DESIGN OF INTERNATIONAL LOGISTICS NETWORKS FOR SUPPLY OF ELECTRIC POWER EQUIPMENT

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ABSTRACT

The transition of international trade and economic relations onto modern scientific foundations implies the use of logistics tools in the organization of supplies. The authors have developed a new scientific idea of designing product-specialized international trade logistics networks in order to solve the problem of supplying electric power equipment for solar power plants. In the course of study, a scientific and methodological approach to modeling logistics networks in international trade was proposed, developed on the basis of studying and evaluating the effectiveness of global chains of customer value creation, taking into account the economic interests of customers, participants of the network structure and stakeholders as representatives of public interests, profit indicators, delivery time of goods, reliability of supplies. The authors have proven the feasibility of developing an integrated logistics flow and end-to-end design of logistics networks in international trade, as opposed to designing by individual links, based on the shift of management tasks from product improvement to customer-oriented approach and achieving public consensus. Methodological recommendations for designing an international logistics network for the supply of power equipment have been developed, tested and used, making it possible to assess the options for configuring the network with respect to the complete structure, taking into account the interests of stakeholders and the priorities of the energy concept.

Keywords: Innovation in Management, Digital Business Model, Business Process, Customer-Oriented Approach, Customer Value, Digital Logistics, Smart Contracting System

INTRODUCTION

Decisions on the design of international logistics networks will be significantly different for goods of mass and individual demand, products used as means of production and items of final consumption, etc. The most complex nuances arise when commodity exchange, namely trading, operations are performed with equipment, i.e., technically complex products having long service life and consuming their resource during operation. Supply chains for such products are extended to cover development processes, product maintenance during operation, and are built in accordance with product life cycle contracts. As a rule, these are multi-level and multi-link chains with a complex configuration, which, in the course of international trade operations, become akin to global supply chains.

Consistent with the principle of customer-oriented logistics, global supply chains perform the function of creating the customer value in order to meet real demand stimulated by means of integrated marketing communications. In the context of development of the international trade, global supply chains are being transformed into network structures, building of which actualizes the problem of performing design feasibility studies. As a part of solutions being developed, along with the interests of customers (i.e., the demanders) and all participants in creation of the customer value (i.e., links in the chain), the interests of stakeholders (i.e., groups of people who can influence the development of supply chains and the network as a whole) should be taken into account as well. From this point of view, the factor of "product specialization" of a logistics network and the characteristics of goods are important, and not only valuable ones that are significant directly for customers, but also their socially significant characteristics, in particular, environmental ones. The sustainability of goods in production and operation is controlled by

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stakeholders by supporting the development of network interactions or, instead, by imposing restrictions on trade operations.

The need to take into account the measures of "green protectionism" in force in the international trade during the design of supply chains and network structures gives additional relevance to the study subject. The authors aim to explore the particularities of the international logistics chain which is designed taking into account the crossing of state borders subject to customs administration procedures, and almost total lack of attention to assessment of compliance of the design results with the interests of various stakeholder groups that effectively influence on development of supply chains.

The authors' idea of scientific support to the design of logistics networks in the international trade is represented by the following constituents:

- Definition of principles for justifying logistics networks in the international trade, also referred to as international logistics networks;
- Study of the problems of modeling logistics networks in the international trade based on the correspondence of parameters of profit, delivery time and reliability to the goals and interests of stakeholders;
- Development of a methodology for creation of an international logistics network in the international trade.

The study subject is elaborated based on the example of the network organization of production and supply of energy equipment for solar power plants.

The active development of supply chains in the field of "green energy" with an insufficient degree of development of the theory and methods of designing logistics networks in the international energy equipment trade determines the choice of "product specialization" of the network. With regard to the supply of components for assembly of solar power plant equipment, a prerequisite for achieving the continuity of the "green energy" customer value flow is defined: maximum compliance with the interests of stakeholders in implementation of the priorities of the global energy concept, i.e., safety, availability and efficiency of energy supply.

