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Georgii Prokudin, Oleksiy Chupaylenko, Viktoriia Lebid,
Olena Denys, Tetiana Khobotnia, Alina Nazarova

CHAPTER 2

LOGISTICS OF FREIGHT TRANSPORTATION AND CUSTOMS SERVICE IN INTERNATIONAL TRANSPORTATION

ABSTRACT

The logistics of cargo transportation and customs service in international communication acquires special importance in the modern conditions of martial law in Ukraine. International cargo transportation is important for supporting the economy of Ukraine. Important aspects of international transport logistics are studied: the development of international transport logistics in Ukraine in modern conditions, logistical risks in international transport service projects, the logistics of using information technologies to increase the efficiency of the organization of international freight transport, the peculiarities of the development of customs logistics of Ukraine in comparison with other countries, peculiarities of the logistics of piggyback transportation in international traffic. Practical measures are proposed to improve logistics solutions in transport and customs services in international traffic to ensure the efficiency and reliability of the national economy of Ukraine.

KEYWORDS

International transportation, customs service, logistics risks, information technologies, piggyback transportation.

The rapid development of the modern economy of Ukraine and its focus on European standards require the optimization of cargo delivery in international traffic. The state of the world market of transport services is characterized by growing competition, which is becoming more and more intense. At the same time, participants in foreign economic activity (customs carriers, buyers, dealers and manufacturers) are directly interested in prompt customs clearance of international cargo with confirmation of the customs value. One of the means of improving international transportation is customs logistics and its principles, which helps to solve complex tasks, helps to optimize the processes of export and import of goods, making them less expensive and faster.

Optimization of international transportation is not possible without the use of information technologies when designing international routes. The organization of cargo delivery in international communication requires coordination of the actions of all participants in the transport and

technological process of transportation, which are regulated and determined by international and national legal bodies, environmental, political and social factors. In the conditions of a high level of competition in the market of transport services, consideration of the issues of implementing the principles of customs logistics in road transport, the search for rational ways of transport service in accordance with the best European practices, the substantiation of transport and technological schemes for the delivery of goods, the implementation of progressive forms and methods of organizing the transportation process deserve special attention, improvement of existing and development of promising transport technologies.

Customs logistics of a subject of foreign economic activity (FEA) should be understood as the theory and practice of managing material, as well as accompanying information, financial, service and other flows, which are related to the need to comply with the requirements of the state customs when conducting foreign economic operations by enterprises. The main principle of logistics, like logistics in general, is cost optimization. In transport, it is achieved by observing savings due to the scale of freight transportation and the distance of routes. Economy due to the scale of freight transportation is due to the fact that the larger the load, the lower the transport costs per unit of weight. Savings due to the distance of the route is due to the fact that the longer the route, the lower the transport costs per unit of distance. These principles must be taken into account when evaluating alternative transport service strategies.

The essence of customs logistics is a combination of logistics processes of the participants of the Customs Union (customs carriers) with the processes of customs control and clearance of goods by the customs authorities of export, import and transit countries.

The main logistics function of customs activity is the logistics organization of the process of customs control of goods, which combines the processes of applying customs regimes related to the physical movement of foreign trade goods across the customs border and delivery conditions. Logistics, in order to accelerate this process of moving goods across the customs border, improves the standard logistics requirements for both customs regimes (i.e. customs) and customs carriers.

Let's note that high-quality customs logistics is closely related to the simplification of conditions and organization of foreign trade, especially with regard to customs operations and procedures and border administration. Improving customs control is becoming increasingly important to avoid unwanted delays and reduce customs risks, because the significant number and complexity of documents during customs control create additional costs of both time and money for businesses. The more complicated, longer and more expensive the procedures, the less competitive a country is on the international market.

2.1 DEVELOPMENT OF INTERNATIONAL TRANSPORT LOGISTICS IN UKRAINE IN MODERN CONDITIONS

In recent years, logistics has become an integral part of business strategy all over the world. Logistics is used differently at different enterprises, and it depends on innovation opportunities and priorities. Along with the processes of transportation, cargo handling and warehousing, the value

chain includes other types of activities that cannot be underestimated, especially if the enterprise is oriented towards the international market. Let's consider the main trends in the development of international transport logistics.

The globalization of the economy has created fierce competition among businesses for locations and accommodation, and the framework conditions of trade continue to undergo new and rapid changes. Mergers of enterprises and intensive development of information and communication systems only intensify these processes. The ability to calculate development trends is decreasing. All of this together leads to shorter planning times and requires faster decision-making and response. The division of labor of the economy, taking into account various distribution systems, is again based on communication (for example, regional networks, cooperative relations, etc.) and logistics. Therefore, it is very important to understand where logistics leads.

It's no secret that globalization of the economy is impossible without well-functioning logistics. The client does not have the goal of working with several transport and logistics companies, and therefore seeks competence in various activities on a one-stop-shop basis. In the automotive industry, this is implemented as follows: the manufacturer concentrates on design, assembly and sales. The share of participation in the production of the final product in this industry fell to 20 % [1]. Parts and components are purchased all over the world, the logistics company supplies them to various factories and distributes the goods in the trade network (supply chain management) supplies due to lack of relevant know-how. The main logistics trends can be characterized as follows:

– change of the production system. From production for the warehouse (Make-to-Stock) to production to order (Make-to-Order) [2]. For managers of manufacturing enterprises operating all over the world, the main task is to master the production of a product according to the individual requirements of customers;

– change in the distribution of goods. At this level, the traditional structure of sellers is reconciled with direct sales through a logistics company. The presence of logistics management at the manufacturer is required. At the same time, compliance with delivery terms is valued more than shortening these terms;

– merger and consolidation of trade and suppliers. Logistics plays an important role in realizing potential synergies in procurement, supply, goods receipt, distribution or e-logistics. Quantitative trends, namely: a decrease in the number of suppliers in the supply. Three quarters of international enterprises intend to reduce the number of their suppliers in the next five years. In the case of sales, as before, the reduction of delivery times remains relevant. Impact of e-business on logistics. Business processes within the framework of the B2C concept provide for the automation of more intensive deliveries, as customer expectations for shorter delivery times are higher than for conventional methods of order fulfillment. The appearance of more expensive delivery logistics and the implementation of after-sales services. Modification of processes within the enterprise with the help of expansion of electronic trading platforms. The integration of new participants into the supply chain will lead to the creation of the so-called "transparent pipeline" [3];

– changing the role of logistics in the international market. European third-level providers (3PL) are market leaders in terms of presence and process implementation capabilities. Ukrainian logisticians, as a rule, work in their country, American ones concentrate their efforts on the North American continent. In past years, the growth rate of European logistics providers on the American and European markets was 10 % per year. In the future, taking into account the development of B2C, this indicator will be exceeded;

– conquest of the logistics market by the fourth level providers (4PL).

Thus, the fourth level logistics provider as a network integrator manages all organizational and informational processes in the supply chain or enables the use of outsourcing based on the application of the Best Practice method for individual processes in order to improve the productivity of the entire network. The fourth level providers, during the creation of their own value, take some links of the supply chain and manage the entire business with the involvement of other logistics enterprises.

COVID-19 continues to have a devastating impact on the commercial trucking industry. The military conflict had a great influence on the logistics of international transport. In all countries of the world, there is an extremely high level of risk of default and insolvency in the field of road transport.

The level of risk in all regions of the world has reached the highest indicators and is nine to ten points on a scale from one to ten. This indicates an impending wave of bankruptcies in the road transport industry, which will affect the global economy and the possibility of its recovery after the pandemic.

The vast majority of motor vehicle enterprises whose interests are represented by the IRU, which is more than 3.5 million companies in the sector, belong to small and medium-sized enterprises [3]. It is the connecting link of all global supply chains and communication networks. Most of them struggle to cover their expenses. This is a huge threat to the world economy.

Tariffs for import freight transportation by road increased by 40–50 % on average. This is due to the shortage of transport in Europe, as well as increased excitement – recipients are trying to replenish stocks of goods. The lack of transport also provokes long queues at checkpoints, on average, it takes 4–5 days to drive a car one way. For example, on November 23, 2021, there was a queue of 800 trucks to leave Ukraine at the Yahodyn checkpoint [4].

The study also showed that the losses of the trucking industry at the global level reached 679 billion USD, and the passenger transport industry – at least 500 billion USD. The new data point to a particularly depressing situation in Europe, where the projected losses of freight transport operators have increased by two-thirds since the summer and reached 125 billion USD, and passenger transport operators – 94 billion USD [4].

If measures are not taken immediately, during the second wave of the pandemic, losses will increase many times over:

– road transport industry does not receive state financial assistance: without targeted measures, the sector is waiting for collapse;

– road transport losses in 2021 – both freight and passenger transport – are currently estimated at more than 1 trillion USD;

– sector is exposed to an extremely high risk of default and insolvency, which leads to mass bankruptcies of motor vehicle enterprises.

If governments do not take urgent action, a catastrophic number of transport operators will go bankrupt in the coming months, causing irreversible damage to supply chains and communication networks, and thus affecting the economy of Ukraine.

Sustainable Development Goals (SDGs) for the period until 2030, taking into account the general principles of the Muscat Treaty, approved at the IRU World Congress in Oman on November 6–8, 2018, as well as the provisions of the Ministerial Resolution "Strengthening cooperation, coordination and integration in the era of digitalization and automation on transport", adopted during the 81st session of the Committee on Internal Transport of the UNECE (February 19, 2019) [5].

The following norms must be included in the legal norms of national legislation:

– to harmonize provisions and norms of regulatory documents and standards in accordance with international agreements and UN conventions that ensure seamless international transportation and transit;

– with the joint efforts of representatives of all types of transport, take operational measures to digitize the industry and form effective interaction in intermodal transportation, striving for maximum complementarity of different types of transport;

– to ensure a smooth transition to paperless document circulation in road transport, including through the implementation of the digital TIR procedure and the electronic waybill e-CMR, which will meet the needs of all key participants in the logistics chain;

– to increase the guarantee limit for the TIR carnet to 100,000 EUR, implement new ones and promote the further promotion of existing TIR tools – iCarnet (guarantee for customs transit between the customs authorities of the same country), TIR+ (additional guarantee to the TIR carnet), eTIR, TIR-EPD (the IRU program on advance electronic information during transportation under the TIR system), participate in the implementation of intermodal projects using the TIR procedure, expand the use of subcontractors during transportation under the TIR system;

– take measures to conclude with China, as well as other countries of Asia and the Middle East, new bilateral and multilateral agreements on international road traffic, which would allow national road transport companies to gain access to the cargo base of China and Asian countries and expand the geography of transportation in new directions;

– to join the participation in the new eTIR pilot projects implemented by the IRU together with the UNECE, as well as to expand the use of the TIR digital procedure in transportation between Turkey and Iran, Georgia and Turkey, Turkey and Ukraine, along the so-called "Batumi Corridor", which covers Ukraine, Georgia, Azerbaijan and the Republic of Kazakhstan;

– to join the Additional Protocol to the Convention on the Contract for the International Carriage of Goods by Road (CMR) concerning the electronic waybill (e-CMR), and to introduce the specified electronic waybill into the practice of international road transport;

– to include in the national legislation norms that provide for mandatory initial and periodic training of drivers, minimum requirements for safety and quality standards of transport services;

– to contribute to the improvement of the working conditions of drivers, the involvement of new workers in the profession, including young people and women, and the solution of the problem of the lack of professional drivers;

– strive to simplify visa formalities, issue multiple annual visas to professional drivers, implement electronic visas as soon as possible;

– to speed up the work on agreeing changes to the European Agreement on the work of crews of vehicles producing international road transport (AETR), on the use of so-called smart tachographs, in order to support trade and tourism, prevent disruptions in the functioning of international supply chains;

– to improve the system of bilateral intergovernmental agreements on international road transport by canceling transit and bilateral permits for cargo transportation;

– to contribute to the creation of conditions for the realization of the potential of the transport market and foreign trade of their countries by raising the awareness of the ministries of transport and departments responsible for the regulation of motor transport activities, about examples of best practice with the simplification of international road transport and the transition to a permit-free principle of their execution;

– to contribute to the further development of high-quality and safe infrastructure and the creation of minimum social and living conditions for drivers while waiting for the crossing of borders or on the way through international transport and transit corridors, including TRACECA, GUAM, SCO, MTK "North-South", the Lazurite Corridor and the ring road motorways around the Black Sea, providing connections of the Trans-European Transport Network (TEN-T) with the Asian Motorway Network (AN);

– to conduct regular monitoring of the situation at border crossing points and, on the basis of best international experience, promote legal trade and cross-border transportation for the purpose of economic development, strengthening of regional stability and cooperation.

