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Ensuring Sustainable Freight Carriage through Interoperability between Maritime and Rail Transport

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Abstract: With increasing freight flows and their carriage, sustainability in the transport sector is one of today's key challenges. With expanding geographical coverage of consumers, manufacturers and all participants in the logistics chain, sustainable carriage is becoming a considerable challenge, which can possibly be tackled by interoperability between different modes of transport. However, even in this context, there are endless difficulties, such as the compatibility of modes of transport, completion of documentation, compatibility of information systems and technologies, and the like. This article examines the importance of interoperability between maritime and rail transport in the development of international freight carriage. A theoretical assessment of maritime and rail transport interoperability covering the need for the application of information systems (IS) in the field of maritime and rail transport is presented, as well as distinguishing research problems relating to this interoperability and the presentation of key results. The quantitative and qualitative research methods applied in this article, the results of the research as well as the expert assessment of the activities of companies providing maritime and rail transport services are presented to verify the adaptation of the developed model.

Keywords: sustainability; maritime transport; rail transport; international routes; intermodal transport; multi-modal transport; interoperability

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1. Introduction

At present, the potential for intermodality in Europe is not well developed. Intermodal transport is a complex mode of freight transport that should combine different modes of transport into one freight transport logistics chain. In most cases, the processing of intermodal traffic flows in international transport corridors is dominated by road transport. In this way, the potential of intermodality is not fully exploited [1].

Intermodal transportation is considered a promising means of efficiently improving logistics performance [2]. Transportation reliability is a measure of the containers being successfully delivered to the receivers by using the planned intermodal routes in actual transportation [3].

With a growing economy, transport flows increase in parallel, which triggers complexity of the transport chain and the need to ensure a sustainable transport process. Therefore, carriers continuously look for ways to deliver freight at the right time, to the right place, and to meet customer needs. There is a need to invest in transport infrastructure and information systems, which would help to optimize processes.

It is also important to note that the need for sustainability in freight transport will only increase in the future, as carriers seek ways to ensure the greenest possible transport chains every day. In the long run, greater customer awareness is also expected, with customers increasingly being prepared to wait a little longer for freight to be delivered, but only if they are sure that it is more environmentally friendly. Companies acting in observance of the sustainability criteria are already choosing their suppliers more carefully, as they want

their business partners to also support similar ideas and care about environmental issues. The future belongs to clean energy: wind, solar and hydropower parks with nuclear power plants, as well as efficient hydrogen generators, will ensure all our energy needs in a while.

The importance of transport to the global economy is invaluable. With the rapid development of globalization, intensifying competition, increasing environmental pollution and changing consumer needs, freight carriers are looking for and choosing increasingly more efficient modes of transport. Transport interoperability is one option for this. Freight carriage by at least two different modes of transport is important for the economy, sustainability, creation of new jobs and mobility of all countries of the world. The use of transport interoperability opens up new opportunities. This process enhances the economic efficiency of the transport chain by using modes of transport in the most productive way. The vision of a competitive and sustainable transport system set out in the European Commission's relevant white paper states that road transport will always remain the most important mode of transport for door-to-door freight, however, choosing other modes of transport should also be encouraged. The integration of different modalities allows the combination of both speed and cost benefits for each transportation mode [4]. Intermodality and combination of advantages offered by individual modes of transport presents a solution to such issues as increasing road traffic flows, fuel consumption and emissions. The interoperability of maritime and rail transport is one type of intermodal transport. The combination of these two modes of transport can reduce traffic flows, environmental pollution and competition. For interoperability to be effective, searching for new opportunities is necessary, responding to changing business conditions, global processes, and customer needs. There is a need to search for ways to develop and improve the interoperability of rail and maritime transport, to address emerging problems and to optimize the entire transport process. Different countries of the world use intermodal transport technologies, but international transport is of different levels due to differences in infrastructure, age of vehicles, equipment, and the level of economic development.

This article addresses issues related to the flexibility of maritime and rail transport interoperability, reduction of traffic jams and the ensuring of sustainable transport. However, this interoperability is dominated by expensive, risky, and time-consuming reloading of parts of freight, and is not very popular due to the lack of efficiency when door-to-door delivery is necessary. Moreover, this process requires lengthy preparation of documents.