METHODOLOGY

Universal Principles of Justification of Organizational Decisions

An integrated transport and logistics services include several elements of the cargo movement process (a material flow in terms of logistics), which form a logistics network for the delivery of goods. Using methods of predictive analytics in logistics allows to substantiate the new prospects, such as 5PL software and hardware services (Silkina & Bakanova, 2016; Trappey et al., 2016). In terms of the concept of customer-oriented approach, the service offer consists of a basic service that meets the shipper's need for cargo delivery and additional elements of the basic service that ensure or increase the efficiency of its implementation (Scherbakov & Silkina, 2019a, 2019b). In general, an up-to-date view of additional services forms the Unified List of Works and Services Rendered by the JSC RZD in the Organization of Cargo Transportation. Some researchers consider the same approach (Genkin & Mikheev, 2020).

The universal principles of justification of organizational decisions are defined, namely: consistency, scientific approach, customer-oriented approach, adaptability, modeling in the context of designing network structures in the international trade, formed on the basis of supply chains and potentially expandable to the maximum dimension by increasing the links (number and composition of participants) when organizing supplies of technically complex products.

The principles of the scientific justification of logistics networks in the international trade investigated by the author are summarized on the basis of the content commonality: consistency, scientific nature, customer-oriented approach, adaptability and modeling.

Consistency means that while maintaining the general features of the network, there is a manifestation of features inherent in the international trade: the logistics flow integrated in the material flow crosses the customs border, the international supply chain expands by adding a customs link. These features shall be taken into account when justifying the subject-functional and structural characteristics of the design object.

The principle of scientific approach implies addressing to the conceptual categories of quality, reliability in particular, in relation to international logistics networks, bearing in mind that the quality of fulfillment of obligations by suppliers depends on the reliability of the delivery system.

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The principle of customer-oriented approach acts in ensuring the integration of logistics into international trade business processes in the light of new economic realities, i.e., a slowdown in the dynamics of the international trade and the imposition of more demanding requirements for energy intensity and sustainability of production.

The principle of adaptability serves as a summarization of the above principles and forms the flexibility of network structures, which is most clearly manifested in its coherence with the principle of customer-oriented approach. Presented in this context, it responds to the trend of customizing goods and services in the international logistics and supply chain management.

The cumulative effect of the principles provides introduction of the principle of modeling. It is used in the design of logistics networks in the international trade for development of organizational solutions.

The author takes into account that the conditions for the design of supply chains are dependent on transport and distribution policies of resident countries of the participants of supply chains. So, for example, the transport and distribution policy of Europe introduces the following standards:

1) Development of supply chains in the interests of ensuring an efficient system for movement of material flows between commercial structures of the European Union (EU), which has the features of sustainability and prospectivity (opportunities for further improvement and development);
2) Strict adherence to environmental requirements for projected supply chains (environmental sustainability, limited fossil fuel resources, especially relevant for the EU, including urbanization and globalization, are key trends in the field of trade and logistics);
3) Optimal use of infrastructure. In this case, infrastructure facilities must be designed and built in such a way as to limit any threat to human health (stability, fire safety, conditions and levels of access, escape and evacuation, etc.);
4) Innovative solutions for supply chain management;
5) Ensuring the integration of neighboring states into European supply chains and their expansion.

An Algorithm for Modeling Logistics Networks in the International Trade

Authors propose an algorithm for modeling logistics networks in the international trade, developed on the basis of studying global chains of customer value creation and assessing the effectiveness of their operation by comparing the economic interests of direct participants in the network structure and customers, expressed by indicators of economic value, delivery time of goods, reliability of supply, as well as the interests of stakeholders as representatives of the public interest.

