section 3.1) and between indicators of logistics flows within groups of parameters. Groups of parameters are more needed to assess the achievement of sustainable development goals and the implementation of a strategy for the development of supply chains, while indicators of logistics flows are used in the operational management of flows in green supply chains.

Secondly, DEMATEL – ANP allows you to assess the relationship between indicators of logistics flows. The variety of properties of logistic flows requires considering the influence on them of many external and internal factors. Accounting for this impact is a prerequisite for the effectiveness of the GSCM.

Thirdly, the DEMATEL method allows visualizing causal relationships between parameters and indicators of logistics flows in the form of network maps. The division of indicators into groups of "Causes" and "Effects" allows you to better understand the structural relationships in the system of indicators of logistics flows and increases the efficiency of management by the decision maker.

Finally, the use of network maps in the ANP method allows one to assess the impact of changes in parameters and indicators of logistics flows on the achievement of GSCM goals.

3. METHODS

3.1. System of parameters and indicators of logistic flows

Research on improving existing or developing new systems for logistics flows evaluation is motivated by the need to solve the problems considered and eliminate the shortcomings of known evaluation methods.

The complexity of GSCM lies in the insufficiently studied relationships between indicators and parameters of logistics flows. Currently, there is no methodology for a comprehensive assessment of parameters and indicators of logistics flows. For example, making decisions to ensure on-time delivery can lead to an increase in the irregularity of freight traffic, which will negatively affect energy intensity and the volume of greenhouse gas emissions. On the other hand, the desire to increase the discreteness of the flow (decreasing the order size) allows you to achieve a more uniform flow, but also leads to an increase in transport costs.

In addition, GSCM uses different sets of logistics flow parameters (indicators) and decision-making methods at different levels of management.

Logistic flows at the operational management level are considered as a collection of flow elements, for example, vehicles, orders, or logistics operations in the service flow. The objects of control of such discrete logistics flows are their individual elements.

Logistic flows at the strategic management level are considered as continuous, characterized by the average values of their parameters and indicators.

Finally, the existing SCM methodology focuses mainly on economic criteria and does not consider environmental and social aspects.

The authors have developed an original universal system of the logistics flows parameters and indicators [6]. The proposed system is focused on logistics flows evaluation for compliance with the principles and goals of sustainable development. The logistic flow evaluation system (LFES) consists of five groups of parameters (Fig. 1):

- economic parameters (P1) characterize the efficiency of using all types of resources in the logistics system, as well as the degree of its economic viability,
- energy-ecological parameters (P2) characterize the efficiency of energy use during the movement of logistics flows and their impact on the environment,
- quality parameters (P3) characterize the safety and timeliness of movement and processing of logistics flows, as well as the quality of their management,
- statistical parameters (P4) reflect the patterns of change in the controlled parameters of logistics flows,
- controlled (physical) parameters of flows (P5) characterize the intensity of logistics flows and their spatio-temporal changes.

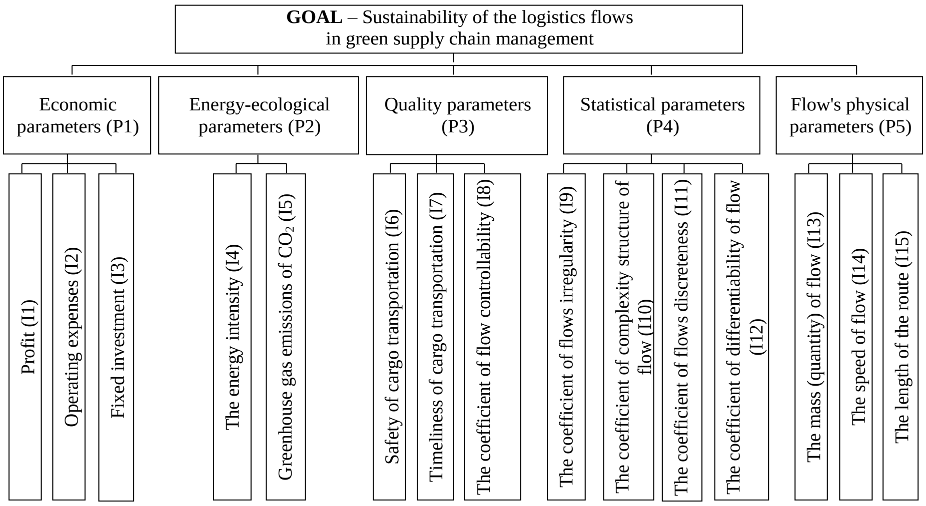

Fig. 1 Logistic flow evaluation system (LFES)

LFES is two-tiered. The logistics flow parameters (criteria P1-P5) form the first level of the hierarchy. The parameters are used to assess the compliance of logistics flows with the sustainable development goals. The indicators of logistics flows (sub-criteria I1-I15) form the second level of the hierarchy. They are used to monitor and manage the logistics flows of a specific supply chain. Bridging the gap between the actual values of indicators and those required in accordance with the sustainable development goals is carried out through the selection and application of green logistics instruments [107].