The level of risk in all regions of the world has reached the highest indicators and is nine to ten points on a scale from one to ten. This indicates an impending wave of bankruptcies in the field of road transport, which will affect the world economy and the possibility of its recovery after the pandemic and the war with russia.

2.2 LOGISTICAL APPROACH TO THE USE OF INFORMATION TECHNOLOGIES TO INCREASE THE EFFICIENCY OF THE ORGANIZATION OF INTERNATIONAL CARGO TRANSPORTATION

In the process of freight transportation, a situation often arises when the volume of goods supplied by its suppliers exceeds the capacity of the consumers' warehouses. In this case, we are faced with the need to use intermediate points for temporary storage of excess cargo and, as

a result, multi-stage transport tasks (MT). Also, often the matrix of transport correspondences between suppliers, consumers and intermediate points is not specified in an explicit form, but simply a cartographic scheme of their placement is introduced, i.e. the transport task is presented using a transport network (TN). We will provide a description of the logistics approach, which with the help of information technologies (IT) solves the task of optimal organization of transportation of unbalanced TN cargo. As a result of socio-economic changes taking place in Ukraine and under the influence of globalization phenomena, the logistics supply chains of goods and raw materials at enterprises are undergoing changes. They become longer and more complex in structure. Under the influence of IT, which accompanies material and financial flows, the integration of individual links of supply chains, which are independent economic units, is strengthened. The geography of the movement of material flows is also expanding, which is manifested, in particular, in the increase of freight transportation both in intercity [6] and in the international direction by road transport.

The efficient functioning of freight complexes (FC) ensures the optimization of the rolling stock of motor transport enterprises (MTE) that carry out freight transportation. The technology of cargo delivery using VC as intermediate temporary points of its preservation during regular mass transportation of cargo will allow to increase the number of MTE road trains on the routes and increase the efficiency of their use [7].

In the case of international cargo transportation on the Ukraine-EU and EU-Ukraine route, the transshipment point can be the FC located on the Ukrainian side of the border [8, 9]. The western regions of Ukraine bordering the EU member states, under the condition of effective cross-border cooperation, make it possible to use the beneficial geopolitical potential of the state. Long-term projects regarding the use of FC along the western border are one of the options for the rationalization of freight transportation, therefore, the rational organization of work and the interaction of MTE with terminal-warehouse complexes are very important and relevant.

The aim of the work is to develop a logistic approach to increase the efficiency of the organization of mass unbalanced cargo transportation on transport networks using methods and means of information technologies.

Let's provide a description of the logistics approach that solves the task of phased transportation of goods in its network presentation. At the same time, two options are considered, when the total storage capacities of cargo consumers and intermediate points are greater or equal (the first option) or less (the second option) than the volume of cargo available at the cargo suppliers.

Let there be m points of departure (PD) of homogeneous cargo $A_1, A_2, \ldots, A_m$, which have it, respectively, in volumes $a_1, a_2, \ldots, a_m$ and n points of its receipt (PR) $B_1, B_2, \ldots, B_n$, for which there are applications in volumes, respectively, $b_1, b_2, \ldots, b_n$. At the same time, the total volume of delivery of this cargo exceeds the total volume of orders for it, i.e.:

$$\sum_{i=1}^{m} a_i > \sum_{j=1}^{n} b_j. \qquad (2.1)$$

There are also l intermediate warehouses (IW) C_1, C_2, …, C_l for temporary storage of excess cargo, which can have it in the volumes, respectively, c_1, c_2, …, c_l, while there can be two versions of the ratios with the mandatory fulfillment of the condition (2.1):

– 1st option:

$$\sum_{j=1}^{n} b_j + \sum_{k=1}^{l} c_k \geq \sum_{i=1}^{m} a_i; \tag{2.2}$$

– 2nd option:

$$\sum_{j=1}^{n} b_j + \sum_{k=1}^{l} c_k < \sum_{i=1}^{m} a_i. \tag{2.3}$$

Let's consider the most interesting from a practical point of view, the 2nd case of cargo delivery (2.3) on a specific example, in which the layout of the points of departure and receipt of the cargo is presented by TN.

TN has: main cargo-generating and cargo-absorbing points; the distance between them (**Fig. 2.1**), namely: the PD of the cargo is marked with black circles (Kyiv – A1, Uman – A2), the PR of the cargo – with black squares (Lutsk – B1, Lviv – B2, Ivano-Frankivsk – B3, Chernivtsi – B4) and IW – with black triangles (Rivne – C1, Ternopil – C2, Kamianets-Podilskyi – C3).

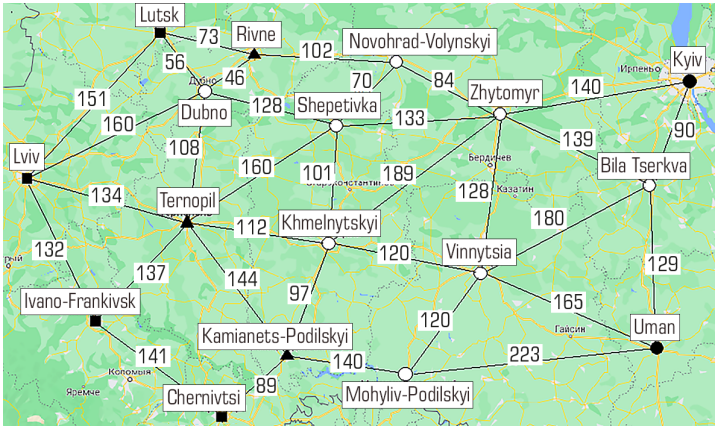

Fig. 2.1 Transport network

On the TN, the number of PD $m=2(A_1, A_2)$, which have its stocks $a_1=10$ cargo units (c.u.), $a_2=10$ c.u.; the number of PR $n=4(B_1, B_2, B_3, B_4)$, which have applications for it $b_1=2$ c.u., $b_2=2$ c.u., $b_3=2$ c.u., $b_4=2$ c.u.; the number of intermediate IW $=3(C_1, C_2, C_3)$, the capa-

city of which is: $c_1=1$ c.u., $c_2=1$ c.u., $c_3=1$ c.u. TN also has 8 intermediate transit points. **Fig. 2.2** presents TN in a simplified form.

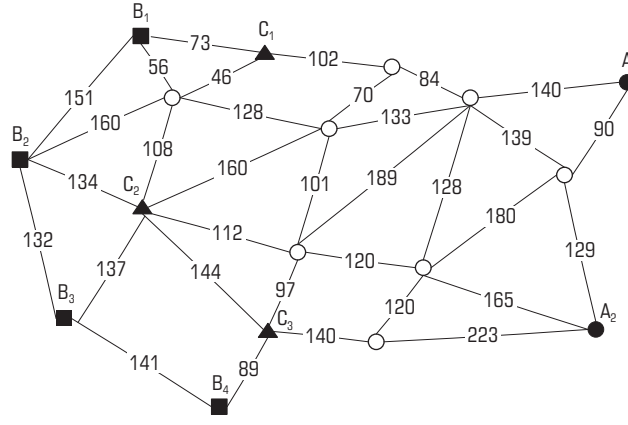

Fig. 2.2 Transport network in a simplified form

For convenience and its further processing, let's reduce the network representation of freight transportation to a matrix form. First, let's manually compile an array of distances between neighboring TN nodes. Secondly, with the help of the corresponding program, let's build an array of transport correspondences between all TN nodes of based on the obtained array [10, 11].

Applying the data of the transport correspondence matrix using the method of the shortest routes, let's find the shortest distances on the TN from each PD of the cargo to each PR and IW (**Table 2.1**), as well as from each IW to each PR of the cargo (**Table 2.2**). In parallel, routes corresponding to these distances are formed, which contain intermediate nodes. As an example, let's present the routes from the Haysyn PD to its four PRs:

Kyiv → Zhytomyr → Novohrad-Volynskyi → Rivne → Lutsk=399;

Kyiv → Zhytomyr → Novohrad-Volynskyi → Rivne → Dubno → Lviv=532;

Kyiv → Zhytomyr → Shepetivka → Ternopil → Ivano-Frankivsk=570;

Kyiv → Zhytomyr → Khmelnytskyi → Kamianets-Podilskyi → Chernivtsi=515.

A software module (SM) was built for the planning of mass freight transportation on TN based on the Delphi algorithmic programming language [12, 13].

Fig. 2.3 presents a fragment of the work of the SM, which shows the results of its operation – the volume of cargo transportation between PD A_1, A_2 and PR B_1, B_2, B_3, B_4 at the first stage of cargo delivery (its realization is 3,834 value units (v.u.)); volumes cargo transportation between PD A_1, A_2 and IW C_1, C_2, C_3 also at the first stage of cargo delivery (its realization is 1086 v.u.); volumes of cargo transportation between IW C_1, C_2, C_3 and PR B_1, B_2, B_3, B_4 at the

second stage of cargo delivery (its realization is 296 t.v.u.); the volume of cargo transportation between PD A_1, A_2 and PR B_1, B_2, B_3, B_4 at the third stage of cargo delivery (its realization is 3834 t.v.u.); the total cost (current) of all three stages of cargo delivery is 9050 o.v.

Table 2.1 Distances from PD to PR and IW

PD/PR points	Lutsk	Lviv	Ivano-Frankivsk	Chernivtsi	PD/IW points	Rivne	Ternopil	Kamianets-Podilskyi
Kyiv	399	532	570	515	Kyiv	326	433	426
Uman	527	531	534	452	Uman	454	397	363

Table 2.2 Distances from IW to PR

IW/PR points	Lutsk	Lviv	Ivano-Frankivsk	Chernivtsi
Rivne	73	206	291	387
Ternopil	164	134	137	233
Kamianets-Podilskyi	308	278	230	89

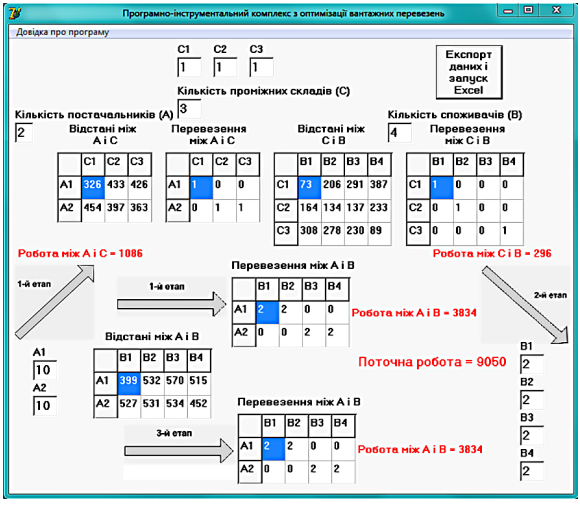

Fig. 2.3 A fragment of SM work at MT stages 1, 2, and 3

Then SM issues an informational message about the continuation of further calculations. In the case of pressing the OK key, the MT solution continues and as a final result we have (**Fig. 2.4**) a fragment of cargo delivery at the fourth stage. The results of the implementation of this stage

are given here, namely: the volume of cargo delivery between PD A_1 and PR B_1 at a cost of 399 v.u. and the total cost of all four stages of cargo delivery, which is equal to 9449 v.u.