A logistics network is presented by the author as a structure to be formed to ensure the operation of international supply chains. The structure is determined by composition of the participating links, clustered into groups of interested persons, i.e., stakeholders, including direct participants (suppliers, customers, agents) and stakeholders representing public interests: customs authorities, state regulation and control bodies of the importing and exporting countries. Each of the group representatives, according to their interests and goals of participation, has an impact on development of supply chains, and the emphasized importance is assumed by the role of investors who can provide financial support for construction of logistics infrastructure facilities.

Based on this, the study defines the key rules for building supply chains and their transformation into a network structure of the international trade:

1) The rule of creating a global customer value chain (product development, ensuring the supply of raw materials, product manufacturing, marketing and sales organization, service organization), taking into account the interests of the end customer;
2) The rule of partial design of logistics networks, taking into account the partial functions of international logistics: pre-contract, contract, packaging, documentation, insurance, monetary and financial, transport, warehouse, customs, control, information and communication;
3) The rule of multi-criteria choice in the process of designing an international supply chain, taking into account the aggregation of interests of stakeholders.

The above rules form the basis for modeling of logistics networks, developed methodically in the form of a step-by-step algorithm, universal in application (when using target criteria of return on investments) and adapted to the conditions of variant design of electric power equipment supply chains in the interaction of China, Russia and the EU countries

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(supplemented by the use of criteria of maximum energy security, maximum energy availability, reliability and maximum environmental sustainability).

End-To-End Design of Logistics Networks in the International Trade

The necessity and feasibility of developing an integrated logistics flow and end-to-end design of logistics networks in international trade (as opposed to designing by individual links) based on the progressiveness of ideas of the theory of integrated logistics and the positivity of trends of development of the international trade, justifying the shift of management tasks from product improvement to customer-oriented approach and achieving public consensus.

According to the rules of logistics and supply chain management, the possible channels of transactions, distribution and document flow determine the creation of an integrated logistics flow as a part of material, financial and information flows. The peculiarity of supply chains in the international trade is that the objects of management are autonomously formed commodity and accompanying flows, there is no unified management structure for the logistics process of international commodity circulation.

Based on this, when transforming supply chains into logistics networks, the author provides for end-to-end organizational and analytical optimization. The summarization of international experience gives grounds to assert that one of the most effective ways to eliminate various problems arising between participants in the movement of goods is the organization of horizontal and vertical supply systems designed to implement global customer value chains. Their targets correlate with improvement of customer service standards, establishment of control over the material flow, order fulfillment schedules, acceptable levels of stock shortages, as well as profit and return on investments.

The idea of creating an integrated logistics flow in the design of logistics networks in the international trade is implemented by shifting the center of gravity of the value chain from the production process to the customer. The shift in the center of gravity is expressed by an increase in importance of working with the customer in the process of modeling logistics networks, taking into account their adaptability to changes not only in external conditions (the influence of risk factors), but also in customer preferences, as well as to achievement of public consensus.

The author’s idea for designing logistics networks in the international trade implies different perceptions of the customer value by different groups of stakeholders, which is a characteristic feature of the emerging inconsistency of logistics networks in the international trade. One of the recommended mechanisms to resolve contradictions is the consideration of partiality by assessing the compliance of the goals of organization of horizontal and vertical supply systems with the interests and goals of stakeholders of the international logistics network. The inconsistency must be eliminated by means of control actions that must be carried out by an integrated logistics provider that provides services for organizing an end-to-end business process and managing a supply network. An integrated approach to logistics services involves the creation of infrastructure facilities (logistics centers) located in local areas in order to organize and coordinate operational logistics activities.

The result of such coordination is, thus, creation of a logistics flow integrated in the material flow.

Results: Case of Russia

A set of methodological recommendations for designing a logistics network in the international trade

A set of methodological recommendations for designing a logistics network in the international trade is presented on the example of developing supply chains of electric power equipment for solar power plants in accordance with the choice of an international strategy in achieving accelerated adaptation to the external environment of the global customer value chain, taking into account the priorities of the energy concept of development of the European countries (energy security, reliability and energy efficiency).