A brief description of the indicators (sub criteria) for assessing logistics flows in green supply chains is presented in the Table. 3.

Table 3 Characteristics of logistics flows indicators

Sub-criteria	Characteristic
Profit (I1)	Difference between total revenue and operating costs
Operating expenses (I2)	The sum of all costs associated with converting investments into profits
Fixed investment (I3)	Cash flow for the formation of fixed assets
The energy intensity (I4)	The amount of energy spent on the movement of the logistics flow
Greenhouse gas emissions of CO_2 (I5)	The total volume of greenhouse gas emissions from all sources involved in the movement of the logistics flow
Safety of cargo transportation (I6)	Comprehensive indicator of the material flow movement without damage, pollution, and loss
Timeliness of cargo transportation (I7)	Comprehensive indicator of the material flow movement by the appointed date, regularly, or at the required speed
The coefficient of flow controllability (I8)	The ratio of the number of information messages on compliance with the indicators of safety and timeliness of transportation to the total number of management decisions
The coefficient of flows irregularity (I9)	Deviation of the logistics flows physical parameters of from their average values
The coefficient of complexity structure of flow (I10)	The number of streams within the logistic flow
The coefficient of flows discreteness (I11)	The number of elements of the logistic flow in the stream
The coefficient of differentiability of flow (I12)	Changing the structure of the logistics flow (number of streams) in the process of movement
The mass (quantity) of flow (I13)	The total number of elements in the logistics flow
The speed of flow (I14)	The speed of movement of the logistics flow elements
The length of the route (I15)	Distance traveled by a logistic flow element while moving along a route

3.2. Decision Making Trial and Evaluation Laboratory Method (DEMATEL)

The DEMATEL method includes five main stages.

Stage 1. Building an initial direct-relation matrix. The initial data for the construction of this matrix are expert evaluating of the strength of the influence of the parameter and indicator (criteria, in general and sub criteria) i on the criterion j, where i, j = 1,2, ... n, n is the number of evaluating criteria. The power of influence is evaluating using a five-level scale: 0 – non influence, 1 – low influence, 2 – medium influence, 3 – high influence, 4 – extremely high influence.

Then the initial average matrix A of size $n \times n$ is formed, containing the average estimates of experts Eq. (1):

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

where a_{ij} is the average expert evaluation of the i-th criterion impact on the j-th criterion, $a_{ij} = 0$, for $i = j$.

Stage 2. Calculate the normalized initial influence matrix. The initial average matrix A is used to calculate the normalized matrix of direct relations X according to Eqs. (2) and (3):

$$X = A\lambda \quad (2)$$

$$\lambda = \min\left[\frac{1}{\max\limits_{1\le i\le n}\sum_{j=1}^{n} a_{ij}}, \frac{1}{\max\limits_{1\le j\le n}\sum_{i=1}^{n} a_{ij}}\right] \quad (3)$$

Stage 3. Compute the total influence matrix Eq. (4).

$$T = \lim_{k\to\infty}(X + X^2 + ... + X^k) = X(1-X)^{-1} \quad (4)$$

Stage 4. Computing the levels of influence and effect. The level of influence and effect of each criterion, as well as its importance in comparison with other criteria, are determined depending on the values of the calculated vectors D_i and R_j. The D_i and R_j values show the direct and inverse influence of each criterion on other criteria and allow establishing causal relationships in the system of criteria and sub criteria. The vector D_i is calculated as the sum of the columns of the common matrix of relations T, and the vector R_j – as the sum of the rows of the matrix T. The elements of the matrix T and the vectors D_i and R_j are calculated using the following Eqs. (5), (6) and (7):

$$T = \left[t_{ij}\right]_{n\times n}, \quad i, j = 1, 2, ..., n \quad (5)$$

$$D_i = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = \left[t_i\right]_{n\times 1}, \quad i = 1, 2, ..., n \quad (6)$$

$$R_j = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = \left[t_j\right]_{1\times n}, \quad j = 1, 2, ..., n \quad (7)$$

The value ($D_i + R_j$), for $i = j$, shows the importance of the i-th criterion in relation to other criteria, that is, the strength of the relationship. The larger the value ($D_i + R_j$), the greater the number of relationships of the i-th criterion with other criteria.

The value $(D_i - R_j)$, for $i = j$, shows the effect of the i-th criterion on other criteria. If the value $(D_i - R_j)$, with $i = j$ is positive, then the *i*-th criterion can be attributed to the "Influence" group. If $(D_i - R_j)$, with $i = j$ is negative, then the *i*-th criterion is influenced by other criteria and belongs to the "Effect" group.