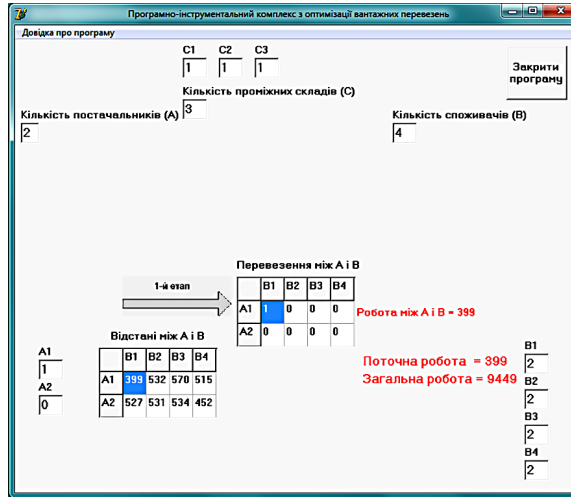

Fig. 2.4 A fragment of SM work at the 4th MT stage

The presented logistic approach to the organization of mass transportation of goods on transport networks in the event of their imbalance is implemented in the form of a software-instrumental complex that combines the stages of reducing the network representation of freight transportation to a tabular form and planning mass transportation of goods on TN. It showed its efficiency and economy in the organization of cargo transportation at the car companies of the association of international car carriers of Ukraine, both in long-distance and international connections.

This approach, which is based on the use of modern methods and means of information technology, demonstrates one of the directions of logistics for solving a multi-stage transport problem. At the same time, it has a limitation, which is contained in the fact that at the 2nd, 3rd and subsequent stages of solving the multi-stage transport problem, an assumption is made about the readiness of all its recipients to place this cargo in the volumes corresponding to their initial order, i.e. is considered in time [14, 15].

2.3 LOGISTIC RISKS IN PROJECTS OF TRANSPORT SERVICE OF INTERNATIONAL TRANSPORTATION

Development of the national network of international transport corridors (hereinafter NNITC) and bringing their condition to international norms and standards is one of the priority directions in

the development of the transport industry of each country. At the same time, 2022 has become the most difficult year for the logistics infrastructure of Ukraine. Since the beginning of the russian federation's war against Ukraine, significant volumes of transport infrastructure have been damaged. In connection with the continuation of hostilities in certain territories of the country, it is currently impossible to establish the total final amount of destruction [16]. Today, transport corridors in Ukraine play an important role related to the change of transport and logistics routes, due to the reorientation of cargo flows and the increase in the load on the western border crossings for the maintenance of international cargo transportation. The challenges that are a consequence of the destruction of the transport infrastructure, and which lead to the need to increase the capacity of the western border crossings and transport infrastructure, including the development of multimodal terminals, as well as the establishment of international transport links of Ukraine, are a key and urgent issue today.

In Ukraine, there are a number of risks in the transport service of logistics flows, which is the result of a forced change in the approaches to the formation of transport logistics in connection with the closure of a number of sea ports, the destruction of transport infrastructure and, as a result, the breakdown of transport and logistics chains of transportation. Therefore, the Government of Ukraine and a large number of scientists pay considerable attention to the issue of the quality of the functioning of the international transport network in Ukraine and the improvement of the infrastructure of logistics flows for the maintenance of international cargo transportation. It is worth noting that the issue of risk management in the projects of reconstruction and development of transport networks of the highest category is currently considered particularly relevant.

Before the start of the full-scale military invasion of the russian federation on the territory of Ukraine, the regulatory and organizational aspects of the transport industry of Ukraine were harmonized with the countries of the European Union. This made it possible to meet the needs for cargo transportation and ensure the development of the country's economy by changing approaches to the formation of transport and logistics solutions and the development of modern transport infrastructure. Thus, Ukrainian legislation corresponds to European legislation regarding road traffic, basic technical requirements for roads, etc. However, despite the presence of the order of the Cabinet of Ministers of Ukraine on the approval of the transport strategy until 2030 and the developed program for the development of NNITC, there is a significant lag in ensuring the quality of transport infrastructure and risk management in road development projects of the highest category [16].

Today, scientists pay considerable attention to the issue of the development of NNITC on the territory of Ukraine for development and note the need for their development from the point of view of increasing the transit capacity of the state and the effectiveness of the interaction of various types of transport on the network of international transport corridors (hereinafter referred to as ITC). At the same time, despite the presence of a large number of developments, a number of problems require further research regarding the improvement of the level of service for carriers on the ITC road routes and the definition of a risk management strategy for the transportation of goods in international traffic.

To ensure the gradual integration of Ukraine into the European and world transport systems, it is necessary to strengthen and expand cooperation within the framework of international transport organizations, which involves the creation of a complex of services on the international road network of transport corridors that meet international standards: increasing the quality of international road transport and increasing the level of competitiveness of transport services to a level attractive to foreign carriers.

As a result of the active development of the infrastructure of transport corridors by neighboring states, competition for the provision of transport services and maintenance of the main transit cargo flows passing through the territory of our state is increasing. It is worth noting that despite the difficult situation in the logistics infrastructure of Ukraine, the European Commission made changes to the indicative maps of the Trans-European transport network, including Ukrainian logistics routes and giving them important strategic importance. At the same time, the Ministry of Infrastructure of Ukraine noted that the inclusion of logistics routes in the TEN-T network makes it possible to eliminate existing obstacles in conducting logistics operations, attract European investments for the modernization of transport infrastructure, and gain access to EU assistance tools in the development of the Ukrainian part of the TEN-T network, to develop multimodal transportation, reduce logistics costs, and improve the quality of services during the transportation of goods [17, 18].

Taking into account such a step, the transport network of Ukraine should guarantee consumers an example of a service (these are international road carriers) of a high, uniform and constant level of comfort and safety. A traffic management infrastructure with available information for users based on the interaction of traffic management projects on the international transport network at the European, national and regional levels should also be included. Therefore, taking into account the prioritization of infrastructure projects in Ukraine, the preparation of proposals for the development of the TEN-T network within the country and coordination with the TEN-T network in the neighboring countries of the European Union should take place today.

In order to evaluate the possible options for the transport service of international cargo transportation (and this includes the delivery of humanitarian aid) in risky situations (today it is a change of logistics routes in connection with military actions), it is advisable to use a mathematical apparatus of simulation modeling. It is necessary to create a risk management algorithm that will provide an opportunity to analyze external and internal factors that contribute to the quality of transport services for international transport in TEN-T transport network projects and to evaluate possible decision-making options taking into account risk.

Today, an unsatisfactory situation has developed in the market of transport services, as not all enterprises involved in the organization of international transportation services are able to provide the entire range of transport services. Some enterprises were forced to radically change the logistics routes of international transportation, some enterprises encountered technical and technological problems in the organization of transportation, which affected financial resources. To the internal factors of the unsatisfactory development of the transport market, external ones are added, which indicate the inactivity of the mechanisms of protection of Ukrainian international

carriers and forwarders from foreign and domestic unscrupulous cargo owners, competitors, criminal elements on highways due to the lack of control over cargo during transportation. External factors of influence are presented in more detail in **Fig. 2.5** [18].

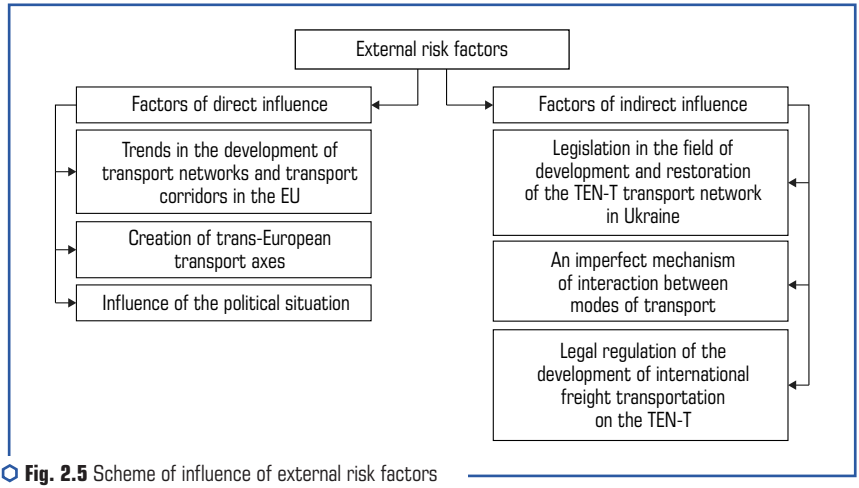

Fig. 2.5 Scheme of influence of external risk factors

As a result of the active development of the infrastructure of transport corridors by neighboring states, competition for the provision of transport services and maintenance of the main transit cargo flows is increasing.

The conducted studies show that today two main risks can be identified, which require a comprehensive solution. The main tools of the risk assessment methodology are presented in **Fig. 2.6**.

The conducted studies show that today two main risks can be identified, which require a comprehensive solution.

First of all, it is the risk of a decrease in the quality of transport services of international carriers due to non-compliance with international standards, the slow implementation of the informatization of the transport process during the delivery of goods and their lack of connection with customs technologies. Secondly, this is a significant decrease in the volume of cargo transportation due to the high level of competition between the routes of neighboring states.

The analysis of export-import and transit cargo flows confirms the loss of a significant share of freight traffic through international road transport corridors on the TEN-T network. On all ITCs passing through the territory of the country, there is a reduction in the volume of transportation and a change in their priority, which is a consequence of the military invasion of the customs territory of Ukraine. Thus, the average reduction in the volume of transportation on the national network of ITC is more than 75 %, a particularly significant reduction in the volume of transportation is observed on the ITC "Baltic-Black Sea" (93.9 %), ITC No. 9 (77.43 %), ITC No. 5 (75.44 %) [19, 20].

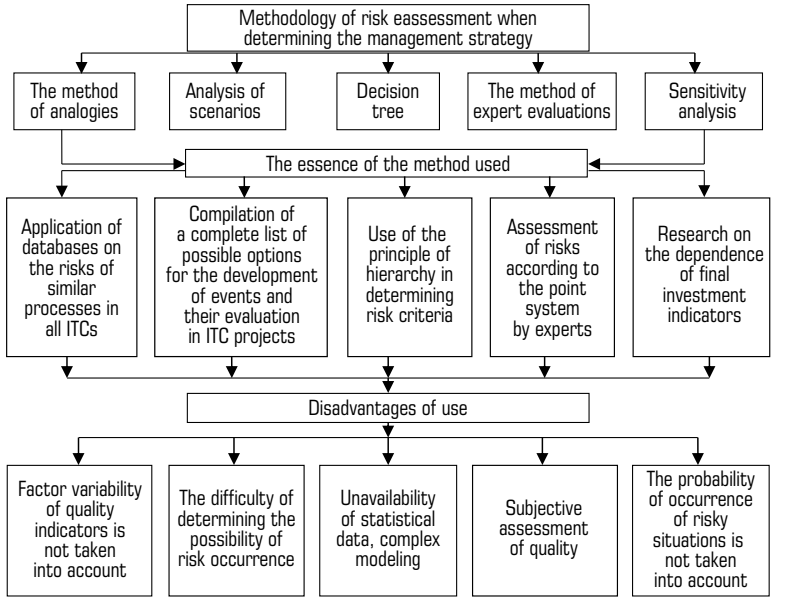

Fig. 2.6 Risk assessment methodology in transport service projects on the TEN-T transport network

Risk management on the ITC network should ensure the adoption of rational management decisions based on a reasonable choice of measures to neutralize risks and corresponding management methods.