In an applied context, the idea of creating an integrated logistics flow has been developed in the study based on the materials of the “green energy” - the supply of energy equipment for solar power plants (SPP). When organizing an end-to-end business process in an international network (Figure 1), the author took into account the priorities of the energy concept in Europe:

1) Energy security (measures to ensure the reliability of imports);

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2) Availability of energy (creation of the necessary infrastructure, affordable prices for customers);
3) Ecology and sustainable development (energy efficiency and transition to the low-carbon economy through renewable energy sources).

The customer value is presented through the prism of the logistical usefulness of the technical state, the spatial and temporal usefulness of the supply of power equipment for SPP.

The scientific-methodological approach and the set of methodological recommendations developed by the author for designing an international logistics network for the supply of power equipment makes it possible to assess the options for configuring the network with respect to the complete structure, taking into account the interests of stakeholders and the priorities of the energy concept. The methodological recommendations are based on the methodology for building a hierarchy (analytical network) with interdependent criteria, which are taken as: maximum net discounted income generated by the links of the logistics network; maximum contribution to reliable operation of the power plant (energy security), maximum availability of energy supply, maximum environmental friendliness.

Configuring the network structure involves development and ranking of options that may differ in composition and sequence of inclusion of stakeholders in the network structure.

During the design process, a basic network structure is developed with the necessary composition of participants (a supplier, a customs authority, regulatory authorities serving the operation of supply chains, a customer). Regarding the basic structure, possible configuration options are elaborated when implementing projects for construction of infrastructure facilities. For each option, the Net Present Value from development of the logistics network (NPV_{LN}) is determined as the sum of increments in discounted cash flows during implementation of measures to develop the logistics infrastructure:

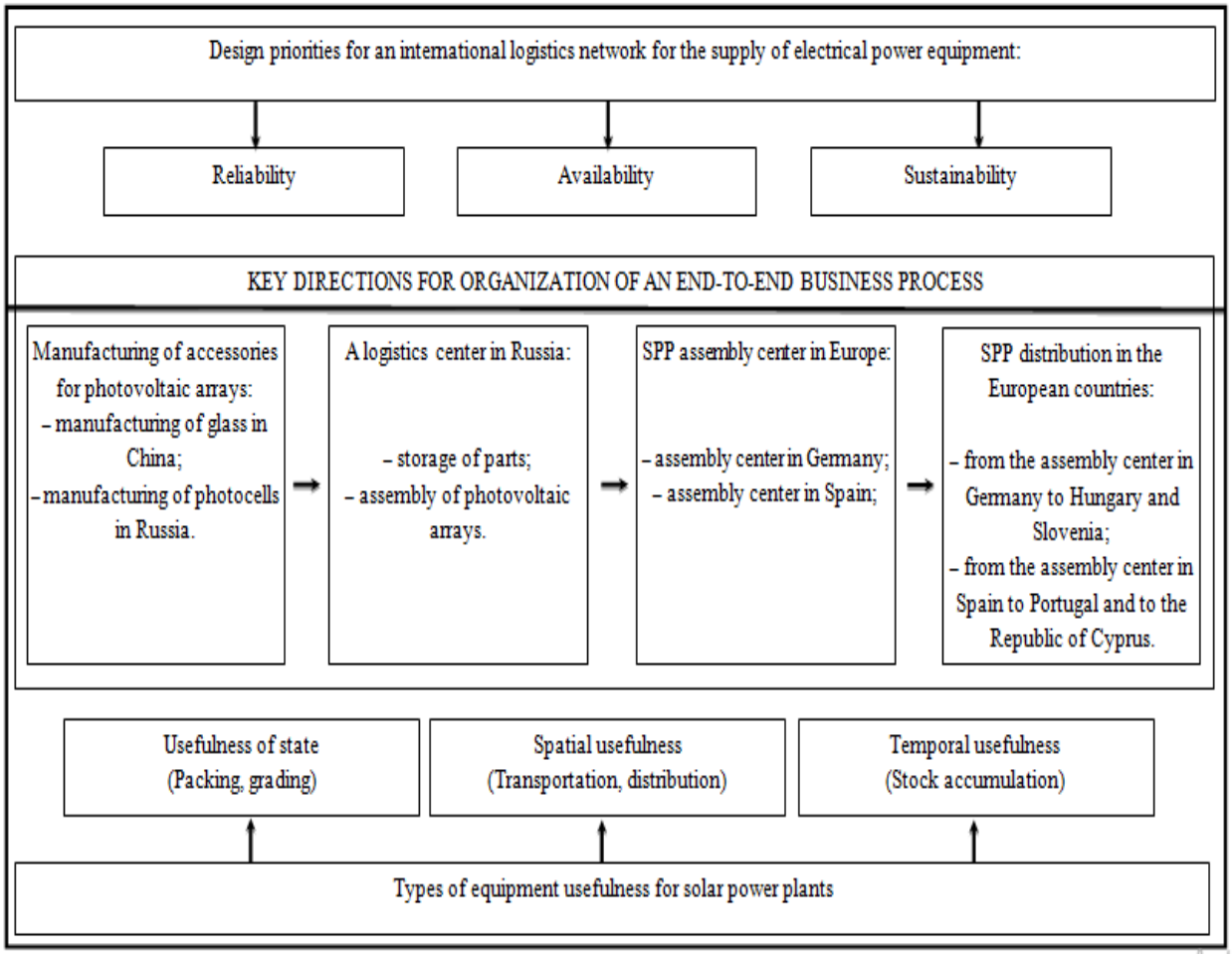

FIGURE 1
ORGANIZATION OF AN END-TO-END BUSINESS PROCESS FOR SUPPLY CHAINS OF ELECTRIC POWER EQUIPMENT IN A NETWORK STRUCTURE

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$$NPV_{LN} = \sum_{t=0}^{T} \frac{\Delta E_t + \Delta R_t - \Delta C_t}{(1+r_d)^t}, \quad (1)$$

where ΔE is the saving of logistics costs due to development of a logistics network in year t for each option compared to the basic option, taking into account operating costs (maintenance costs and overhead costs) in year t; ΔR_t is the increase in revenue (for example, according to the option of assembly in Europe due to a higher degree of confidence in the goods produced in the EU with the corresponding certificates compared to those assembled in Russia) in year t; ΔC_t is the increase in capital investments in year t; T is the calculation period (step number of exclusion of a link in the supply chain that has the right of ownership or the right to use an infrastructure object); r_d is the discount rate.

The indicator $NPV_{LN(s)}$ determines the economic value of the s-option of configuration of the international logistics network. The contribution of the option under consideration to the total value of $NPV_{LN\,(s)}$ for all options of network development (s=1, 2, ..., S) according to the criterion of the maximum $NPV_{LN\,(s)}$ is determined by the formula:

$$k_s(NPV_{LN}) = \frac{NPV_{LN}(s)}{\sum_{s=1}^{S} NPV_{LN}(s)}. \quad (2)$$

The task of ranking the configuration options is laid out in a hierarchy (Figure 2) and must be solved using the methods of expert assessments.