Stage 5. Obtaining the causal diagram, Network Relation Map. A causal diagram shows the structure of the relationship between the studied criteria. The basis of the diagram are points, the ordinate of which is the value $(D_i + R_j)$ in a rectangular coordinate system, and the abscissa is the value $(D_i - R_j)$. Each point on the diagram corresponds to the *i*-th criterion. The points of the diagram are connected by relationships. The chart displays only those relationships between criteria that satisfy the condition Eq. (8):

$$t_{ij} > \alpha, \quad \forall i, j \tag{8}$$

where α is the threshold value, which is set by experts or calculated by the Eq. (9):

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} t_{ij}}{2n} \tag{9}$$

Filtering relationships using a threshold value eliminates insignificant relationships between criteria in the decision-making model.

3.3. Analytic Network Process

The ANP method includes five main stages.

Stage 1. Formation of the network structure of the criteria system model. Criteria are clusters of model elements. The elements of the model are sub criteria. Indicators are classified as sub criteria for the investigated LFES model. Accordingly, the clusters are parameters in the LFES model. Elements and clusters of the network model are connected by relationships. The initial structure of the network model can contain all possible links between elements and clusters, or only pre-selected links in the original criteria model, such as in LFES (Fig. 1). Moreover, the network structure of the model can only include those relationships that are determined to be significant using various methods, such as DEMATEL (section 3.2., Stage 5).

Stage 2. Construction of a pairwise comparison matrices and priority vectors. Pairwise comparison of elements is carried out with the involvement of experts and using a nine-point rating scale by analogy with the AHP [83] The priority vector is constructed by normalizing the eigenvectors of the local priorities of the judgment matrix. Eigenvectors are calculated as geometric mean of the judgment matrix elements. The priority vector shows the strength of the influence of each element on other elements in the model.

Stage 3. Unweighted supermatrix formation. An unweighted supermatrix is constructed based on the results of the previous stage. The unweighted supermatrix includes the priorities obtained because of various pairwise comparisons. Objectives, criteria (sub criteria) and alternatives are placed in the rows and columns of the supermatrix. The order of the elements in the supermatrix is irrelevant. If there are no interconnections between the elements of the criteria system, then zero is set at the intersection of the corresponding row and column of the supermatrix. The relationships are determined according to the criteria system model or using different methods, for example, DEMATEL. The unweighted supermatrix shows the influence of each criterion on other criteria in the studied model. The general equation for the unweighted supermatrix T_c Eq. (10):is:

$$T_c = \begin{array}{c} \\ X_1 \begin{array}{c} c_{11} \\ c_{12} \\ \vdots \\ c_{1m_1} \end{array} \\ \vdots \\ X_i \begin{array}{c} c_{i1} \\ c_{i2} \\ \vdots \\ c_{im_i} \end{array} \\ \vdots \\ X_n \begin{array}{c} c_{n1} \\ c_{n2} \\ \vdots \\ c_{nm_n} \end{array} \end{array} \begin{array}{c} \begin{array}{ccccc} X_1 & & X_j & & X_n \\ C_{11}...C_{1m_1} & \cdots & C_{j1}...C_{jm_j} & \cdots & C_{n1}...C_{nm_n} \end{array} \\ \begin{bmatrix} T_c^{11} & \cdots & T_c^{1j} & \cdots & T_c^{1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{i1} & \cdots & T_c^{ij} & \cdots & T_c^{in} \\ \vdots & & \vdots & & \vdots \\ T_c^{n1} & \cdots & T_c^{nj} & \cdots & T_c^{nn} \end{bmatrix} \end{array} \tag{10}$$

where X_n is the n-th cluster; C_{nm} is the m-th element in the n-th cluster; T_c^{ij} is the vector of the priority of the elements influence which compared in the j-th cluster with the i-th cluster.

Stage 4. Weighted and limit supermatrices formation. The unweighted supermatrix T_c is transformed into a weighted T_w supermatrix by normalizing the sum of elements in any of its columns to one [83]. This is because the clusters are usually interdependent on the network, and the items in the columns are separated by the number of clusters.

Then the weighted supermatrix T_w is transformed into the limit supermatrix T_l by raising it to a large power Eq. (11):

$$T_l = \lim_{k \to \infty} T_w^{\ k} \tag{11}$$

where k is an arbitrarily large number.

The exponentiation of k is performed until all elements of each row of the supermatrix are identical. The final weights of the criteria and subcriteria of the model under study (LFES) are the result of the calculations presented.

3.4. Combined DEMATEL-ANP

The general scheme of the combined DEMATEL-ANP method is shown in Fig. 2.