The main strategies of risk management in projects of transport service of international transportation of international transport corridors include:

1) risk avoidance (creating a transport service quality system; bringing the level of quality to European requirements by modernizing existing and building new logistics multimodal terminals in the western regions of Ukraine with the functions of integrated transport and logistics centers, implementation of customs services and the use of modern digital solutions for managing logistics flows (TMS, YMS, WMS)). This is the most simple and radical direction in risk management projects in the organization of international cargo transportation [21, 22];

2) risk acceptance (the development of a system of restrictions that helps reduce the degree of risk in international road freight transportation) means that the participant in the transport operation (carrier) considers it appropriate to accept the risk in order to obtain higher profits or other benefits, but on the condition that this does not harm other carriers;

3) reducing the degree of risk directly by carriers involves guaranteeing the safety of cargo transportation by complying with AETR requirements, developing a contractual and legal framework

with partner countries to ensure the regulation of technological issues of international multimodal transportation.

Applying simple methods of risk analysis, it is possible to get the necessary information about the probable values of risk factors in projects and understand which factors are associated with the largest fluctuations of the output parameter (the quality of international transport service projects). At the same time, human and financial resources are saved. In particular, the application of quantitative risk analysis facilitates and makes more effective the use of the experience of experts (information from carriers), who seek to express their judgments in the form of probability distributions of different assessment values, and not in the form of reducing them to a single numerical value of the indicator.

To reduce the degree of risk, conditions should be applied that will ensure an increase in the quality of transport services, namely:

– diversification (laying of traffic routes not only on the ITC, but also on roads of international importance of class M);

– limiting (establishment of a system of restrictions, which contributes to reducing the degree of risk on the ITC);

– localization (prediction of conditions that may lead to risky situations);

– impact on the source of risk (so that the threat becomes minimal).

Thus, the improvement of the quality system in transport corridor development projects should contain components that will be used to avoid risk manifestations:

– quality assurance of transport services on road routes (quality assurance of transport services, Q_a) [23];

– quality management in ITC development projects (quality management, Q_m) [24];

– planning of the quality of transport service of motor carriers (quality planning, Q_p) [25];

– improving the quality of transport services (improving the quality, I_q) [26].

Therefore, the analysis of risks in the management of the quality of transport services of international transportation is an important component not only when attracting investment funds for the development of the TEN-T transport network within Ukraine, but also when determining the strategy for managing infrastructure objects within the limits of road routes.

The adoption of changes to legislation that simplify the procedures for attracting investments for infrastructure projects will make it possible to forecast the volumes of export-import flows, as well as to attract transit cargo flows. And the implementation of joint projects and integration with EU transport and logistics networks through the harmonization of organizational and legal aspects of activity will provide an opportunity to achieve harmonization both in terms of quantitative indicators regarding the increase in transit transportation, and in terms of a system of qualitative indicators. Such indicators include the level of ensuring the speed of transportation, the safety of transportation, compliance with weight standards, the preservation of cargo during transportation, the level of service at the state border, and others.

As a result, ensuring the quality of transport service in the continuity of cargo traffic by road transport across the state border is key to the functioning of the country's economy, ensuring the

transportation of export cargo, as well as the import of humanitarian and defense cargo, which is a necessary component for the country's recovery.

2.4 PECULIARITIES OF DEVELOPMENT OF CUSTOMS LOGISTICS OF UKRAINE IN COMPARISON WITH OTHER COUNTRIES

The essence of customs logistics is a combination of logistics processes of participants in foreign economic activity with processes of customs control and clearance of goods by customs authorities of export, import and transit countries.

The main logistics function of customs activity is the logistics organization of the process of customs control of goods, which combines the processes of applying customs regimes related to the physical movement of foreign trade goods across the customs border and delivery conditions. Logistics, in order to accelerate this process of moving goods across the customs border, improves the standard logistics requirements for both customs regimes (i.e. customs) and customs carriers.

Let's note that high-quality customs logistics is closely related to the simplification of conditions and organization of foreign trade, especially with regard to customs operations and procedures and border administration. Improving customs control is becoming increasingly important to avoid unwanted delays and reduce customs risks, because the significant number and complexity of documents during customs control create additional costs of both time and money for businesses. The more complicated, longer and more expensive the procedures, the less competitive a country is on the international market [27].

In order to pass customs control, there is a need to calculate logistics processes for predicting and preventing customs risks, the need for a financial guarantee, studying customs regimes and the features of their application, choosing the most optimal of them [27].

As for the efficiency of customs logistics in international trade systems, it is evaluated using the Logistics Performance Index (hereinafter LPI), which is calculated by the World Bank for 160 countries of the world, includes various indicators that demonstrate the level of development of national sectors of logistics services and the degree of integration of countries to global value chains.

The TOP-10 countries according to the Logistics Efficiency Index are as follows: Germany, Sweden, Belgium, Austria, Japan, the Netherlands, Singapore, Denmark, Great Britain, Finland closes the top ten. The lowest position in the ranking of countries according to the Logistics Efficiency Index is occupied by Afghanistan – the sum of points is equal to 1.95, this country has the lowest score for all components of the Index [27]. In **Fig. 2.7** presents the aggregated international results of the Logistics Efficiency Index of the TOP-10 countries, Ukraine and Afghanistan (occupies the last position).

The index is based on seven main indicators of logistics efficiency: the efficiency of the customs and other border clearance process; the quality of transport and IT infrastructure in the field of logistics; ease and accessibility of organization of international transportation; competencies of the local logistics industry; the ability to track international transportation; internal logistics costs; timeliness of cargo delivery to the delivery point [27].

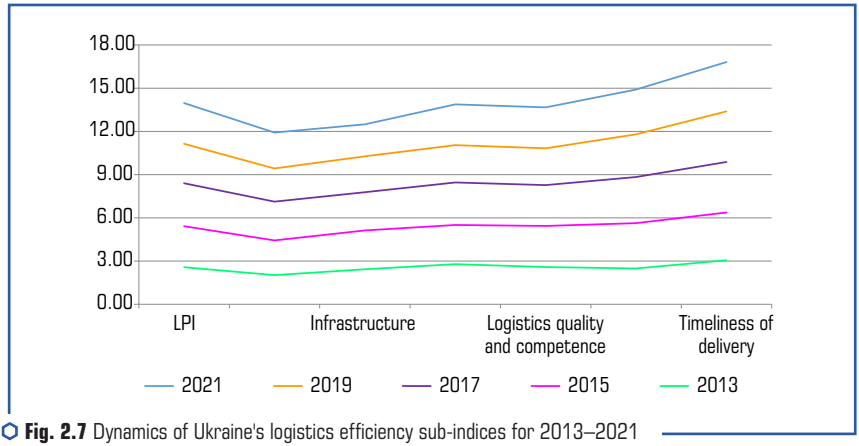

Fig. 2.7 Dynamics of Ukraine's logistics efficiency sub-indices for 2013–2021

Ukraine ranks 66th out of 160 in the ranking of the LPI based on the aggregated results of 2021. The number of points is 2.83, as a percentage of the maximum logistics efficiency index – 57.17 %. As for the LPI components, the work of the customs of Ukraine was rated at 2.49 points, which is 85th place, infrastructure – at 2.22 points (119th place), international transportation – at 2.83 points (68th place), the quality of logistics and competence – 2.84 points (61st place), cargo tracking and consumption – 3.11 points (52nd place), cargo delivery timeliness – 3.42 points (56th place). In general, the results of the efficiency of logistics processes in Ukraine **Fig. 2.7** are satisfactory [27, 28].

We are observing growth in all sub-indices and the general LPI. Undoubtedly, Ukraine has higher than average indicators in the ranking according to LPI, but there is still a need to improve the work of customs, develop infrastructure, increase the quality of logistics and reduce its cost.

In today's world, logistics has become an integral part of business strategy, especially for organizations or industries that focus on the international market. Globalization of the economy has caused fierce competition among enterprises for locations and accommodation. In addition, the conditions of trade suggest the implementation of new and rapid changes. Mergers of enterprises and intensive development of information and communication systems only strengthen these processes. In such conditions, interaction between organizations and improvement of their economic efficiency is built on logistics. This is due to the increase in the role of logistics services in the modern world market. Therefore, recently, the growth of the volume of logistics services, characteristic of developed countries, has already begun to be observed in almost all countries involved in world trade [28].

Logistics has a significant impact on the development of market relations:

– product and service competition is developing;

– costs of moving goods, i.e. procurement, warehousing, unloading and shipping of products, are reduced;

– resources are rationally used;

– branches of production infrastructure function effectively.

In general, the logistics services market in Ukraine is poorly developed, poorly structured, and there is no reliable information about its structure and revenues (**Fig. 2.8**).

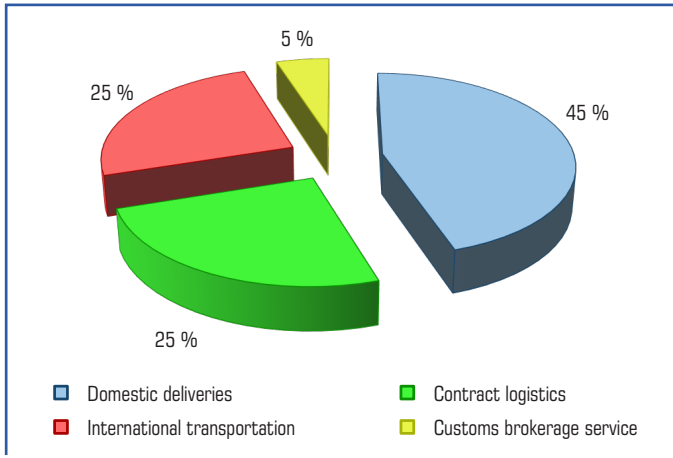

Fig. 2.8 The structure of the logistics market of Ukraine for 2021

Any cargo entering the territory of Ukraine must pass customs control – this is clearly stated in the Customs Code of Ukraine. Calculation of logistics processes from the point of view of customs operations, risk prediction and financial guarantee is the entire task of customs logistics.

Customs logistics includes a number of measures aimed at solving issues related to the organization of international delivery of products and goods. Customs logistics is designed to solve complex tasks designed to make import and export processes the most optimal and less costly [29].

Among the main tasks of customs logistics, let's highlight:

1) selection of delivery conditions;
2) choice of customs regime;
3) choosing a guarantee for the delivery of goods;
4) optimization of the customs clearance procedure;
5) improvement of the customs control procedure;
6) customs clearance;
7) placement and optimization of the functioning of cargo customs complexes;
8) outsourcing technologies in customs affairs;
9) selection of an intermediary in customs matters;
10) information provision of customs activities.

Functions of customs logistics are presented in **Fig. 2.9**.