This article analyses the peculiarities of maritime and rail transport and the possibilities for the development of an interoperability between them, highlighting problem areas, creating a model of interoperability for these vehicles and making recommendations based on the conducted expert assessment.

The object of this article is the interaction of rail and water transport for the transportation of goods on international routes.

The aim of this article is to identify the possible problem areas of these modes of transport by analyzing the peculiarities of rail and maritime transport modes, as well as the possibilities of their interaction, and to present the developed model.

The remainder of this paper is organized as follows. Section 2.1 provides on overview of the scientific literature of intermodality and the interoperability of maritime and rail transport. In Section 2.2 legal problems are proposed relating to maritime and rail transport interoperability. In Section 2.3 research problems are shown relating to maritime and rail transport interoperability. In Section 2.4 the method of research is proposed and in Section 3 results and discussion are provided.

2. Methods and Methodology

This part of the article examines theoretical problems of the interoperability between maritime and rail transport and describes the issue of the selected methodology for further research.

2.1. Theoretical Assessment of Interoperability of Maritime and Rail Transport

Maritime and rail transport interoperability is very useful for carrying large amounts of freight over long distances. In the article, the authors [5] note that according to a report by a United Nations commission, 67% of containers between Europe and China have been carried by way of maritime and rail transport interoperability and 7% by road transport. Thus, this interoperability is effective, combining the advantages and disadvantages of the two modes of transport (Table 1).

Table 1. Advantage and disadvantages of maritime and rail transport.

Mode of Transport	Advantages	Disadvantages
Maritime transport	• Possibility of intercontinental carriage • Low cost of long-distance carriage • Significant possibilities for carriage and capacity • Low intensity of freight carriage capital data	• Narrow scope of carriage • Slow deliveries • Dependence on geographical, nav-igational and weather conditions, • The need to develop complex port infrastructure
Rail transport	• Significant possibilities for carriage and capacity • Independent of climatic conditions, time of the year and day • High regularity of shipments • Relatively low rates • High speed of long-distance freight delivery	• Limited number of carriers • Large investments in the production and technical base • Poor access to end points of sale • Insufficient level of freight maintenance

Source: compiled by the authors.

The interoperability of maritime and rail transport can be described as an integration of modes of transport, an improvement of their interconnection by integrating them into a single system and ensuring the optimal use of each mode of transport in carrying freight. Interoperability between rail and maritime transport can be described as intermodality, the essence of which is the use of the advantages offered by each mode of transport in optimizing the entire transport system [6].

The logistics network of intermodal maritime and rail transport is very large, and is a social economy network. Factors affecting this transport interoperability network can be divided into internal and external factors (Table 2).

Table 2. Internal and external factors of interoperability between maritime and rail transport.

Internal Factors of Maritime and Rail Transport Interoperability	External Factors of Maritime and Rail Transport Interoperability
• Equipment technology • Infrastructure • Transport services	• Transport policy • Environment • Natural resources

Source: compiled by the authors based on [7].

Internal and external logistics factors are interrelated and directly affect each other.

In this context, it can be said that the modernization and development of rail and maritime transport infrastructure is an essential condition for the successful operation of the transport system. Priority is given to the renovation and modernization of rail and maritime transport infrastructure on international transport corridors. The main focus of infrastructure development must be on ensuring the technical interoperability of the country's rail and maritime transport, the implementation of modern safety and environmental requirements, increasing the load on railways and the speed of trains, promoting combined transport, etc.

In order to maintain the existing technical interoperability of rail and maritime systems, great attention must be paid to the implementation of the technical interoperability directives. Technical interoperability means the ability of the rail and maritime transport systems to allow safe and uninterrupted traffic, something which depends on all the regulatory, technical, and operational conditions which must be satisfied in order to meet the essential requirements and ensure the quality of transport services.

On the other hand, transport policy is a set of legal acts, documents, various legal, social, and economic instruments designed to ensure the unified functioning of the transport sector, thus enhancing the well-being of members of society [8].

