Cargo delivery management in global supply chains under sustainable development conditions

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Abstract. The article aims to propose new approaches to cargo delivery management in global supply chains in the context of sustainable development. Recently, this issue gaining in importance and needs to be addressed, as international supply chains are becoming more complex, the range of transported goods is increasing, the requirements of the cargo clientele and the reliability of delivery in general are significantly increasing. Within the framework of the study, a critical analysis of scientific sources on cargo delivery technologies, the functioning of transport systems, the formation of global supply chains was carried out. The empirical research is based on the use of methods of systematization, deduction, expert assessments, statistical analysis – in the classification of cargo flows. Methods of statistical observation, correlation and regression analysis, mathematical modeling and optimization were used in the management of airline cargo flows and determining organizational-technological principles of interaction between participants in global supply chains. Scientific and practical recommendations for managing the cargo delivery technology in global supply chains are provided, which ensured the interests of all participants and allowed to unify this process in general. Keywords: management, cargo, cargo flow, logistics flow, technology, airline, supply chain.

1 Introduction

Technological parameters of delivery depend on the type of cargo, terms and conditions of delivery, infrastructure constraints, the nature of consumer demand for this type of goods, etc. The cargo delivery effectiveness can be ensured only with the highest quality interaction of all participants in this process and the use of advanced technical and technological solutions. In global supply chains, the competition between companies of different transport modes, between transport companies of the same transport mode, freight

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agents, logistics operators, freight forwarders is now fading into the background. Under these conditions, when organizing joint supply chains, competing companies turn into partners united by a common goal – ensuring the effectiveness of deliveries.

2 Literature Review and hypothesis development

The technology of cargo delivery significantly depends on international trade and changes in its development trends. The study of trends in production and global supply chains, including the module of international trade, the module of technological support and the module of users, as well as determining the possibility of changing trends until 2040 is relevant [1].

The symbiosis of scenario planning and urban freight transport management as a key way to reduce transport costs, reduce congestion and improve the urban environment should be recognized as a pioneering work in this direction [2]. Technological innovations, in particular electric transmission and autonomous technology seemed to be able to change also the delivery of goods and services, which should be recognized as a very likely scenario today [3].

The integration of urban logistics in order to optimize urban freight transport should be realized by mathematical modeling with the evaluation of scenarios under adequately defined constraints [4]. Solving the problems of developing sustainable transport systems in the European Union in most studies is now focused on reducing the impact on the environment [5].

An empirical study on the cargo delivery technology management by transport companies in global supply chains, at the first stage, was implemented by identifying the types and features of the classification of cargo flows and cargoes served by air transport. It is the involvement of air transport in supply chains that has been found to be a distinctive trend in the last decade.

Further, data on the network of Ukraine International Airlines, flights of partner air carriers, ground carriers, etc. were used. The cost of transportation of general and special categories of cargo was taken into account when forming the data.

The interconnectedness of trends in the development of global supply chains and sustainable development is considered in [6]. In the study [7], the authors aimed to analyze the company's effectiveness in implementing sustainable development goals throughout the supply chain. Sustainable development decisions that are made to improve the supply chain are studied in [8]. The gradual development of aspects of supply chain management in the context of sustainability is studied in [9]. In [10], the governance sustainable development mechanisms within the supply chains were examined including consideration of the possibilities of application in retail trade.

The mathematical apparatus for modeling the cargo flows of a network air carrier, on the basis of which the calculations were made, was presented by the authors in previous works and described in general [11]. Initial data were prepared using the Excel program. Then the tables were exported into Matlab program, where the raw data was transformed into the initial data of the optimization problem. A separate matrix was prepared for each group of constraints. The matrices were prepared in a sparse format.

Models for planning cargo flows in supply chains included a number of features that should be systematized to determine approaches to forming one's own. Thus, the internal cargo flow model takes into account the additional costs associated with different delivery times at borders and seaports under scenario planning [12]. The stochastic integer programming model of inter-terminal interaction in intermodal rail-maritime transportation allowed to minimize the waiting time for containerized cargo in sea terminals, as well as

the total train travel time [13]. All this allowed to determine the optimal model for solving the set tasks.

3 Metodology

A number of studies were carried out by some authors earlier. Thus, the simulation of network air carrier cargo flow management on the basis of the use of well-developed application software packages using the model in the author's formulation, characterization of the basic principles of modeling and the stages of this process was implemented [11]. Practical recommendations for the implementation of a linear-dynamic model of cargo flow management of a network air carrier were considered, taking into account retrospective analysis of airline cargo flow data, including tariff planning [14]. Assessment of the impact of implementing the cargo flow management system of a network air carrier on the logistics processes within the supply chain, as well as the calculation of the coherence coefficient to establish the degree of commonality of expert opinions on assessing the impact of the implementation of the cargo flow management system of a network air carrier were studied [15].