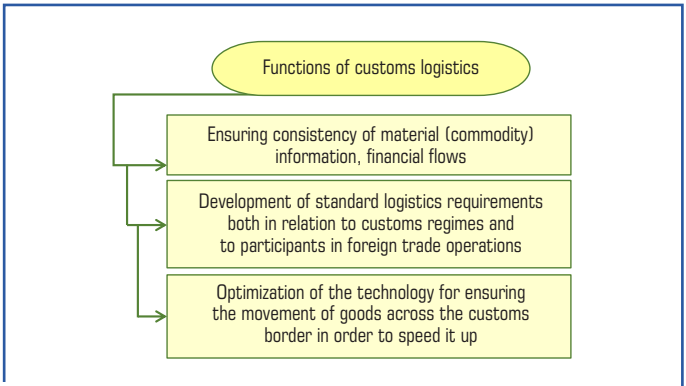

Fig. 2.9 Functions of customs logistics

The basis of customs and logistics flows are foreign trade material flows of a cross-border, transit nature. They include input (import) and output (export) types of material flows. They are accompanied by information flows: outgoing (from customs to the central authority), incoming (on the contrary), accompanying (documents for goods).

Financial flows are outgoing (transfer of duty to the state budget) and incoming (state financing of customs).

After analyzing the given data, let's conclude that the volume of implemented logistics services in the period from 2016 to 2021 is characterized by a growth trend. Comparing the total indicator for 2021 with the indicator for 2016, let's observe a two-fold increase. The index of warehouse services increased fivefold, and the value of auxiliary services in the field of transport increased by 70 % [28, 29].

This trend can be explained by the active growth of demand for logistics services, both in the world and in Ukraine. The expansion of the international network of multimodal transportation is accompanied by a change in service priorities in the direction of reducing the risk of disruptions in the continuity of transportation of goods and passengers [30].

The development of international trade, which contributed to the arrival of global manufacturers on the market together with global operators that serve them, the development of retail networks, terminal and customs clearance of goods, a large circle of participants in the supply chain, unification of rules and norms of foreign economic activity, standardization of parameters of technical means in various countries, the emergence of flexible automated production.

External economic indicators of the provision of auxiliary and additional transport services are presented in **Fig. 2.10** [31, 32].

As it is known, the main principle and method of logistics consists in finding optimal management influences on economic objects under the given conditions of their functioning. The search for optimal managerial influences includes the formalization of the goals of economic activity (construction

of objective functions of optimization criteria) or the assignment of preference relations in the interval of possible results [33–35].

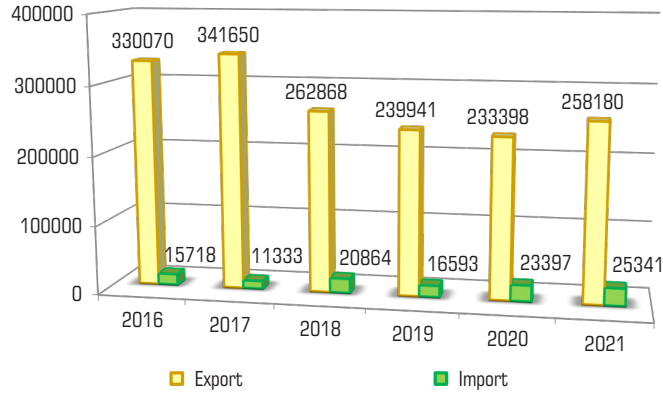

Fig. 2.10 Dynamics of foreign trade in auxiliary and additional transport services (thousands of USD)

Therefore, the customs logistics of the foreign trade entity should be understood as the theory and practice of managing material, as well as accompanying information, financial, service and other flows, which are connected with the need to comply with the requirements of the state customs affairs when conducting foreign economic operations by enterprises to ensure their competitiveness on domestic and foreign markets.

2.5 IMPROVEMENT OF THE LOGISTICS OF PIGGYBACK TRANSPORTATION IN INTERNATIONAL TRAFFIC

The current level of economic development and its globalization are making increasingly high demands on the transport sector. In the first place is the speed, economy of delivery, as well as the preservation of cargo. An important factor is the environmental friendliness of freight transportation. All of these requests are completely met by a new method of cargo delivery for our country – contra-railway transportation. piggyback transportation is a combined road and rail transportation for the delivery of goods. For such transportation, special railway platforms are needed, on which car trailers, semi-trailers, removable bodies or the entire road train together with cargo are installed and secured. It is not easy to develop piggyback transportation. One of the reasons is that they are not provided for in our customs legislation. What is a piggyback? This is a certain vehicle, a symbiosis of a car and a railway carriage, which in principle is a separate type

of transport. Piggyback transportation is quite complicated, and practically no one can handle it on our transport market. This business is not developed and cannot develop if there is no economic efficiency and demand for this transportation.

The technology of piggyback transportation originated in the USA and Canada, and when it was transferred to Western Europe, it encountered significant difficulties: many artificial structures, such as bridges, tunnels, and the height of the power supply suspension, did not allow the successful application of this technology. To solve this problem, part of the artificial structures were reconstructed, pockets were deepened in the area of the bottom of the platforms, where the wheels of road trains and truck trailers descend. This technology is called a "running" highway. This is the transportation of a car with a trailer or semi-trailer on a railway platform with a lowered floor. At the same time, if the driver follows along with the cargo in a special passenger car, then it will be accompanied intermodal/combined transport. If the cargo is transported without a driver, it is unaccompanied intermodal/combined transport. Auto plants have established the production of highway tractors equipped with a sleeping place for one of the drivers, with a large fuel reserve, with speeds of 100 km/hour and above. The coupling of such a tractor with a van or with a container chassis was called a road train. The "running" highway technology has a number of significant disadvantages: the transportation of excess weight, i.e. the tractor, semi-trailer and accompanying driver; the need to create comfortable conditions for the accompanying driver during the journey. However, such technology finds its application in a number of countries with highly developed road transport [36, 37], since the increase in the volume of rail-road road transports, their routing led to the conclusion of the possibility of reducing the number of special transshipment cargo ramps at railway terminals, as well as the terminals themselves on the roads. Railway routes with trailers are formed at a limited number of nodal railway stations. Cargo from numerous customers is delivered to these hub terminals by road transport. Here they are combined into a railway route destined for another hub terminal, from which they are also delivered to the recipient by road transport to the destination.

Piggyback transportation is one of the promising areas of interaction between modes of transport, because it uses two types of transport: road and rail, and their further growth is expected. Important factors in favor of piggyback transportation are:

– a significant reduction in the time of customs and border control;
– passing customs control at the border without the direct participation of the driver;
– significant savings in costs for issuing shipping documents;
– high speed and guarantee of cargo delivery in accordance with the train schedule (justin time);
– safety of transportation in any weather conditions;
– preservation of the vehicle and its motor resources;
– maintenance of highways;
– preservation of the environment.

At the moment, the functioning of this type of combined transportation has been suspended in Ukraine. The reason for this is the imperfect legal framework, as well as the low level of education

of carriers on this issue, which is quite low. Piggyback transportation for Ukraine could solve a number of problems:

– the problem of a limited number of transportation permits, including transit permits;
– the problem of wear and tear of highways;
– facilitating the work of drivers and reducing the number of accidents;
– more efficient use of fuel;
– reducing the level of environmentally harmful emissions, exhaust gases and noise;
– increasing the transit potential of the country with the lowest costs.

The potential of Ukraine in the field of piggyback transportation is quite large. Two powerful international routes pass through the territory of Ukraine: Kyiv (Ukraine) – Klaipėda (Lithuania) – Kyiv (Ukraine) – piggyback train "Viking" and Kyiv (Ukraine) – Slavkuw (Poland) – Kyiv (Ukraine) – combined transport train "Yaroslav". The question of choosing the type of connection in modern realities is becoming more and more relevant [37].

To date, many systems of cargo delivery by combined modes of transport have been developed. Wide distribution of piggyback transportation in Austria and Switzerland.

The main advantage of systems for the organization of piggyback transportation is the improvement of the efficiency and productivity of logistics processes. The system makes it possible to increase the competitiveness and quality of services during cargo transportation.

The first is the well-known RoLa (Rollende Lanrstrasse – rolling road) system of transit rail transportation through the Alps. This is the transportation of motor vehicles on railway platforms with a lowered floor using the Ro-Ro (roll-on-roll-off) horizontal method of loading and unloading, when the vehicles themselves enter or leave the railway platform. The advantages of such loading are the possibility of parallel loading and unloading of each individual platform in the train and the possibility of opening and closing on both sides of the terminal.

Let's consider the technological aspect of this system. The design involves a standard carriage consisting of two supporting ramps and three standard trolleys. Support ramps are connected in the middle compartment. Each ramp has a rotating platform and a mounting device. The platform is articulated and symmetrical with two loading platforms.

Characteristics of rolling stock: speed of movement – up to 120 km/h; wheels with a diameter of 957 mm; length – 32 m, weight – 42 tons; standard coupling devices; loading rotary platforms [38].

There is also the RoLo technique (lift-on-lift-off) – a lifting technique of loading with the help of cranes. This technique is widely used in Europe for unaccompanied trailers, has a universal platform and a saddle-shaped floor profile with pockets for trailer wheels. It is used for removable bodies and containers. The system is intended for transporting trailers on a railway platform with a lowered floor. The loading and unloading of the trailer is carried out on its own from the end of the vehicle, and the trailer is attached to the platform by the drivers themselves by installing a rolling device under the wheels.

However, such a system significantly reduces the operational characteristics of rolling stock, which must be taken into account when choosing a transportation system.

The use of these systems allowed European carriers to reduce the time required to form a piggyback train to 40 minutes. According to the latest technical standards, the requirements for piggyback transportation are as follows: vehicle waiting time – no more than 20 minutes; time to form a train – no more than 1 hour; track change time is minimal; easy access to the terminals by road and rail; the maximum border crossing time is 20 minutes for a train.

In Europe, the following cargo delivery systems are also widely used, such as Flexiwaggon, which is adapted to the specific needs of Swedish transport. The platform rotates hydraulically. The process of its management is fully automated. The truck driver has only to press a button. No equipment or special terminal is required. Flexiwaggon can move at a speed of up to 160 km/h. It takes 7 minutes to load or unload the entire batch onto the train. Loading and unloading operations can be carried out anywhere. The only requirement is the strength of the foundations, they must withstand the weight of the car. The Flexiwaggon can load 50 tonnes compared to the 42 tonnes offered by similar systems. The volume load is also higher because the Flexiwaggon platform is lower and has improved passability along the rail [39, 40].

CargoBeamer (German – freight train) combines automated, parallel, fast and inexpensive cargo transshipment between road transport and railways. A saddle platform with a floor height of 200 mm and a wheel diameter of 920 or 950 mm is used.

The vehicle is installed on a pallet, which is pulled onto the platform by electric traction. At the same time, the pallet with the trailer is loaded in the opposite direction. A strict condition for this system is the need for accurate positioning of trains at the terminal. Parallel, automated horizontal overloading of fifth-wheel coupling devices is carried out in the following sequence: the vehicle approaches the loading gate; the vehicle enters the platform attachment; removal of the semi-trailer on the platform attachment; receiving a semi-trailer; the tractor leaves the cargo gate; cargo in standby mode for an electronic loader; the electric forklift arrives at the cargo gate; start of horizontal movement; parallel horizontal loading of a semi-trailer; end of horizontal movement; the electric forklift leaves the loading gate.

The main advantages of the system are high productivity and the ability to quickly load the entire train. The difficulty in operating this system is the need for traction mechanisms for the platform and appropriate hydraulic equipment. The system is characterized by a high cost of transportation.

Modalohr is currently used in the mode of unaccompanied transportation. The Modalohr system has an extensive network on the territory of the European Union.

A feature of the system is the need for an appropriately equipped terminal. This technology is a development of the French company Lohr. It offers the possibility of sequential loading. The loading platform rotates around the middle of the train. The possibility of transporting both individual semi-trailers and road trains gives this system a great advantage in comparison with the above-mentioned systems.