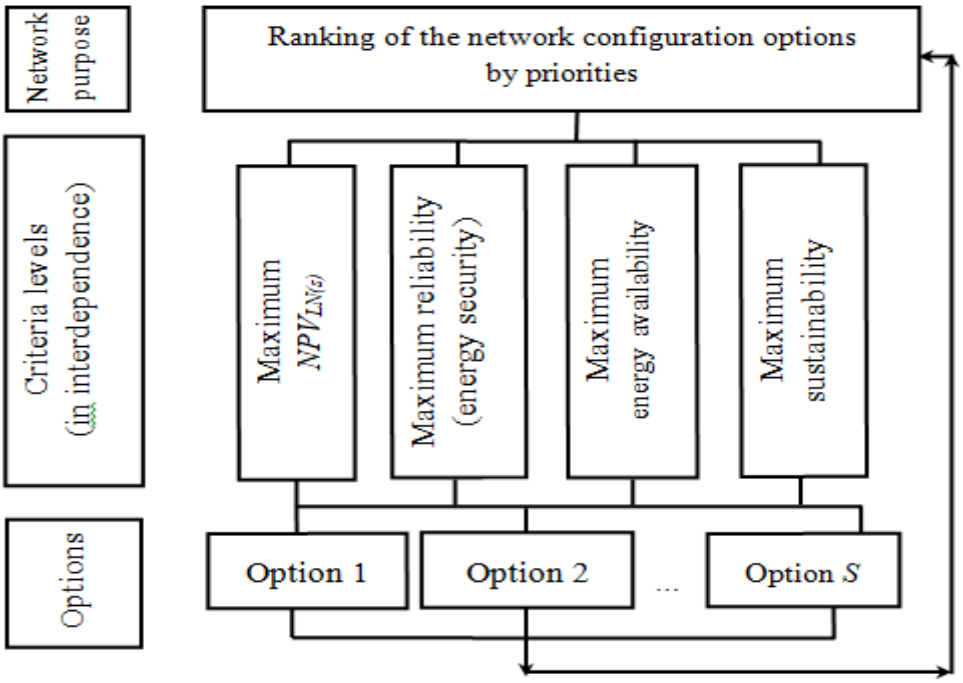

FIGURE 2
CLOSED-LOOP HIERARCHY OF RANKING THE OPTIONS FOR DEVELOPMENT OF A LOGISTICS NETWORK

The Relationship between the Quality Parameters of a Logistics Network and the Reliability Parameters of Links in International Supply Chains

The relationship between the qualitative parameters of a logistics network and the reliability parameters of the links of international supply chains in the context of investigating the ability of a logistics network to adhere to the planned level of stocks and functionality of operations in the international trade, justifying proposals for implementation of a scientific and methodological approach to designing a logistics network in the international trade.

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The author identified the main links of the international logistics network for the supply of energy equipment for solar power plants to the EU markets, consisting of:

- 2nd level suppliers (PRC and RF);
- 1st level suppliers: manufacturers of glass (PRC) and photocells (RF);
- Photocell assembler (the focal company - RF);
- 1st level customer: the European center for assembly of photovoltaic panels for solar power plants (Germany);
- 2nd level customers: centers for final assembly of solar power plants for private customers in the EU countries;
- 3rd level customers: official distributors in the EU countries;
- Final customers: households.

As alternatives, the author has elaborated seven options for configuration of an international logistics network for the supply of electric power equipment, presented by the analytical network as development options from the position of maximally satisfying the customers' needs, goals and interests of stakeholders and measures to integrate logistics flows and coordinate supply chains:

1) Creation of a logistics center in the Leningrad region with the possibility of assembling photovoltaic arrays from photovoltaic cells developed in Russia (by the company "Solnechny Veter") and special glass imported from China (LC in the Leningrad Region):

1.1) Delivery from China to St. Petersburg by sea;
1.2) Delivery from China to St. Petersburg by road;
1.3) Delivery from China to St. Petersburg by rail.

2) Transfer of other solar cells from St. Petersburg to Spanish or German production:

2.1) Transportation of individual parts necessary for the assembly of solar cells by sea from a Chinese port to ports in Spain or Germany;
2.2) Transportation of parts necessary for the assembly of solar cells by air from China to Spain or Germany;

3) Delivery of goods by air from China to St. Petersburg and their further shipment by trucks to Germany or Spain;

4) Delivery of goods from China to St. Petersburg and further shipment to Germany or Spain by sea.