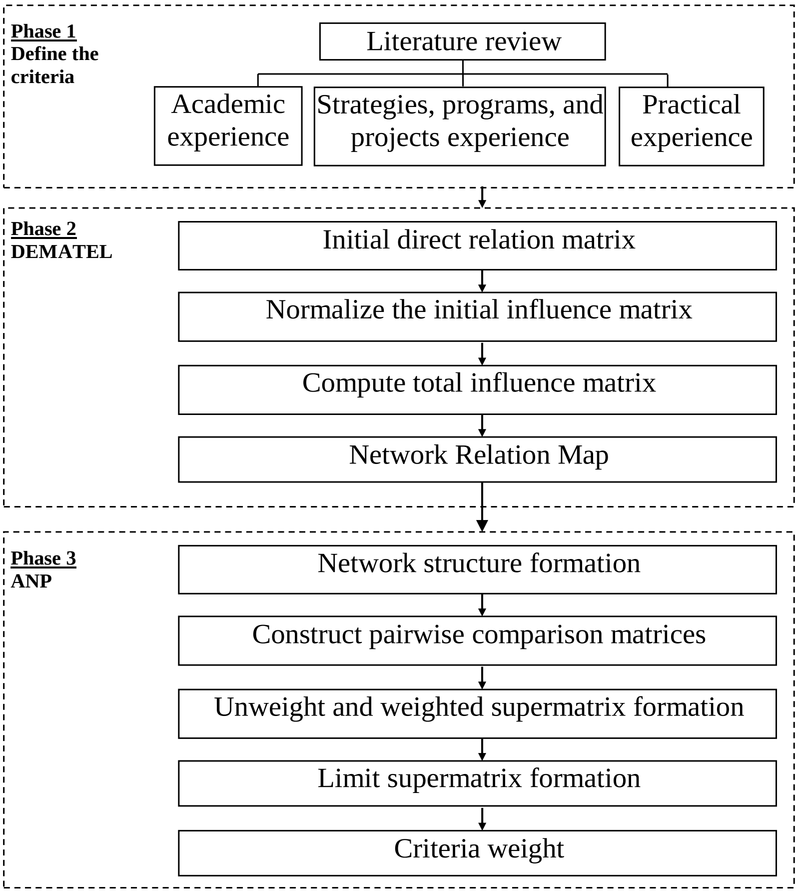

Fig. 2 Combined DEMATEL-ANP algorithm

Evaluation of logistics flows parameters and indicators in GSCM is carried out in three stages using the combined DEMATEL-ANP (Fig. 3).

Phase 1. The selection and justification of logistics flows parameters and indicators for a specific transport system or supply chain is performed based on a literature review and management practice. This case study uses the logistics flows parameters and indicators system presented in Section 3.1.

Phase 2. Relationships between groups of the logistics flows parameters and indicators are analyzed using DEMATEL. A network map of the relationship between parameters and indicators is the result of this analysis.

Phase 3. The results of Phase 2 are used to build the network structure of the logistics flow sustainability model in GSCM, that is, to achieve the main goal of the LFES. The weight and rank of each logistic flow parameter and indicator in the GSCM is calculated using ANP.

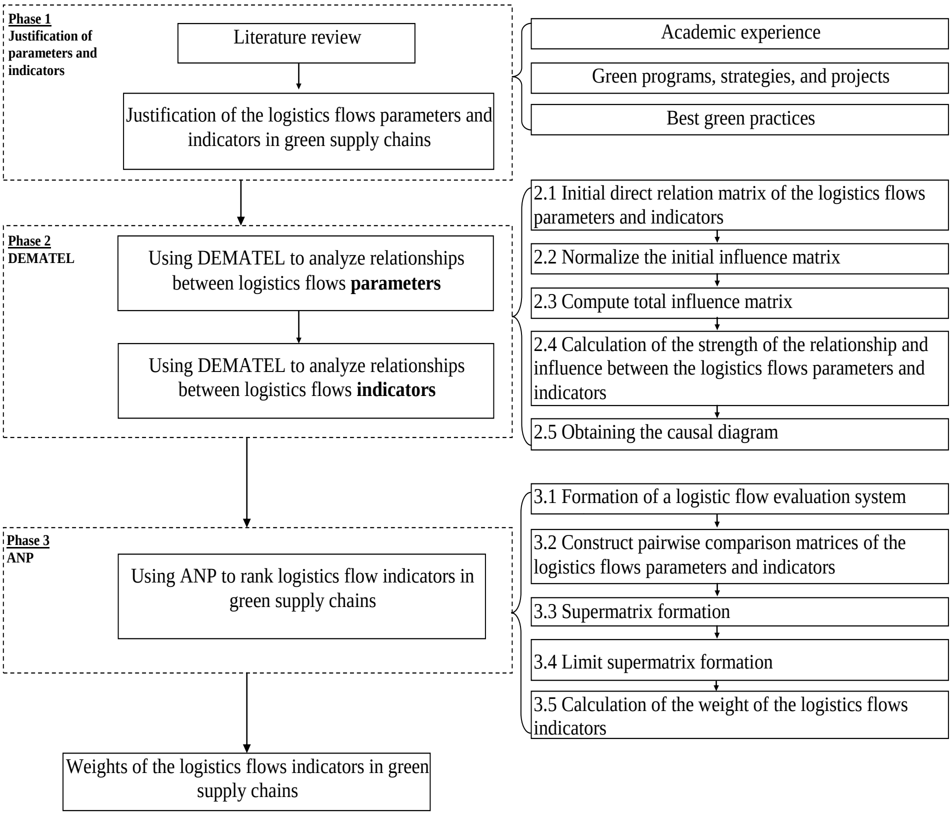

Fig. 3 Algorithm of the combined DEMATEL-ANP method for evaluating the parameters and indicators of logistics flows in green supply chains