Mulley et al. [9] state that regulatory policies have a direct impact on both technical and corporate activities, it is likely that changes in regulatory policies may reduce the impacts of impediments to interoperability. Generally, these will be brought about by changes in technical or corporate activity, but they will be initiated by regulatory changes. Hence, in general, regulatory changes that enhance interoperability may be considered as two broad groups:

1. The first are those regulatory changes which improve the standardization of technology.
2. The second are those regulatory changes that improve the harmonization of corporate activity [9].

However, as Mulley et al. [9] state, interconnectivity is achieved when different transport systems, of either the same or different modes are physically and operationally linked to facilitate transfers across the boundaries between different systems [10]. Achieving interconnectivity is a necessary preliminary step towards interoperability.

However, keep in mind that legislation, in particular the differences between European and national legislation, may cause impediments to juridical interoperability. For instance, co-operation between organizations in the transport sector, that may contribute to interoperability, is limited by European and national anti-trust laws. Also, differences between countries in the implementation of European directives may cause barriers to interoperability. For example, differences in the implementation of the European Rail Directive 440/91 in different EU member states cause different conditions of access to the railway network [11].

Language differences between countries can act as impediments to travel as can difficulties associated with cultural identity. Different cultural attitudes to access to travel facilities are amongst the impediments which may inhibit the achievement of cultural interoperability [11].

Therefore, using these dimensions of interoperability, full interoperability is achieved when transport systems are deemed to have technical, organizational, legal and cultural interoperability and through the fair and sustainable use of natural resources.

Figure 1 presents the scheme illustrating how goods are carried by way of maritime–rail interoperability. Freight is carried by sea in containers. It is brought to an embankment—a container terminal, and containers are unloaded at the pier using stevedoring equipment. Containers are then carried to the railway station which is located on the opposite side of the port, where they are filled with partial freight, loaded onto wagons, and further carried by rail [12].

Maritime and rail transport interoperability is usually divided into three parts: freight is concentrated at a central station, and when technical conditions meet the requirements, loading and unloading operations are performed thereon. A train leaves for the port station; having arrived at the port, the conditions for direct loading and unloading are determined taking into account the time of arrival and the volume of the container. Containers that are suitable for the freight are chosen, and freight is loaded at the port dock. The ship then leaves the port on schedule.