The MegaSwing technology is designed for various unaccompanied transports and is currently being tested under various temperature conditions. As indicated in specialized platform used is divided into two parts with the help of hydraulic systems. The system is adapted for the

transportation of any semi-trailers and containers. MegaSwing requires less investment, as it does not require the use of additional intermodal terminals and specialized equipment. Transshipment occurs horizontally (Ro/Ro). For the loading and unloading process, it is necessary for one of the employees to monitor the transshipment process and the operation of the hydraulics. There are two types of platform Single (weight – 24 t, length – 19.5 m) and DUO (6 axle) station wagon. Features of the system are ease of operation, lack of necessary precise positioning of the platform along the loading/unloading front of the vehicle, and high productivity [41].

Next, let's present the comparative characteristics of the above systems (**Table 2.3**).

Table 2.3 Comparative characteristics of the main piggyback systems of cargo transportation in Europe [38]

Features	System				
	Cargo Speed	**Flexi waggon**	**Mega swing**	**Cargo Beamer**	**Modalohr**
Maximum speed	120 km/h				
Overload time	5 min	10 min	5 min	5 min	5 min
Type of load	Horizontal				
Parallel loading/unloading	Available				
Congestion at the terminal	yes	no	no	yes	yes
The need for qualified personnel	yes	yes	yes	no	no
Maximum permissible weight	38.5 t	44 t	38.5 t	44 t	38 t
Maximum number of semi-trailers	33	27	33	31	36
Cost of platforms (EUR)	120 000	175 000	–	105 000	355 000
Terminal cost (million EUR)	2.3	–	–	1.2	3

The use of one of the above systems when carrying out cross-rail transportation significantly reduces the time spent on forming a cross-rail train, which significantly affects the time of delivery of the cargo to the recipient. Undoubtedly, the implementation of one of the above systems requires large capital investments, but the benefits that the transport industry of Ukraine can receive from this are undoubtedly greater.

According to the cost criterion, the CargoBeamer and Flexiwaggon systems are the most profitable, but they are poorly developed and technologically designed for the transportation of either individual road trains or individual semi-trailers.

In Ukraine, it is more expedient to consider the issue of implementing the Modalohr system, which is adapted for the transportation of both individual semi-trailers and road trains, and also has an extensive network of active routes across Europe.

Now let's consider the cost indicators of one or another type of transportation.

Value indicators, or more precisely, the cost of transportation is one of the factors that allows to determine the advantages of one or another type of connection. Let's create a graphic model of transportation. This will allow not only to correctly present the initial data, but also to determine

the equivalent distance for direct car and piggyback connections, that is, the distance at which the transportation costs for both types of connections are equal.

Cost indicators, or more precisely, transportation costs, are one of the factors that make it possible to determine the advantages of one or another type of connection. The principle of cost minimization is at the basis of determining the efficiency of transportation, when choosing between direct road and piggyback connections [39]:

$$F = \begin{cases} C_a \\ C_k \end{cases} \rightarrow \min, \tag{2.4}$$

where C_a – the cost of direct road transportation; C_k – costs for piggyback transportation to the same point (taking into account the costs of railway and automobile components).

The basis of the developed models is the equivalent transportation distance according to the cost criterion L_{eq} – this is the distance of direct automobile transportation, when the equality $C_a = C_k$ is fulfilled. Since the basis of the model for determining the area of effective use of backhaul coupling is the principle of cost minimization, that is, backhaul coupling will be effective if:

$$C_k < C_a. \tag{2.5}$$

This is possible provided that:

$$L_a > L_{eq}, \tag{2.6}$$

where L_a – the distance of a direct road connection from the consignor to the consignee.

Formula (2.4) can be detailed in the form:

$$\begin{cases} C_a = S_a \cdot L_a; \\ C_k = S_a \cdot L_{ad1} + T_r \cdot L_r + S_a \cdot L_{ad2} \end{cases} \rightarrow \min, \tag{2.7}$$

where S_a and T_r are, respectively, the cost of 1 km by road transport and the tariff for transporting a car by railway, which includes all associated costs for the organization of the railway part of the rail link; L_{ad1} – the distance of the approach from the consignor to the railway station of departure; L_{ad2} – the distance of the approach from the railway station of departure to the consignee; L_{ad} – the distance between the consignor and the consignee when delivering goods by road transport [40].

To determine the equivalent distance of cargo delivery, the hypothesis was adopted that the consideration of the displacement parameters of all participants in the transport process affects the final result:

$$L_{eq} = \left(\frac{L_r \left(k^2 - 1\right)}{2k\left(k \cos\alpha - 1\right)} \right). \tag{2.8}$$

In order to establish the distance of equivalent cargo delivery, the hypothesis was adopted that taking into account the location parameters of all participants in the transport process will increase the efficiency of cargo delivery in international traffic. With the help of the developed mathematical model for determining the equivalent distance according to the cost criterion, when the consignor coincides with the railway terminal of departure and the model when the consignor is far from the terminal, the factors affecting the definition of the area of effective use of piggyback connections were established.

2.6 METHODOLOGY FOR CHOOSING THE OPTIMAL LOGISTICS CHAIN OF CARGO DELIVERY IN INTERNATIONAL TRAFFIC

The structure of the technological process of delivery of a batch of cargo is described by the structure of the logistics chain (LC), which reflects the sequence of participation in the delivery process of various subjects of the transport market. At the same time, the task of choosing the optimal structure of LC should be distinguished from the task of choosing the optimal carrier (logistics operator, contractor for the performance of certain types of work, cargo terminal, checkpoint, etc.) or the optimal delivery route. The selection of optimal options for logistics chains (LC) for cargo delivery is carried out on the basis of alternative options, which largely determines the efficiency of cargo transportation.

In the work of Shyriaeva, S. and Svirin, D. [41] studied LC of supplies during international road transportation of goods, in particular: principle diagram and general structure of LC, main types of LC, options of supply chains. Unfortunately, the content of these studies is of a generalized nature, which is not specified and does not contain the specifics of international cargo transportation.

Authors Lysa, S. and Zimina, A. [42] in their article highlight the problems and prospects for the development of the cold logistics market of Ukraine, namely, they analyze approaches to the interpretation of the concepts of cold supply chains, cold logistics, logistics of perishable goods, which can be used as synonyms. The issue of managing the cold chain of supply was also considered, key logistical solutions for effective management were determined, such as: ensuring and controlling the temperature regime during transportation, storing them in specialized warehouse complexes, assembly, receiving; informational support of cold LC. The current state of logistics service of cold supply chains in Ukraine is assessed. The article is purely descriptive and statistical in nature.

In the article by Naboka, R. and Shuklina, V. [43], which is devoted to the influence of the integration of LC of supplies on increasing the company's potential, it was established that integrated LC of supplies allow the most effective implementation of the company's goals and help the enterprise to get out of the economic crisis. It has been established that when using integrated supply logistics, all functional units of the enterprise are combined into a single process, and the purpose of such unification is to prevent irrational losses of resources and achieve the maximum economic result. The authors emphasize that the integration of LC supplies leads to an increase in the potential of the entire enterprise, and all interrelated logistics functions must be performed in a coordinated man-

ner – in the form of a single function. It was concluded that the integration of LC supplies allows to achieve a synergistic effect of the enterprise's activities. The content of the article is declarative in nature and does not contain specific measures to implement the goal of integrated supply logistics.

Scientific and methodological work of authors of Tokmakova, I., Ovchynnikova, V., Korin, M. [44] devoted to the management of supply chain management and aimed at harmonizing the interests of the participants of the process of product movement, optimization in accordance with the requirements of society as a whole and end consumers in particular. According to the authors, the management of supply chains is aimed at achieving two main effects: increasing the amount of income from sales of products/services by increasing the level of service, accuracy of supply and reducing demand fluctuations; reduction of costs by reducing the level of inventories, invoices and transactional costs in purchases, storage and marketing, as well as improving the use of production and logistics capacity. The content of work is educational in nature, provides theoretical knowledge of the management of supply chain management, but does not give practical experience.

The authors Tiurina, N., Goy, I., Babiy, I. [45] give a generalized definition of LC as a linear-orderly set of individuals and legal entities (suppliers, intermediaries, carriers, etc.), which are directly involved in bringing a particular batch of products to the consumer. Generalized examples of LC and logistics network are also given. The content of the submitted material is generalized, does not contain applied direction.

Therefore, based on the analysis of recent studies and publications concerning the issues of logistical chains of delivery of goods, it is advisable to explore in more detail the logistics chains of international car transportation of goods and focus on determining new ways of improving the efficiency of such transportation.

Let's consider the main options of LC when delivery of goods by road. For a single option of LC delivery of cargo in the logistics system, the initial link, which generates a material flow, is a cargo owner of one of the subsystems (consignor), and the final link, absorbing, is a cargo owner of the second subsystem (cargo). Accordingly, the initial and final link of the LC is the cargo. Physical movement of the material flow is carried out by the carrier. The function of organizing the process of moving material flows is implemented by the freight forwarder (4PL provider), using the resources of freight terminals (3PL providers). As the organizer of the process of realization of the need for freight owners in the movement of cargo, the freight forwarder is a link of LC, on which information flows are closed. Since the cargo owner, in order to fulfill its need for moving the cargo, appeals to the freight forwarder, the financial flow in LC passes first and foremost from the freight owner to the freight forwarder, and then – to other participants of the chain. The simplest option of LC is presented in **Fig. 2.11**.

Formally, the simplest *LC* is a collection of elements of the following species:

$$LC^{1F} = \left\{FO; C^{A}; FF^{A}; CP; FC\right\}, \tag{2.9}$$

where FO – consignor; C^{A} – carrier to the consignor country; FF^{A} – freight forwarder in the consignor country; CP – checkpoint at customs; FC – consignee.

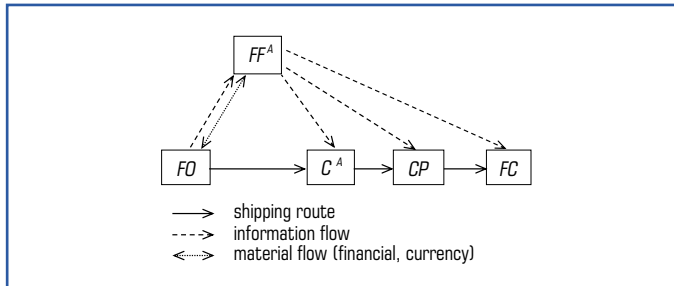

Fig. 2.11 The easiest LC option

For the presented option, the coordination of the cargo delivery process is carried out by one forwarder, one carrier is involved in the transportation, cargo terminals do not participate in the cargo delivery process. The consignor declares the need to move the delivery. The forwarder chooses a carrier that can deliver the given lot to the consignee, after contacting the consignor, bilateral agreements on the organization of delivery are concluded between the forwarder and the consignor, as well as between the forwarder and the carrier. The consignor pays for the forwarder's services, and the forwarder pays for the carrier's services from the amount received from the customer. The carrier delivers the delivery from the consignor to the consignee (if the delivery is carried out in domestic traffic) and to the border, and then from the customs checkpoint to the consignee (if the delivery is carried out in international traffic) [3]. This LC option is typical for the delivery of goods by road transport if the volume of the delivery being sent corresponds to the carrying capacity of the vehicle.

A more complex LC option with the participation of two forwarders and, accordingly, two carriers is shown in **Fig. 2.12**.