4. CASE STUDY OF LOGISTICS FLOW EVALUATION FOR GREEN SUPPLY CHAIN MANAGEMENT

The authors used in the case study a system of 5 groups of parameters and 15 indicators of logistics flows, formed in accordance with aspects of the concept of sustainable development (Fig. 2). Academic experts (5 people, Table 4) performed evaluation of the logistics flows parameters and indicators. An example of the results of evaluating the parameters of logistics flows is presented in Table. 5.

Table 4 Expert data

Academic degree	Number of experts	Average work experience, years
Professor, Doctor (Technical Sciences)	2	34
Assistant professor, PhD (Technical Sciences)	3	18.5

Table 5 The results of an expert evaluation of the logistics flows parameters

Parameters	P1					P2					P3					P4					P5				
Experts	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Parameters P1	0	0	0	0	0	3	3	4	3	3	3	3	4	4	4	1	3	2	2	2	4	3	3	2	3
P2	4	3	1	4	2	0	0	0	0	0	2	2	1	3	0	1	2	0	3	0	2	3	2	2	0
P3	4	4	4	4	3	3	4	2	2	2	0	0	0	0	0	3	3	1	2	2	3	4	3	1	2
P4	1	0	1	2	2	0	0	0	2	1	1	0	0	2	4	0	0	0	0	0	1	0	0	2	1
P5	4	4	3	3	3	3	4	2	3	4	3	4	3	2	1	3	4	1	2	1	0	0	0	0	0

The authors calculated the initial average matrix *A*, normalized matrix of direct relations *X*, and total influence matrix *T* using Eqs. (1-4). The results of calculating the matrices *A* and *T* for the logistics flows parameters are presented in Tables 6 and 7.

Table 6 Initial average matrix *A* of logistics flows parameters

Parameters	P1	P2	P3	P4	P5
P1 (Economic)	0	0.27119	0.30508	0.169492	0.254237
P2 (Energy-ecological)	0.237288	0	0.13559	0.101695	0.152542
P3 (Quality)	0.322034	0.22034	0	0.186441	0.220339
P4 (Statistical)	0.101695	0.05085	0.11864	0	0.067797
P5 (Physical parameters)	0.288136	0.27119	0.22034	0.186441	0

Table 7 The total influence matrix *T* of logistic flows parameters

Parameters	P1	P2	P3	P4	P5
P1 (Economic)	0.9278	1.0423	1.0291	0.7980	0.9300
P2 (Energy-ecological)	0.8261	0.5709	0.6691	0.5427	0.6339
P3 (Quality)	1.1314	0.9732	0.7634	0.7832	0.8777
P4 (Statistical)	0.4477	0.3698	0.4118	0.2548	0.3460
P5 (Physical parameters)	1.1122	1.0097	0.9433	0.7836	0.6978

The authors are computing the levels of influence and effect between the parameters of logistic flows in accordance with Eqs. (5-7). The calculation results for *D*, *R*, (*D* + *R*), and (*D* – *R*) are presented in Table 8.

Table 8 Results of the DEMATEL calculation for logistic flows parameters

Parameters	D	R	D + R	D – R
P1	4.7272	4.4452	9.1724	0.2820
P2	3.2426	3.9660	7.2086	-0.7234
P3	4.5290	3.8167	8.3457	0.7122
P4	1.8302	3.1622	4.9924	-1.3321
P5	4.5466	3.4854	8.0320	1.0612

The authors performed similar calculations for 15 logistics flows indicators. Initial average matrix *A*, the total influence matrix *T*, and the results of calculating the levels of influence and effect between logistics flows indicators are presented in Tables 9-11.

Table 9 Initial average matrix *A* of logistics flows indicators

Indicators	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
I1	0	2.2	3.4												
I2	3.8	0	2.2												
I3	3.6	3	0												
I4				0	3.2										
I5				1.8	0										
I6						0	2	1.4							
I7						1.2	0	1.8							
I8						2.2	3.2	0							
I9									0	1.8	1.6	1.8			
I10									2.6	0	2	2.4			
I11									3	2.6	0	1.6			
I12									2.2	3.2	1.8	0			
I13													0	3.2	1
I14													0.8	0	0.4
I15													1	2.4	0