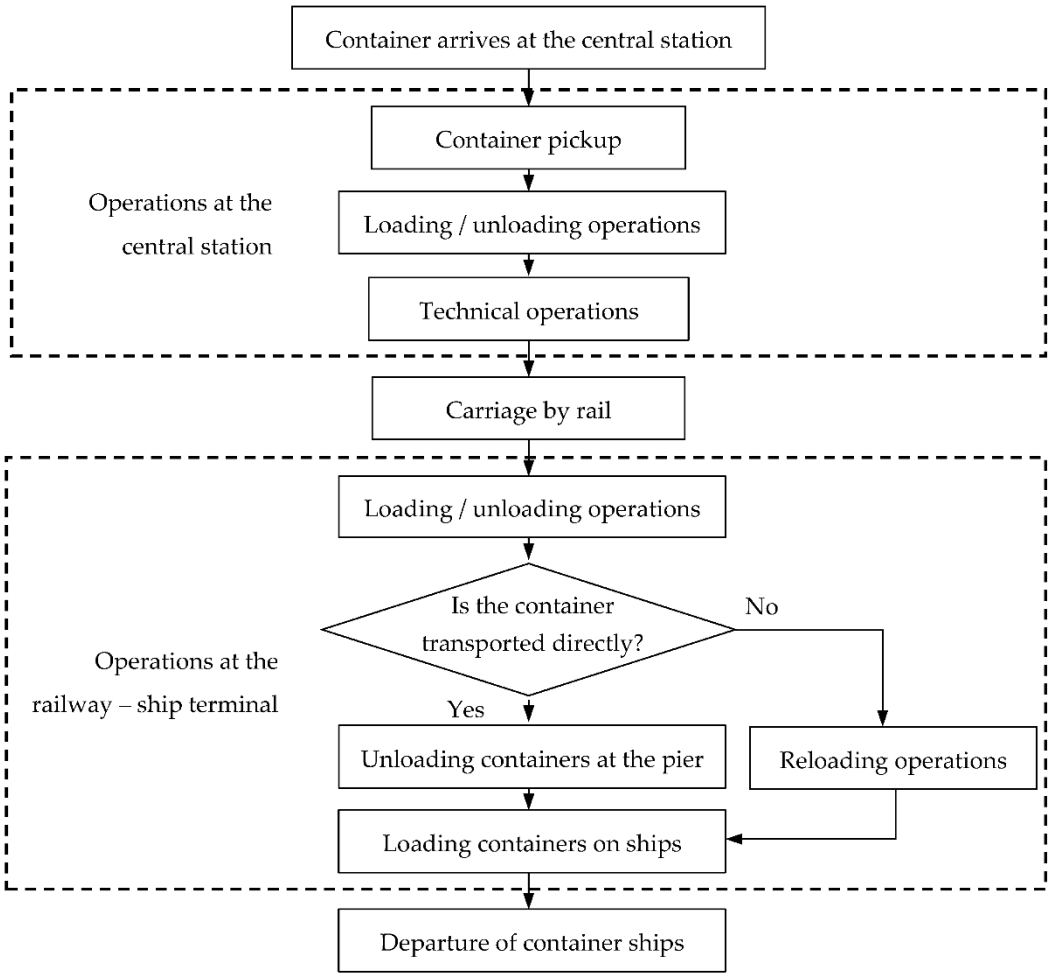

Figure 1. Scheme of maritime and rail transport interoperability Source: compiled by the authors based on [13].

The efficiency of the maritime and rail intermodal network depends on how well rail and maritime transport operations are carried out, how quickly a container is reloaded, and how fast it can arrive at a pre-determined place at a scheduled time. So, it all involves two aspects: loading and unloading times.

Interoperability between maritime and rail transport includes: (1) a plan of operation of a train or a ship; (2) loading containers; (3) capacities of the loading equipment.

An analysis of the scientific literature suggests that a scheduling aspect could be included in Figure 1. Because of the interactions between these modes of transport, it is important to evaluate the existing aspects of their work and planning and scheduling. The analysis of the literature revealed that the main focus in this regard is on each mode of transport separately:

- **Maritime transport.** Maritime transport is often part of the supply chain. However, in this case, very little attention is paid to ship routing and planning issues, and the focus is on the entire supply chain. Ship work planning, on the other hand, involves a great deal of uncertainty. Therefore, a risk- and cost-based routing and planning system for a single freight supplier with multiple customers should be borne in mind. The existence of alternative maritime routes means that the necessary costs and risks need to be taken into account in route decisions and planning [14].
- **Rail transport.** The scheduling of trains is an essential element in the design problem of the overall railway operation plan. This determines network utilization, train driver or crew requirements, and customer service and it affects locomotive requirements and so is a major factor in network efficiency [15]. The problems of train scheduling have also been analyzed by [16].

An analysis of the literature revealed that scheduling, potential risks and costs for intermodal and multimodal transport are only increasing. Therefore, it is important to ensure timely delivery of cargo to and from the terminal. In this case, it is important for the participants in the process to know exactly when the cargo arrives. Because routing and planning issues are closely related to the operational planning issues of many fleets and other process participants. Therefore, in the case of intermodality, the challenge is not only the timely delivery of goods, the dissemination of information and the completion of documents, but also the harmonization of joint work, routes, and timetables. Intermodal transport requires the cooperation of many actors. It is more complex than homogeneous transport, so tasks need to be distributed among different actors as well as synchronization of different schedules. The problems of intermodal transport scheduling have been examined in detail [17–21].

Obviously, most interoperability depends on technological and physical freight movement flows and components, but interoperability of information systems also plays a very important role.

Modern information systems can help to effectively manage information flows by facilitating and accelerating information and data exchange processes. The efficiency of transport services is a very important criterion and consists of several different criteria that make up the overall efficiency of services. According to [22], each consignor takes into account the following criteria to assess the efficiency of the service provided: suitability, security, availability, delivery time, reliability and flexibility. IS improves the organization of transport, changing the structure of logistics operations.