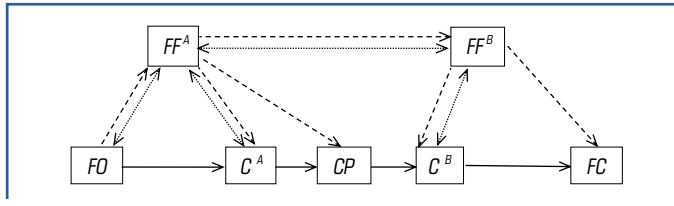

Fig. 2.12 LC option with two forwarders

This LC option (LC^{2F} type chain) is a combination of the following elements:

$$LC^{2F} = \left\{FO; FF^{A}; C^{A}; CP; C^{B}; FF^{B}; FC\right\}, \quad (2.10)$$

where C^{B} – carrier in the consignee's country; FF^{B} – freight forwarder in the country of the consignee.

The forwarder of one of the subsystems, after receiving the application from the consignor, determines the carrier for delivery of the delivery to the border, and also sends the application to the forwarder-partner. The forwarder-partner organizes the delivery of the delivery from the border to the consignee, using a carrier in the country of destination for this purpose. In this case, four bilateral agreements are signed: between the forwarder and the consignor, between the forwarder and the carrier from the shipping subsystem, between two forwarders, and between the foreign forwarder and the carrier. At the same time, the consignor pays for the services of the first forwarder, who, in turn, pays for the services of the carrier in the country of destination, as well as the services of a foreign forwarder, from the remuneration received. The forwarder-partner pays for the services of the carrier in its country from the received remuneration.

The cargo terminal takes part in the process of moving the material flow in the LC option presented in **Fig. 2.13**.

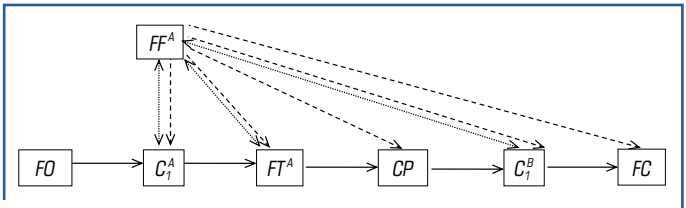

Fig. 2.13 LC option with one terminal

This LC option (LC^{1T} type chain) is a set of 7 main elements:

$$LC^{1T} = \left\{FO; FF^A; C_1^A; FT^A; CP; C_2^B; FC\right\}, \tag{2.11}$$

where C_1^A – carrier in the country of the consignor, which ensures the delivery of the cargo to the terminal; C_1^A – carrier in the country of the consignee, which ensures the delivery of cargo in international traffic; FT^A – cargo terminal in the country of the consignor.

After receiving the application from the cargo owner, the freight forwarder assesses the feasibility of delivering the cargo through the cargo terminal. If such a chain option is economically feasible, the freight forwarder searches for carriers to deliver the cargo to the cargo terminal and to take out the consolidated batch for delivery directly to the consignee. After determining the participants in the delivery process of the delivery, four bilateral agreements are signed: between the forwarder and the consignor, between the forwarder and the carrier in the country of delivery, between the forwarder and the cargo terminal, between the forwarder and the international carrier. The freight forwarder pays for the services of the carriers and the cargo terminal from the funds received in the freight forwarder's account from the cargo owner. This LC option is used when transporting a delivery of cargo to the terminal by road transport, consolidating

shipments by direction and subsequent delivery by main transport (railway). A possible option is when the cargo terminal organizes the removal of a consolidated delivery, acting as a 4PL provider.

A more common option of delivery of a delivery of cargo with the participation of trunk transport is the LC option with two terminals, which is shown in **Fig. 2.14**.

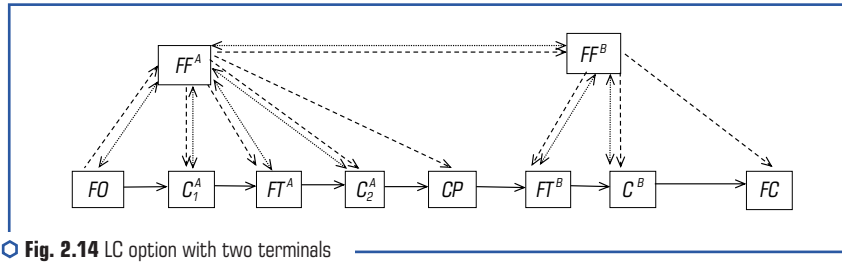

Fig. 2.14 LC option with two terminals

LC option with two LC^{2T} terminals is a set of the following elements:

$$LC^{2T} = \left\{FO; FF^A; C_1^A; FT^A; C_2^A; CP; FF^B; FT^B; C^B; FC\right\}, \quad (2.12)$$

where FT^B – cargo terminal in the country of the consignee.

In this case, the cargo owner declares the need to move the delivery. The freight forwarder, upon receiving the application, determines that the most effective option with two cargo terminals will be the most effective of the many options for LC. After that, the freight forwarder determines the carrier in the country of dispatch to deliver the delivery from the consignor to the terminal, concludes an agreement with the terminal and the trunk carrier, and also sends an application for the need to deliver the delivery with a foreign forwarding partner. The freight forwarder-partner organizes the delivery of the delivery from the terminal in its country to the consignee. For this, it chooses a carrier in the country of destination and concludes an agreement with the terminal. For this option of the chain, the following agreements are signed: in the consignor and the carrier in the country of dispatch, between the forwarder and the cargo terminal in the country of the sender, between the forwarder and the international carrier; in the country of the consignee – between the forwarder and the cargo terminal in the consignee's country, between the forwarder and the carrier in the country of destination; an agreement is also concluded between the two forwarders. The freight forwarder in the country of the consignor pays for the services of the carriers in the country of departure and destination, the terminal in the country of departure, and the services of the freight forwarder-partner from the remuneration received from the cargo owner. The freight forwarder in the country of the consignee pays the terminal and the carrier in its country from the funds received from the first freight forwarder. There is also an option where the carrier's services are paid for by the terminal in the country of the consignor, and the carrier's services for the delivery of the delivery to the consignee are paid for by the cargo terminal in the consignee's country.

Considered in **Fig. 2.12**–**2.15** situations can be used as the main LC options of when developing a set of alternatives. LC options are considered taking into account the availability of freight terminals and forwarder-partners in the direction of delivery.

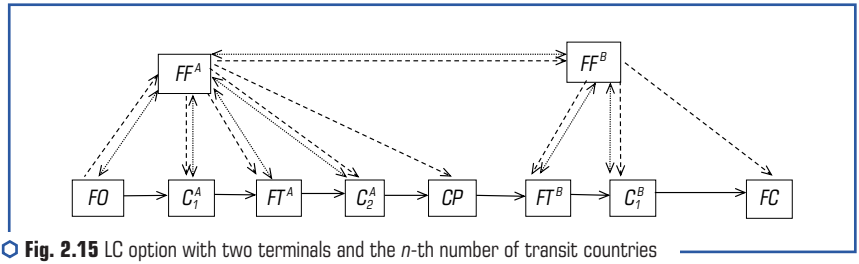

Fig. 2.15 LC option with two terminals and the *n*-th number of transit countries

The structure of any LC of cargo delivery by road transport can be attributed to one of the following options: 1FF – the simplest delivery option with one forwarder, 2FF – delivery with the participation of two forwarders without the involvement of cargo terminals, 1FT – delivery of a batch of cargo through a cargo terminal, 2FT – delivery with the participation of two cargo terminals, $N_{c.t.}$ delivery with the *n*-th number of transit countries. The set of data options of delivery of cargo delivery.

CONCLUSIONS

In recent years, logistics has become an integral part of business strategy all over the world. Logistics is used differently at different enterprises, and it depends on innovation opportunities and priorities. Along with the processes of transportation, cargo handling and warehousing, the value chain includes other types of activities that cannot be underestimated, especially if the enterprise is oriented towards the international market. Let's consider the main trends in the development of international transport logistics.

COVID-19 continues to have a devastating impact on the commercial trucking industry. The war with russia had a great impact on the logistics of international transportation. In all countries of the world, there is an extremely high level of risk of default and insolvency in the field of road transport.

The level of risk in all regions of the world has reached the highest indicators and is nine to ten points on a scale from one to ten. This indicates an impending wave of bankruptcies in the road transport industry, which will affect the global economy and the possibility of its recovery after the pandemic and martial law.

Studies have shown that the logistics of transportation and customs service in international communication acquires special importance in the modern conditions of martial law in Ukraine. International cargo transportation is important for supporting the economy of Ukraine. Important aspects

of international transport logistics are studied: the development of international transport logistics in Ukraine in modern conditions, logistical risks in international transport service projects, the logistics of using information technologies to increase the efficiency of the organization of international freight transport, the peculiarities of the development of customs logistics of Ukraine in comparison with other countries, peculiarities of the logistics of cross-trailer transportation in international traffic.

The following norms must be implemented into the legal norms of national legislation:

– to harmonize provisions and norms of regulatory documents and standards in accordance with international agreements and UN conventions that ensure seamless international transportation and transit;

– with the joint efforts of representatives of all types of transport, take operational measures to digitize the industry and form effective interaction in intermodal transportation, striving for maximum complementarity of different types of transport;

– to ensure a smooth transition to paperless document circulation in road transport, including through the implementation of the digital TIR procedure and the electronic waybill e-CMR, which will meet the needs of all key participants in the logistics chain;

– to increase the guarantee limit for the TIR carnet to 100,000 EUR, introduce new ones and promote the further promotion of existing TIR tools – iCarnet (guarantee for customs transit between the customs authorities of the same country), TIR+ (additional guarantee to the TIR carnet), eTIR, TIR-EPD (the IRU program on advance electronic information during transportation under the TIR system), participate in the implementation of intermodal projects using the TIR procedure, expand the use of subcontractors during transportation under the TIR system;

– take measures to conclude with China, as well as other countries of Asia and the Middle East, new bilateral and multilateral agreements on international road traffic, which would allow national road transport companies to gain access to the cargo base of China and Asian countries and expand the geography of transportation in new directions;

– to join the participation in the new eTIR pilot projects implemented by the IRU together with the UNECE, as well as to expand the use of the TIR digital procedure in transportation between Turkey and Iran, Georgia and Turkey, Turkey and Ukraine, along the so-called "Batumi Corridor", which covers Ukraine, Georgia, Azerbaijan and the Republic of Kazakhstan;

– to join the Additional Protocol to the Convention on the Contract for the International Carriage of Goods by Road (CMR) concerning the electronic waybill (e-CMR), and to introduce the specified electronic waybill into the practice of international road transport;

– to include in the national legislation norms that provide for mandatory initial and periodic training of drivers, minimum requirements for safety and quality standards of transport services;

– to contribute to the improvement of the working conditions of drivers, the involvement of new workers in the profession, including young people and women, and the solution of the problem of the lack of professional drivers;

– strive to simplify visa formalities, issue multiple annual visas to professional drivers, implement electronic visas as soon as possible;

– to speed up the work on agreeing changes to the European Agreement on the work of crews of vehicles producing international road transport (AETR), on the use of so-called smart tachographs, in order to support trade and tourism, prevent disruptions in the functioning of international supply chains;

– to improve the system of bilateral intergovernmental agreements on international road transport by canceling transit and bilateral permits for cargo transportation;

– to contribute to the creation of conditions for the realization of the potential of the transport market and foreign trade of their countries by increasing the awareness of the ministries of transport and departments responsible for the regulation of motor transport activities, about examples of best practice in simplifying international road transport and transitioning to a permit-free principle of their execution;

– to contribute to the further development of high-quality and safe infrastructure and the creation of minimum social and living conditions for drivers while waiting for the crossing of borders or on the way through international transport and transit corridors, including TRACECA, GUAM, SCO, MTK "North-South", the Lazurite Corridor and the ring road motorways around the Black Sea, providing connections of the Trans-European Transport Network (TEN-T) with the Asian Motorway Network (AN);