Table 10 The total influence matrix *T* of logistic flows indicators

Indicators	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
I1	1.5606	1.4439	1.6838												
I2	2.0437	1.3185	1.7536												
I3	2.0742	1.6424	1.5301												
I4				1.2857	2.2857										
I5				1.2857	1.2857										
I6						0.5138	0.9885	0.7220							
I7						0.6754	0.6872	0.7375							
I8						1.0170	1.4025	0.7312							
I9									1.1223	1.2748	1.0137	1.0900			
I10									1.6628	1.3682	1.2649	1.3719			
I11									1.7144	1.6299	1.0749	1.3228			
I12									1.6764	1.7073	1.2837	1.1755			
I13													0,1573	0,7735	0,2619
I14													0,1858	0,1558	0,1157
I15													0,2863	0,6335	0,0964

Table 11 Results of the DEMATEL calculation for logistic flows indicators

Indicators	Designation	D	R	D + R	D – R
Profit	I1	4.6883	5.6785	10.3668	-0.9902
Operating expenses	I2	5.1158	4.4047	9.5205	0.7110
Fixed investment	I3	5.2466	4.9675	10.2141	0.2792
The energy intensity	I4	3.5714	2.5714	6.1429	1.0000
Greenhouse gas emissions of CO_2	I5	2.5714	3.5714	6.1429	-1.0000
Safety of cargo transportation	I6	2.2243	2.2062	4.4304	0.0181
Timeliness of cargo transportation	I7	2.1001	3.0782	5.1783	-0.9781
The coefficient of flow controllability	I8	3.1507	2.1906	5.3413	0.9600
The coefficient of flows irregularity	I9	4.5008	6.1759	10.6768	-1.6751
The coefficient of complexity structure of flow	I10	5.6678	5.9802	11.6480	-0.3124
The coefficient of flows discreteness	I11	5.7420	4.6372	10.3792	1.1048
The coefficient of differentiability of flow	I12	5.8429	4.9601	10.8030	0.8828
The mass (quantity) of flow	I13	1.1927	0.6293	1.8221	0.5634
The speed of flow	I14	0.4573	1.5628	2.0200	-1.1055
The length of the route	I15	1.0161	0.4740	1.4901	0.5421

Parameters P1 (Economic), P3 (Quality), P5 (Physical parameters) and indicators I2 (Operating expenses), I3 (Fixed investment), I4 (The energy intensity), I6 (Safety of cargo transportation), I8 (The coefficient of flow controllability), I11 (The coefficient of flows discreteness), I12 (The coefficient of differentiability of flow), I13 (The mass (quantity) of flow), I15 (The length of the route) are assigned to the "Influence" group in accordance with the values ($D_i - R_i$) in Table 8 and 11. Parameters P2 (Energy-ecological), P4 (Statistical) and indicators I1 (Profit), I5 (Greenhouse gas emissions of CO_2), I7 (Timeliness of cargo transportation), I9 (The coefficient of flows irregularity), I10 (The coefficient of complexity structure of flow), I14 (The speed of flow) are assigned to the "Effect" group.

The authors have developed a Network Relation Map of logistics flows parameters and indicators at the final stage of DEMATEL (Fig. 4).

The developed structure of relationships between logistics flows parameters and indicators of is used to calculate the weight of each parameter and indicator based on the ANP method (Section 3.3, Stage 3).

The authors used Super Decisions software (http://www.superdecisions.com/) to build the ANP model. The unweighted supermatrix, weighted and limited supermatrix (Appendix 1-3) are constructed based on pairwise comparison of the model elements on the Saaty's nine-point scale.