A unified technology combining the work of the seaport and railway stations is of particular importance in the interoperability between maritime and rail transport, and information systems (IS) could help to unify the work of these points [23]. However, maritime and rail transport each use different IS, so exchange of information depends on staff alone. In order to organize joint maritime and rail transport activities, ensure their smooth operation, and disseminate information requires combining two ISs related to the transport operators ("e-Krovinys" (e-Freight) and "KIPIS") [24]. This would create a common database that would be useful for organizing freight carriage by rail and maritime transport.

Information management is one of the key aspects in developing efficient rail and maritime transport interoperability. The exchange of information ensuring timely provision of accurate information to the parties in the supply chain is essential for the creation of an efficient supply chain and efficient freight transport covering both modes of transport. The five key aspects that define effective interoperability of rail and maritime transport [25]:

1. Technical interoperability. The ability of different information technology systems and software applications to communicate and exchange data between rail and maritime transport.
2. Technological interoperability. Technological interoperability is a data exchange platform that allows the secure exchange of information between rail and maritime transport organizations. To connect to it, the existing data exchange environment, comprehensive user interface and server security system are used.
3. Exchange of information. The implementation of ISs is very important to ensure efficient information exchange between the chain parties because they enable fast and timely information exchange allowing faster and more precise planning of activities in the terminal, vessels and railways, as well as to exploit advantages of both modes of transport and reduce their disadvantages.
4. Legal interoperability. Legal interoperability is about ensuring that organizations operating under different legal frameworks, policies and strategies are able to work together. This might require that legislation does not block the establishment of European public services within and between member states and that there are clear agreements about how to deal with differences in legislation across borders, including the option of putting in place new legislation.

5. Economic interoperability. This means the business processes of the railway and maritime transport authorities, in particular the exchange of information, coordination for effective cooperation, including re-engineering of economic processes, formalized service provision agreements, quality assessment, management of economic change, promoting economic cooperation.

Therefore, the following are the key factors that ensure efficient interoperability of maritime and rail transport: the use of an IS, coordination of many participants, strict adherence to the timetable, quality operation of the terminal, qualification of employees, and processing large amounts of information [24]. The study showed that the development of an efficient common IS the key factor in ensuring efficient rail and maritime transport interoperability. Thus, a suggestion was made in the conclusion to create an efficient common IS by integrating the individual maritime and rail IS into a single IS, integrating the key elements of the systems.

2.2. Legal Problems Relating to Maritime and Rail Transport Interoperability

The legal environment is another obstacle to the development of interoperability between different modes of transport. Each mode of transport has its own convention, tailored specifically for it, including the CMR Convention, which governs the carriage of goods by road, the Hague Rules (HR), the Hague–Visby Rules (HVR) and the Hamburg Rules, which govern maritime transport. There also are regional agreements that govern rail transport, namely COTIF-CM, and conventions that govern the carriage of goods by air, namely, the Warsaw Convention (WC) and the Montreal Convention (MC). All these agreements have been updated, but despite several attempts and efforts by the international community, there still is no unified legal framework for multimodal freight carriage in force at the international level [26].

In the absence of a single multimodal transport law, many inconsistencies occur when concluding transport agreements. It is often unclear which law—international or national—should apply, and whether individual articles or the entire document should be used.

2.2.1. Different Legal Liability

The main legal problem in the interoperability of maritime and rail freight transport is the unpredictability of application of legal rules. Thus, in case of an accident where freight gets damaged or lost, the claimant and the carrier will not be able to agree on a compensation, and the parties to the agreement will not know which document to follow. Differences in compensations in the two legal modes can be staggering, and neither the recipient nor the carrier wants to incur extra costs. This is due to the fact that transport law was created for each mode of transport separately, both at national and international level. The law of each mode of transport provides for certain limits on the carrier's liability. These monetary limitations of liability were designed to facilitate the carrier's liability burden in case of freight loss or damage. When carrying goods in maritime transport, the limit of liability is 8–9 times lower than that of a rail carrier (Table 3).