At the previous stage of solving the problems of air cargo transportation planning and management, in the first decade of the 21st century, mathematical models were characterized by NP-complexity, which implied their step-by-step simplification in order to bring them to practical calculations. This imposed significant restrictions on the methodological component, limiting the use of a number of methods. However, scholars have successfully solved a number of problems, even in the face of such limitations. Thus, an alternative model with a limited number of population, in the framework of dynamic income management models, for the first time allowed to avoid the problem of time fixation and allowed to extend the range of demand distribution, preserving the useful marginal properties of the finite-period model [16].

An integrated planning model combining the planning of passenger, cargo and combination flights to determine the maximum operating profit subject to appropriate constraints allowed the first integrated combination of purely air cargo transportation and cargo transportation on passenger aircraft [17]. In terms of methodological contribution, for the first time the flow connection technology was implemented to build a model that included multiple flows of the carrier's aircraft fleet, passenger flows and cargo service networks. The model was formulated as an integer multiprogram network consumption, and a family of heuristics based on Lagrangian relaxation, subgradient method, and the use of flow composition was proposed to solve the model.

Paper [18] reviews scientific studies on optimization methods in the cargo delivery management process and provides an analysis of risks. In [19], the authors conducted a comprehensive overview of the literature on issues of multimodal freight transportation quality. The problem of cluster routing of vehicles is investigated in [20]. The authors of [21] consider a relevant dynamic lot-size problem that includes a problem of delivery scheduling.

As part of the study, the following methods were used: systematization, deduction, expert assessment, statistical analysis, statistical observation, correlation and regression analysis, mathematical modeling and optimization. Nonlinear multiproduct model applied by air carrier was designed to project such scenarios in advance. Upon unexpected capacities shortage caused by demand fluctuation, model helps air carrier to decide what cargos have to be declined and related penalties paid. Decision made enables required capacities availability to move highly paid cargo that hit the market. This model gives precise determination to special cargo categories.

4 Results and discussions

An example of a technological scheme of the cargo flow movement in road and air transportation is given in Fig. 1. It shows that the sales system is formed by own system, agency sales, and sales through global cargo distribution systems under sustainable development conditions.

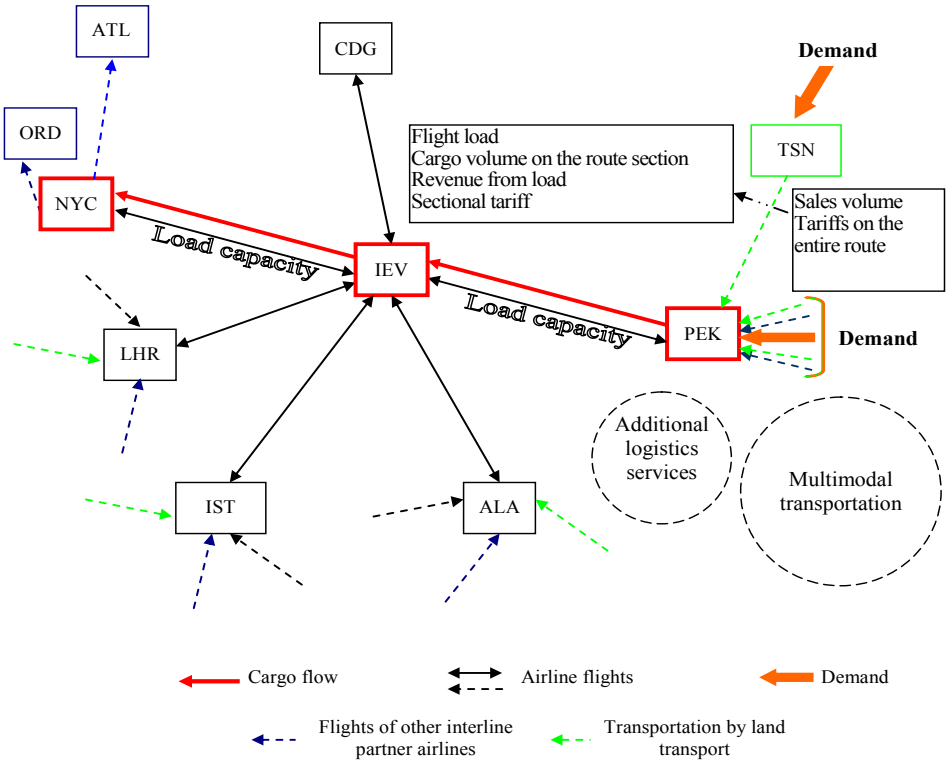


Fig. 1. Technological scheme of cargo flow movement in road and air transportation.