– conduct regular monitoring of the situation at border crossing points and, on the basis of best international experience, promote legal trade and cross-border transportation for the purpose of economic development, strengthening of regional stability and cooperation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

REFERENCES

1. Statystychni dani po haluzi avtomobilnoho transportu (2020). Ofitsiinyi sait Ministerstva infrastruktury. Available at: https://mtu.gov.ua/content/statistichni-dani-po-galuzi-avtomobilnogo-transportu.html
2. Derzhavna sluzhba statystyky Ukrainy. Available at: http://ukrstat.gov.ua/
3. AsMAP Ukrainy. Available at: http://www.asmap.org.ua
4. Ministerstvo infrastruktury Ukrainy. Available at: http://mtu.gov.ua/
5. IRU (International Road Transport Union). Available at: https://www.iru.org/ru_rts
6. Juman, Z. A. M. S., Nawarathne, N. G. S. A. (2019). An efficient alternative approach to solve a transportation problem. Ceylon Journal of Science, 48 (1), 19. doi: https://doi.org/10.4038/cjs.v48i1.7584

7. Jamali, A. R. M. J. U., Jannat, F., Akhtar, P. (2017). Weighted Cost Opportunity Based Algorithm for Initial Basic Feasible Solution: A New Approach in Transportation Problem. Journal of Engineering, 8 (1), 63–70. Available at: https://www2.kuet.ac.bd/JES/images/files/v42/7-JES_1001.pdf
8. Jamali, A. J. U., Mondal, R. R. (2021). Modified Dynamically-updated Weighted Opportunity Cost Based Algorithm for Unbalanced Transportation Problem. Journal of Engineering Science, 12 (2), 119–131. doi: https://doi.org/10.3329/jes.v12i2.54637
9. Carp, D., Popa, C., Serban, C. (2016). A general iterative solver for unbalanced inconsistent transportation problems. Archives of Transport, 37 (1), 7–13. doi: https://doi.org/10.5604/08669546.1203199
10. Ghazali, Z., Majid, M. A. A., Shazwani, M. (2012). Optimal Solution of Transportation Problem Using Linear Programming: A Case of a Malaysian Trading Company. Journal of Applied Sciences, 12 (23), 2430–2435. doi: https://doi.org/10.3923/jas.2012.2430.2435
11. Uddin, Md. S., Miah, M., Khan, Md. A.-A., AlArjani, A. (2021). Goal programming tactic for uncertain multi-objective transportation problem using fuzzy linear membership function. Alexandria Engineering Journal, 60 (2), 2525–2533. doi: https://doi.org/10.1016/j.aej.2020.12.039
12. Ibrahim, A. A., Lonardi, A., Bacco, C. D. (2021). Optimal Transport in Multilayer Networks for Traffic Flow Optimization. Algorithms, 14 (7), 189. doi: https://doi.org/10.3390/a14070189
13. Danchuk, V., Bakulich, O., Svatko, V. (2017). An Improvement in ant Algorithm Method for Optimizing a Transport Route with Regard to Traffic Flow. Procedia Engineering, 187, 425–434. doi: https://doi.org/10.1016/j.proeng.2017.04.396
14. Prokudin, G., Oliskevych, M., Chupaylenko, A., Dudnik, O. (2019). Development of vehicle speed forecasting method for intelligent highway transport system. Eastern-European Journal of Enterprise Technologies, 4 (3 (100)), 6–14. doi: https://doi.org/10.15587/1729-4061.2019.174255
15. Prokudin, G., Lebid, I., Luzhanska, N., Chupaylenko, O. (2020). Logistics Approach to the Organization of Unbalanced Freight Transportation in Transport Networks. Proceedings of 24th International Scientific Conference. Transport Means 2020. Sustainability: Research and Solutions. Part I. Kaunas, 22–26. Available at: https://transportmeans.ktu.edu/wp-content/uploads/sites/307/2018/02/Transport-means-A4-I-dalis.pdf
16. Proekt Planu vidnovlennia Ukrainy (2022). Materialy robochoi hrupy "Vidnovlennia ta rozbudova infrastruktury". Available at: https://www.kmu.gov.ua/storage/app/sites/1/recoveryrada/ua/restoration-and-development-of-infrastructure.pdf
17. Alekseychik, T., Bogachev, T. Bogachev, V., Bruhanova, N. (2017). The choice of transport for freight and passenger traffic in the region, using econometric and fuzzy modeling. Procedia Computer Science, 120, 830–834. doi: https://doi.org/10.1016/j.procs.2017.11.314
18. Kunda, N. T., Lebid, V. V. (2019). Assessment of the Quality Indicators Interconnection of Transport Services while Cargo Transportation, Journal of Advanced Research in Law and Economics, 10 (8 (46)), 2394–2406. Available at: https://journals.aserspublishing.eu/jarle/article/view/5286
19. Enterprise Europe Network. Corridors. Available at: https://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/corridors_en

20. New UK-Ukraine transport partnership to rebuild war-torn infrastructure (2022). GOV.UK. Available at: https://www.gov.uk/government/news/new-uk-ukraine-transport-partnership-to-rebuild-war-torn-infrastructure
21. Infrastructure – TEN-T – Connecting Europe. Maps. URL: https://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/maps_en
22. Athukorala, P., Narayanan, S. (2018). Economic corridors and regional development: The Malaysian experience. World Development, 106, 1–14. doi: https://doi.org/10.1016/j.worlddev.2018.01.009
23. Wang, C., Huang, C., Guan, H., Zeng, T. (2020). A Comparative Analysis of Strategic Values of Four Silk-Road International Transport Corridors Based on a Fuzzy Integral Method with Comprehensive Weights. Discrete Dynamics in Nature and Society, 2020, 1–15. doi: https://doi.org/10.1155/2020/4760862
24. Laird, J. J., Venables, A. J. (2017). Transport investment and economic performance: A framework for project appraisal. Transport Policy, 56, 1–11. doi: https://doi.org/10.1016/j.tranpol.2017.02.006
25. Alam, M., Dappe, H., Melecky, M. (2019). Wider Economic Benefits of Transport Corridors: Evidence from International Development Organizations. The World Bank. Washington. doi: https://doi.org/10.1596/1813-9450-9057
26. Roberts, M. Melecky, T. Bougna, and Y. Xu. (2020).Transport corridors and their wider economic benefits: a quantitative review of the literature, Journal of Regional Science, vol. 60, no. 2, pp. 207–248. doi: https://doi.org/ 10.1111/jors.12467
27. Prokudin, H. S. Chupailenko, O. A., Khobotnia, T. H., Hilevska, K. Yu., Denys, O. V. (2022). Logistic approach to the organization of unbalanced freight transportation on transport networks. The National Transport University Bulletin, 1 (51), 323–331. doi: https://doi.org/10.33744/2308-6645-2022-1-51-323-331
28. Prokudin, H. S., Remekh, I. O. (2022). Theoretical fundamentals of the organization of freight transportation on transport networks. The National Transport University Bulletin, 3 (53), 312–321. doi: https://doi.org/10.33744/2308-6645-2022-3-53-312-321
29. Chupaylenko, O. A., Bilokur, M. V., Polishchuk, R. V., Kolesnyk, Y. O. (2022). Logistics of functioning of multimodal transportation. The National Transport University Bulletin, 3 (53), 409–426. doi: https://doi.org/10.33744/2308-6645-2022-3-53-409-426
30. Prokudin, G., Chupaylenko, A., Khobotnia, T., Remekh, I., Lyamzin, A., Kovalenko, M. (2022). Optimizing unbalanced freight deliveries in transportation networks. Eastern-European Journal of Enterprise Technologies, 2 (3 (116)), 22–32. doi: https://doi.org/10.15587/1729-4061.2022.253791
31. Polishchuk, V. P., Guzhevska, L., Denys, O. (2021). Economic and mathematical model of cargo transportation in international piggyback connection. European Journal of Intelligent Transportation Systems, 1 (3). doi: https://doi.org/10.31435/rsglobal_ejits/30032021/7371
32. Guzhevska, L., Denys, O. (2021). Modern problems of organization of multimodal transportation. Science Review, 1 (36). doi: https://doi.org/10.31435/rsglobal_sr/30012021/7375

33. Denys, O. (2018). Analysis of the influence of the length of the contrailer route on the equivalent distance of cargo delivery. SWorldJournal, 6, 76–80. doi: https://doi.org/10.30888/2410-6615.2020-06-06-120
34. Aloshynskyi, Ye. S., Prymachenko, H. O. (2018). Vprovadzhennia Lohistychnykh Pidkhodiv do Analizu Perspektyv Rozvytku Mizhnarodnykh Pasazhyrskykh Zaliznychnykh Perevezen. European Journal of Intelligent Transportation Systems, 1 (1), 30–35. doi: https://doi.org/10.31435/rsglobal_ejits/30112018/6221
35. Gulamov S. S., Shermukhamedov A. T. (2018). "Digitalization" of logistics. European Journal of Intelligent Transportation Systems, 1 (1), 3–6. doi: https://doi.org/10.31435/rsglobal_ejits/30112018/6215
36. Terminology on Combined Transport English-French-German-Russian (2006). European Conference of Ministers of Transport, 71. doi: https://doi.org/10.1787/9789282102114-en-fr
37. Prokudin, G., Chupaylenko, O., Prokudin, O., Khobotnia, T., Kopiak, N. (2021). Decision making under uncertainty in international freight transportation. Science Review, 1 (36). doi: https://doi.org/10.31435/rsglobal_sr/30012021/7374
38. Prokudin, G., Chupaylenko, O., Prokudin, O., Khobotnia, T. (2021). Management decision support system freight transportation on transport networks. European Journal of Intelligent Transportation Systems, 1 (3). doi: https://doi.org/10.31435/rsglobal_ejits/30032021/7352
39. Prokudin, G., Chupaylenko, O., Dudnik, O., Prokudin, O., Dudnik, A., Svatko, V. (2018). Application of information technologies for the optimization of itinerary when delivering cargo by automobile transport. Eastern-European Journal of Enterprise Technologies, 2 (3 (92)), 51–59. doi: https://doi.org/10.15587/1729-4061.2018.128907
40. Melnyk, T. S. (2019). Holistic Management of Consumer Value in RailwayPassenger Transportation. European Journal of Intelligent Transportation Systems, 1 (2), 39–44. doi: https://doi.org/10.31435/rsglobal_ejits/31072019/6583
41. Shyriaieva, S. V., Svirin, D. O. (2017). Research logistics supply chain in the performance of international road transportation of goods. Visnyk Natsionalnoho transportnoho universytetu. Seriia "Tekhnichni nauky", 1 (37), 459–466. Available at: http://publications.ntu.edu.ua/visnyk/37/459.pdf
42. Lysa, S., Zimina, A. (2020). Problems and prospects of development cold logistics market in ukraine. Market Infrastructure, 44, 87–92. doi: https://doi.org/10.32843/infrastruct44-15
43 Naboka, R., Shuklina, V. (2020). Influence of integration of logistics supply chains on increase of potential of the enterprise. Efektyvna Ekonomika, 4. doi: https://doi.org/10.32702/2307-2105-2020.4.87
44. Tokmakova, I. V., Ovchynnikova, V. O., Korin, M. V. (2021). Upravlinnia lantsiuhamy postachan. Kharkiv: UkrDUZT, 1, 55. Available at: http://lib.kart.edu.ua/handle/123456789/5690
45. Tiurina, N. M., Hoi, I. V., Babii, I. V. (2015). Lohistyka. Kyiv: "Tsentr uchbovoi literatury", 392. Available at: https://www.logistics-gr.com/index.php?option=com_content&id=23650&c-72&ltemid=99