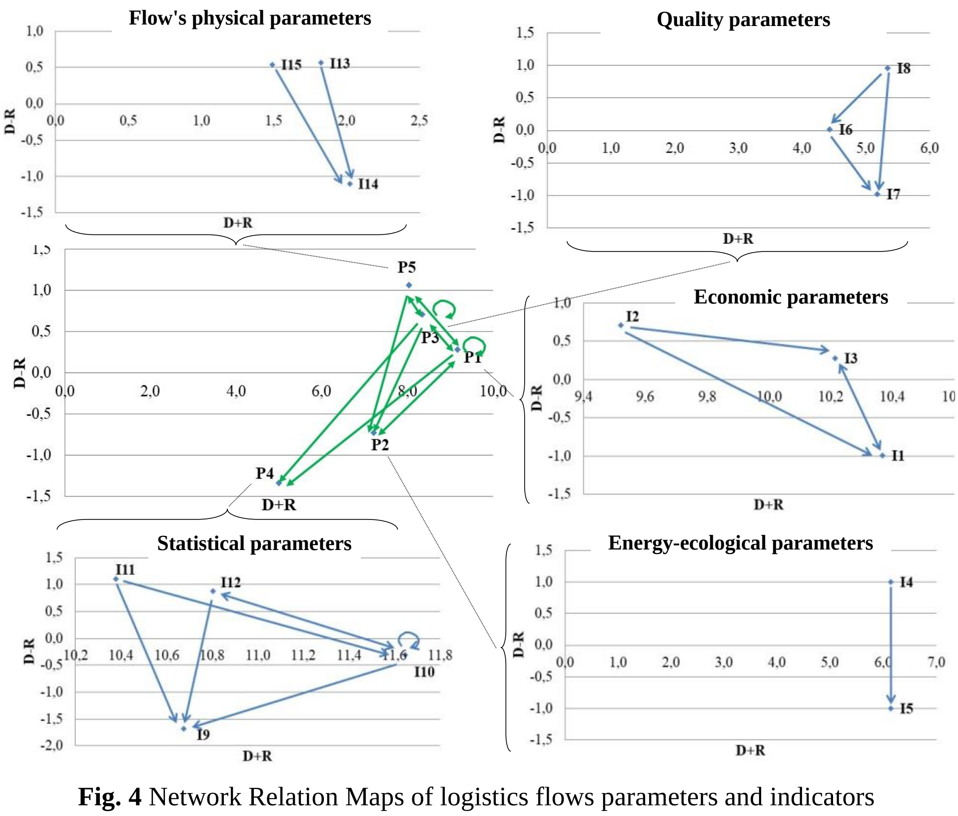

Fig. 4 Network Relation Maps of logistics flows parameters and indicators

The results of ranking the logistics flows indicators in GSCM are presented in Table 12.

Table 12 Weights and ranks of the logistics flows indicators

Indicators	Designation	Weight	Rank
Profit	I1	0.16405	1
Operating expenses	I2	0.01481	14
Fixed investment	I3	0.12434	2
The energy intensity	I4	0.09495	4
Greenhouse gas emissions of CO_2	I5	0.07913	7
Safety of cargo transportation	I6	0.09098	5
Timeliness of cargo transportation	I7	0.09698	3
The coefficient of flow controllability	I8	0.02335	11
The coefficient of flows irregularity	I9	0.06597	8
The coefficient of complexity structure of flow	I10	0.02301	12
The coefficient of flows discreteness	I11	0.04357	10
The coefficient of differentiability of flow	I12	0.01174	15
The mass (quantity) of flow	I13	0.06085	9
The speed of flow	I14	0.02081	13
The length of the route	I15	0.08545	6

The authors have identified interrelationships both between groups of parameters of logistics flows, and between indicators of logistics flows within groups of parameters. The relationship between economic (P1), quality (P3) and physical (P5) groups of parameters is shown in Fig. 4. Within these groups, profit (I1), the speed of flow (I14) and timeliness of cargo transportation (I7) have the greatest influence.

The group of energy-ecological parameters (P2) does not affect the physical parameters and quality parameters. However, a relationship has been established between environmental and economic parameters.

Decisions to change the values of physical parameters will affect the values of energy and environmental indicators (P2).

Statistical parameters (P4) group has little effect on the other parameter groups. This group is influenced by physical (P5) and economic parameters (P1). At the same time, the study [108] substantiates the influence of the coefficient of flows irregularity (I9) and the coefficient of complexity structure of flow (I10) on the efficiency of logistic flows management.

The predominance of economic and quality indicators is justified by the need to achieve the key goals of SCM - increasing efficiency and quality. However, study [105] shows the possibility and necessity of improving MCDM by eliminating strong economic criteria at the first stage of ranking. The authors propose to implement this approach relates to assessing the indicators of logistics flows in green supply chains in future studies.

The authors recommend using the results of ranking the logistics flows indicators in GSCM to select green logistics instruments. A detailed description of these instruments, as well as the methodology for their application, are presented in [107]. The obtained ranks of the logistics flows indicators with green logistics instruments are proposed to be used in the GSCM to adjust the actual parameters of the logistics flows to achieve the goals of the sustainable development concept.

5. CONCLUSION

A new universal system of the logistics flows parameters and indicators in supply chains has been developed and justified. A feature of the proposed system is its compliance with the principles of the concept of sustainable development and focus on use in green supply chains management. The authors chose a combined DEMATEL-ANP method for evaluating and ranking indicators of logistics flows in the GSCM. A methodology of applying the combined DEMATEL-ANP method for ranking of the logistics flows indicators has been developed.

The results of estimating the parameters and indicators of logistics flows using the DEMATEL showed that the parameters P1 (Economic), P3 (Quality), P5 (Physical parameters) and indicators I2 (Operating expenses), I3 (Fixed investment), I4 (The energy intensity), I6 (Safety of cargo transportation), I8 (The coefficient of flow controllability), I11 (The coefficient of flows discreteness), I12 (The coefficient of differentiability of flow), I13 (The mass (quantity) of flow), I15 (The length of the route) are assigned to the “Influence” group. Parameters P2 (Energy-ecological), P4 (Statistical) and indicators I1 (Profit), I5 (Greenhouse gas emissions of CO2), I7 (Timeliness of cargo transportation), I9 (The coefficient of flows irregularity), I10 (The coefficient of complexity structure of flow), I14 (The speed of flow) are assigned to the “Effect” group.