Table 3. Financial liability of carriers (source: compiled by the authors).

Maritime Transport			**Rail Transport**
The Hague Rules	The Hague–Visby Rules	Hamburg Rules	COTIF-CIM *
£ 100/pkg	2 SDR/kg or 666.67 SDR/pkg ****	2.5 SDR/kg *** or 666.67 SDR/pkg	17 SDR **/kg

* COTIF-CIM (The Convention concerning International Carriage by Rail—The Contract of International Carriage of Goods by Rail). ** SDR: special drawing rights. *** 2.5 SDR/kg: SDR 2.5 per kilogram of gross weight of the cargo. **** SDR/pkg: SDR 666.67 per package/unit.

2.2.2. Legal Conflict between the Modes of Transport Used

A problem arises when two legal modes apply simultaneously. There are no rules to determine which rules take precedence and which rules are to be followed in multimodal transport.

The analysis of the problematic aspects of the development of multimodal transport distinguishes the following main problems, or factors, that affect multimodal transport: (1) Organizational barriers; (2) legal barriers; (3) technical barriers; (4) infrastructure barriers; (5) operational, logistics and service barriers; (6) financial and economic barriers; (7) software barriers; and (8) psychological barriers.

States are often interested in establishing land ports as a link in the multimodal transport chain.

2.3. Research Problems Relating to Maritime and Rail Transport Interoperability

Many researchers of the world have analyzed interoperability between maritime and rail transport. Table 4 highlights the problems distinguished by researchers that emerge when carrying freight by way of interoperability between maritime and rail transport.

Table 4. Problem areas in the maritime and rail transport interoperability identified by researchers.

Researcher	Identified Problem
[27]	Transit or change of vehicles takes place at stations, terminals, and ports only. Such a model of carriage does not take time into account, thus organization of carriage is constrained—reaching the destination and delivering freight at the optimal time becomes difficult.
[28]	There are no rules regulating which rules take precedence and which are to be followed in multi-modal carriage.
[29]	Insufficient compatibility between rail and maritime transport has been observed in international carriage, creating an unappealing approach to interoperability between the two modes of transport for freight owners, as ports are the weakest link due to their low efficiency. Warehousing infrastructure must be developed in ports and their territories, which would unload freight from wagons and store it elsewhere.
[30]	Lack of reliability and efficiency. This is due to insufficient technical and administrative interoperability and the preference given to passenger trains on mixed traffic lines. Action must be taken to increase interoperability and reduce delays caused by mixed traffic.
[31]	A lengthy procedure for drafting rail and maritime export and import documents, which reduce the competitiveness of interoperability. Insufficient terminal capacity leads to poor efficiency of intermodality. Ship and wagon downtime results in higher losses.
[32]	Infrastructure is outdated and underdeveloped, customs clearance procedures are complex and time-consuming; outdated legal framework, which should regulate relations between different modes of transport, users of transport services, and customs authorities.
[13]	A mutual information system of carriers is needed, with a system which allows the use of information for public and commercial interests being developed at the same time.
[24]	Rail and maritime transport companies work with different IS or with different platforms. Moreover, staff arranging transport by rail and sea must work with two or even more different IS. One of the biggest issues ensuring efficient interoperability of rail and maritime transport is the requirement for timely exchange of accurate information, while different IS lead to information gaps.

Source: compiled by the authors according to the above sources.

Table 4 illustrates that many factors and problems affect this particular transport interoperability. The authors distinguish the following problems: (1) transit takes place at stations, terminals, and ports only; (2) there are no general rules indicating which rules are to be followed; (3) there is insufficient vehicle compatibility; (4) there is insufficient technical and administrative base; (5) there are lengthy procedures for drafting import and export documents; (6) there is an outdated and underdeveloped infrastructure; and (7) there is no mutual information system for carriers.