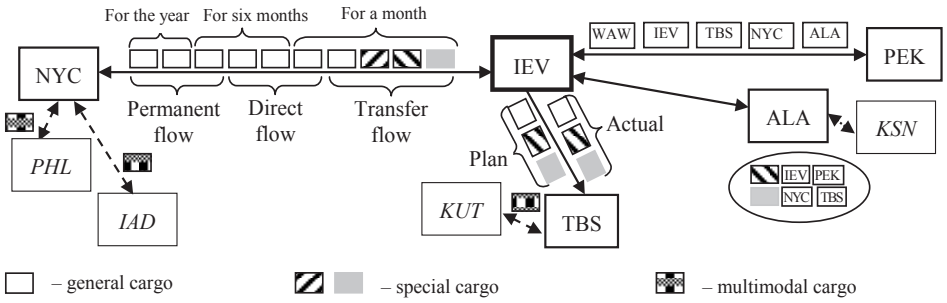
In addition, there is a practical possibility of providing multimodal transportation at the airport at the beginning of the flight, for which special ground deliveries are organized (in the analyzed case of Tianjin). Also it is possible to use the network of other air carriers (in the given example, on the New York–Chicago and New York–Atlanta routes). Ground carriers, providing interaction with air carriers, organize the maintenance of supply chains of goods, thus generating cargo flows of multimodal and intermodal transportation of goods. Air transportation becomes especially popular in combination with road transportation on the initial and final stages of the path, as air transport is purely mainline and cannot provide door-to-door and last-mile delivery alone.

Close cooperation with air transport is observed among international freight forwarders which are moving to a higher level of service and becoming 3-PL and 4-PL operators. In many cases, international freight forwarders act as agents of air carriers, organizing multimodal cargo deliveries for their clients involving air transport. Air carriers are generally interested in developing such cooperation with ground carriers, as this leads to an increase in the overall cargo flow in their airline network.

There is also the opportunity of obtaining additional services determined not only by the cargo carrier's capabilities, but also by the capabilities provided by other participants in the delivery chain, in particular, airports, as well as freight forwarders, logistics companies and

ground carriers. At the starting point, the sales volume and tariffs for the entire route are determined, while at the intermediate airport, the flight load, the volume of cargo on the route section can be changed, and the revenue from the load and the sectional tariff are determined.

Fig. 2 shows a scheme of cargo flows distribution on a part of the airline network including multimodal flows. Cargo flow can be divided into: by time frame – for the year, for six months, and for a month; by structure – permanent, direct, and transfer; and by cargo category – special and general. There is also a multimodal cargo flow, which is delivered at air tariffs by air carrier with one of the segments being serviced by road transport.



Airports: NYC – New York; IEV– Kyiv; WAW – Warsaw; TBS – Tbilisi; ALA – Almaty; PEK – Beijing.
Airports from and to which delivery is carried out by road to the airline's base airports: PHL – Philadelphia; IAD – Washington; KUT – Kutaisi; KSN – Kostanay.

Fig. 2. Scheme of cargo flows distribution on the part of the airline network including multimodal flows.

Overall, the costs of transportation with additional cargo will not change much, with fuel costs increasing slightly due to the increase in commercial loading. Revenues from freight loading are more clearly measured because freight tariffs and load size are known. The increase in cargo loading on passenger flights has resulted in a significant net profit, as costs grow at a slow rate, while cargo revenues increase significantly.

The technological processes of cargo handling on scheduled passenger and cargo flights are somewhat more complex than on purely cargo flights, due to the simultaneous performance of technological operations related to baggage, cargo handling and passenger service. This means that air carriers need to pay extra attention to the organization of cargo handling, including at the apron and when loading onto the aircraft. The process of transshipment from one mode of transport to another will also become much more complicated. As practice shows, the greatest losses of cargo are possible at the points where modes of transport join. The proposed innovations will significantly synchronize the global supply chain under sustainable development conditions and allow the logistics operator to build relationships with the air carrier according to more correct standards.

5 Conclusions and implications

Based on the critical analysis of scientific literature and practice, the most appropriate methods for conducting the study were identified, in particular, the methods of systematization, statistical analysis, correlation and regression analysis, mathematical modeling and optimization were used. When determining the patterns of cargo flows formation of network air carriers, it was found that among them a special role is played by the use of air transport as a key element of a significant number of global supply chains. Also, the current stage of the world economy development is characterized by the active

development of e-commerce and a significant increase in demand for fast and high-speed delivery of customer orders, and the use of cargo capacities of passenger aircraft. The regularities of cargo flows established during the study allowed to improve their classification and identify cargo flows suitable for air transport service.

By specifying the limitations and factors that affect the commercial interaction of air carriers and participants in the global supply chain, the task of increasing the air transportation profitability was achieved. The program implementation of the task of multimodal cargo delivery with the air transport participation made it possible to conduct computational experiments and, based on their results, provide scientific and practical recommendations for improving the cargo delivery technology by transport companies in global supply chains under sustainable development conditions.

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