Ranking of indicators of logistics flows using ANP method showed priority I1 (Profit) > I3 (Fixed investment) > I7 (Timeliness of cargo transportation) > I4 (The energy intensity) > I6 (Safety of cargo transportation) > I15 (The length of the route) > I5 (Greenhouse gas emissions of CO2) > I9 (The coefficient of flows irregularity). The least important indicators: I13 (The mass (quantity) of flow) > I11 (The coefficient of flows discreteness) > I8 (The coefficient of flow controllability) > I10 (The coefficient of complexity structure of flow) > I14 (The speed of flow) > I12 (The coefficient of differentiability of flow) > I12 (The coefficient of differentiability of flow). The authors propose to use the obtained results in the GSCM to adjust the actual logistics flows parameters in accordance with the goals of the sustainable development concept.

The authors intend to improve the proposed approach in two directions. The first direction is based on the combination of MCDM with simulation modeling. The use of a simulation model will allow evaluating the effectiveness of decisions in the GSCM, predicting changes in the parameters and indicators of logistics flows, as well as choosing the optimal sequence for implementing green logistics instruments to adjust of the logistics flows parameters. The second direction of research development is associated with the improvement of MCDM used to evaluation logistics flows. Finally, it is planned to improve the accuracy of logistics flows evaluation as a result of the use of several MCDM and their combinations.

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Appendix 1 Unweighted supermatrix T_c

	SD	P1	P2	P3	P4	P5	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
SD	0	0.1485	0.2250	0.2874	0.0647	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P1	1.0	0.1485	0.2250	0.2874	0.0647	0.2742	0.6347	0.0977	0.2675	0	0	0	0	0	0	0	0	0	0	0	0
P2	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P3	1.0	0.2036	0.2263	0.2511	0.0723	0.2465	0	0	0	0.75	0.2500	0.5381	0.3103	0.1514	0	0	0	0	0	0	0
P4	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5125	0.2086	0.1467	0.1321	0	0	0
P5	1.0	0.2294	0.3345	0.3540	0.0819	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4818	0.1647	0.3533
I1	0	1.0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0
I2	0	1.0	0	0	0	0	0.7624	0	0.2375	0	0	0	0	0	0	0	0	0	0	0	0
I3	0	1.0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I4	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I5	0	0	1.0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0
I6	0	0	0	1.0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0
I7	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I8	0	0	0	1.0	0	0	0	0	0	0	0	0.6875	0.3125	0	0	0	0	0	0	0	0
I9	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0
I10	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0.5779	0.2299	0	0.1921	0	0	0
I11	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0.8076	0.1923	0	0	0	0	0
I12	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0.8076	0.1923	0	0	0	0	0
I13	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0
I14	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0
I15	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 Weighted supermatrix T_w

	SD	P1	P2	P3	P4	P5	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
SD	0	0.3333	0.3333	0.3333	0.5	0.3333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P1	0.1485	0.0495	0.3333	0.0678	0	0.0764	0.5	1.0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
P2	0.2250	0.0750	0	0.0754	0	0.1115	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	0	0
P3	0.2874	0.0958	0	0.0837	0	0.1180	0	0	0	0	0	0.5	1.0	0.5	0	0	0	0	0	0	0
P4	0.0647	0.0215	0	0.0241	0	0.0273	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5	0	0	0
P5	0.2742	0.0914	0	0.0821	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	1.0
I1	0	0.2115	0	0	0	0	0	0.3812	0.5	0	0	0	0	0	0	0	0	0	0	0	0
I2	0	0.0325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I3	0	0.0891	0	0	0	0	0.5	0.1187	0	0	0	0	0	0	0	0	0	0	0	0	0
I4	0	0	0.2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I5	0	0	0.0833	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0
I6	0	0	0	0.1793	0	0	0	0	0	0	0	0	0	0.3437	0	0	0	0	0	0	0
I7	0	0	0	0.1034	0	0	0	0	0	0	0	0.5	0	0.1562	0	0	0	0	0	0	0
I8	0	0	0	0.0504	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I9	0	0	0	0	0.2562	0	0	0	0	0	0	0	0	0	0	0.2889	0.4038	0.4038	0	0	0
I10	0	0	0	0	0.1043	0	0	0	0	0	0	0	0	0	0	0.1149	0.0961	0.0961	0	0	0
I11	0	0	0	0	0.0733	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
I12	0	0	0	0	0.0660	0	0	0	0	0	0	0	0	0	0	0.0960	0	0	0	0	0
I13	0	0	0	0	0	0.1606	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I14	0	0	0	0	0	0.0549	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I15	0	0	0	0	0	0.1178	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0

Appendix 3 Limited supermatrix T_l

	SD	P1	P2	P3	P4	P5	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
SD	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827	0.1827
P1	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317	0.1317
P2	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100
P3	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340	0.1340
P4	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418
P5	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097
I1	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475	0.0475
I2	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042
I3	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360	0.0360
I4	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275
I5	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229
I6	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263
I7	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281
I8	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
I9	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191
I10	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066
I11	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
I12	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
I13	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176
I14	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060
I15	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247