2.4. Selection of the Method of Research and Its Course

The analysis of the scientific literature examined the problems identified and analyzed by foreign researchers in relation to maritime and rail transport interoperability. The

next part of the article presents the results of the conducted research, which allows for the definition of the current situation regarding the interoperability of the Lithuanian rail and maritime transport systems, as well as the determination of problem areas of rail and maritime transport interoperability in the development of freight carriage on international routes.

Object of research—maritime and rail transport interoperability.

Aim of research—identification of the current problems relating to maritime and rail transport interoperability when carrying freight.

Research of maritime and rail transport interoperability was conducted in two stages in Lithuania:

1. The first stage was a quantitative study. Economic entities, namely, maritime, rail transport and rail forwarding companies, were selected for the research. In order to clarify the possibilities of improving the interoperability between maritime and railway transport, an empirical research method—a questionnaire survey—was used.

A survey is a research method widely used in social sciences [33]. The survey has been used when getting to know the researched object through empirical research methods, such as an experiment or an observation, is impossible [34]. It uses structured questions—multiple-choice, "or-or", or non-structured questions [35].

Given the fact that the object of research is interoperability between rail and maritime transport, survey participants were selected according to the type of services which their activities cover. The research sample was determined according to the Paniotto formula [36]:

$$n = \frac{1}{\Delta^2 + \frac{1}{N}}, \quad (1)$$

where n is the sample size; Δ is the sample error value (= 0.09; since this research analyzes the opinion of freight forwarders rather than certain quantitative parameters, the error can be increased to 9%); and N is the general aggregate value.

$$n = \frac{1}{\Delta^2 + \frac{1}{2}} = \frac{1}{0.09^2 + \frac{1}{142}} = 66.22. \quad (2)$$

The questionnaire was sent to respondents who operate in "transport services, forwarding" [37]. One hundred forty-two companies that carry freight by maritime and rail transport, as well as related companies engaged in carriage, stevedoring, shipping, and forwarding, were selected. The sample size calculations revealed that with a population size of 142 respondents, 67 respondents should be interviewed with a 95% likelihood and an error of 9.

Given the COVID-19 situation, questionnaires were e-mailed to companies. E-mails had the link to www.apklausa.lt (accessed on 10 August 2021) platform, as the aim was to ensure better feedback rates by offering the option of answering questions on the online platform. The online survey was created not to obligate respondents to complete the questionnaire, and it was anonymous in order to ensure confidentiality. The questionnaire consisted of 13 questions. The first 7 questions were related to respondent's activities. Questions 8–10 were aimed at finding out the respondent's opinion about the development of interoperability and identifying possible reasons that determine the organization of interoperability and the respondent's motives that cause problems in ensuring interoperability. Questions 11–13 were intended to find out the company's approach to how the state should encourage the development of this interoperability.

2. Second stage—expert assessment. To assess the idea of the developed model and the possibilities of its application, and taking into account the COVID-19 situation, assessment by eight experts by means of a questionnaire was selected. This method is suitable for testing the developed model, justifying the possible uses and the benefits provided. The questionnaire consists of a group of related questions. Questions in the questionnaire are short and specific, as questions must be simple but understandable in order to obtain

correct assessment. In order to obtain a competent assessment of the model, experts related to rail transport and logistics services were consulted, as well as IT specialists. Based on the results of the research of the stage, the aim was to identify the model based whereon maritime and rail transport systems should be integrated in order to make the transport system more efficient.

3. Results and Discussion

This section presents the results of the quantitative research based upon which the model was developed, and expert assessment results that describe the suitability of the model.

3.1. Results of the Research of Activities of Companies Providing Maritime and Rail Transport Services

Medium-sized companies accounted for the major share of participants in the research. The research determined that loyal employees who have extensive experience and in-depth knowledge of the work they do and who have worked in the companies for more than 5 years constitute the majority of employees in the surveyed companies (56%), employees with 3 to 5 years' experience accounted for 25%, 1 to 3 years for 14% and new employees working in the surveyed companies for up to 1 year accounted for 5% of all employees.

The research determined that the core activity of the majority of companies was forwarding (47.3%) and freight transport (44.2%), while companies providing logistics services accounted for the smallest share (8.50%) of respondents. Having assessed the area of activities of the companies, another important task was to find out directions of their operations (Figure 2).