DISCUSSION

Some methodological issues could arise regarding the nature of business processes from the open innovation theory point of view. Open innovations creating ecosystem for interacting people and organizations consider that the logic of creating and capturing value dynamically transcend organizational boundaries within that innovation ecosystem (Bogers, Chesbrough & Moedas, 2018). Such innovations were defined by Clayton M. Christensen as disruptive. With his term - disruptive innovation, Clayton M. Christensen reflected the complexity and inconsistency of innovation in General (Christensen et al., 2018). (Christensen, Olesen & Kjær, 2005) address how the open innovation concept can be analyzed from an industrial dynamics perspective, considering the specific measures that different companies take to manage open innovation from the standpoint of their differential position within the innovation system in question, the nature and stage of maturity of the technological regime, and the particular value proposition pursued by companies focusing closely on the complex interplay between technology entrepreneurs and incumbents. A concept model of open innovation built up in (Yun, Kim & Yan, 2020) is intended for exploring the existing open innovation channels, which can be useful to motivate engineering research increasing the development of open innovation and new open business models. In his article Chesbrough notes that the key trends in the development of open innovation are related to the field of digital transformation (Bogers et al., 2019). The development of digital technologies allowed small organizations to rapidly increase their influence in the market.

Authors could discuss the results of the study forming a scientific basis for the development of the logistics network process management practice based on the integrating of the separate business models into a system of business processes end-to-end design of logistics networks in international trade (as opposed to designing by individual links) using modern information and communication technologies in their digital format. Specifically, they reveal the

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prospects for creating smart contracting systems in companies as a complex of organizational and technological solutions to ensure the operation of smart contract and blockchain technologies (Silkina, Shevchenko & Sharapaev, 2021). By this, the results of the study determine the necessary conditions for achieving prospects related to the formulation of tasks related to the economy in the field of digital transformation (Osinovskaya et al., 2020). Currently, information and communication technologies being developed in a digital format (Shcherbakov & Silkina, 2017; Silkina & Shcherbakov, 2019) are radically changing the concept of management (Liao et al., 2018; Silkina, 2017; Zemtsov, Barinova & Semenova, 2019), and, in turn, challenging its methodology.

Some authors explore the complexity of the process of blockchains in logistics (Giordano, 2020; Jamal et al., 2019; Silkina et al., 2019; Verny et al., 2020). Authors suppose take into account both the features of digital ecosystems (Barykin et al., 2020a, 2020b, 2021a) and concept of digital twin in logistics (Barykin et al., 2021b, 2021e, 2021c, 2021d).

CONCLUSIONS

The study developed a scientific hypothesis on application of the idea of partiality in the design of international logistics networks, tested on the example of the “green energy” - the supply of electrical equipment for solar power plants to the EU markets with the interaction of the PRC and the Russian Federation:

1. The principles of creation of logistics networks in the international trade of electric power equipment during the transformation of supply chains into network structures, taking into account the interests of stakeholders and the priorities of the energy concept of the European countries, have been introduced into scientific and practical use.
2. The fundamentals of designing international logistics networks have been developed in the light of achieving customer-oriented logistics and the “green energy” supply chain management, ensuring the coherence of design solutions with the implementation of global customer value chains.
3. A multi-option approach has been developed to justify and make design decisions based on a choice, taking into account the interdependence of economic and environmental criteria (net discounted income on invested capital, energy security, reliability and energy efficiency).
4. The developed methodology has been tested with justification of the option of building an international logistics network for the supply of power equipment for solar power plants, providing for creation of a logistics center in Russia to coordinate the supply of components from the PRC and the assembly of finished products in the European countries.

In general, the idea of partiality supports the advantages of logistics integration in the development of trade and economic relations between the PRC and the Russian Federation.

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CONFLICTS OF INTEREST

The authors confirm that there is no conflict of interests to declare for this publication

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