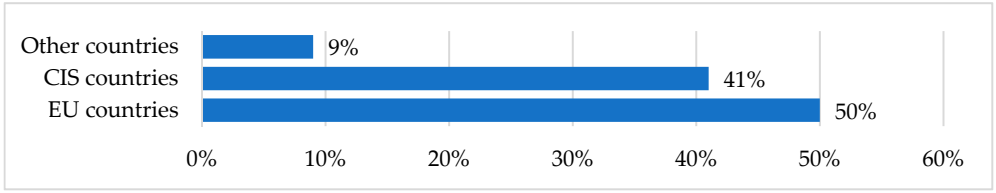

Figure 2. Directions of freight carriage of the respondents.

Respondents' answers revealed that most of the freight is carried to and from the European Union countries (50%), but a significant share, as many as 41%, is carried to and from the CIS countries. 9% of respondents answered that they carry freight to other countries. Thus, it was also important to find out what mode of transport they use to carry freight (Figure 3).

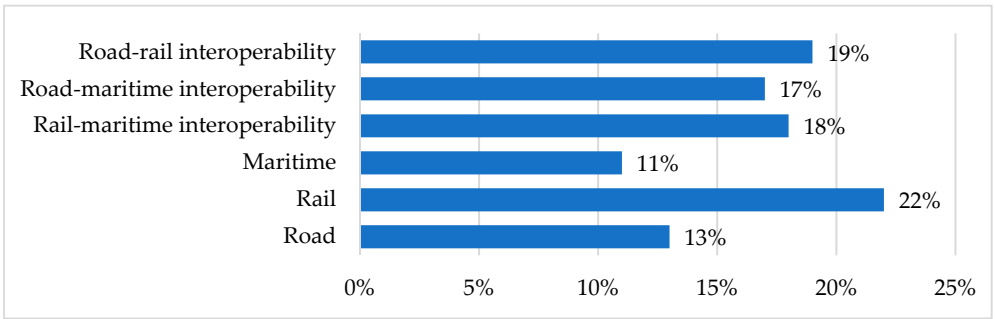

Figure 3. Most common method of carriage of respondents.

Data in Figure 3 reveals that the majority of the surveyed companies (22%) chose rail as their mode of transport. Nineteen percent of respondents chose road-rail interoperability, 18% chose rail-maritime interoperability, 17% road-maritime interoperability, 13% road

transport and 11% of respondents chose maritime transport. Since many respondents use rail transport, it was important to find out which particular means of rail transport they usually use (Figure 4).

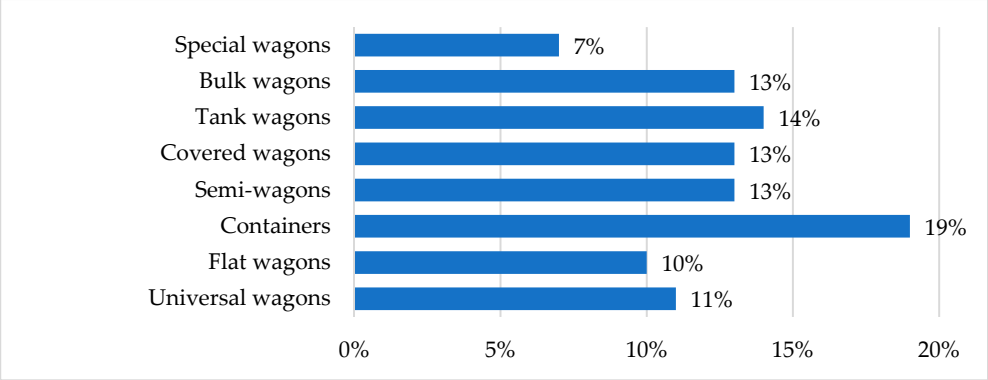

Figure 4. Most commonly used means of rail transport.

The research results revealed that containers have mainly been used in rail transport, as they are convenient not only to carry freight, but also to easily unload another vehicle, for example, a ship. Thus, it was important to assess means of maritime transport that dominate in freight transport (Figure 5).

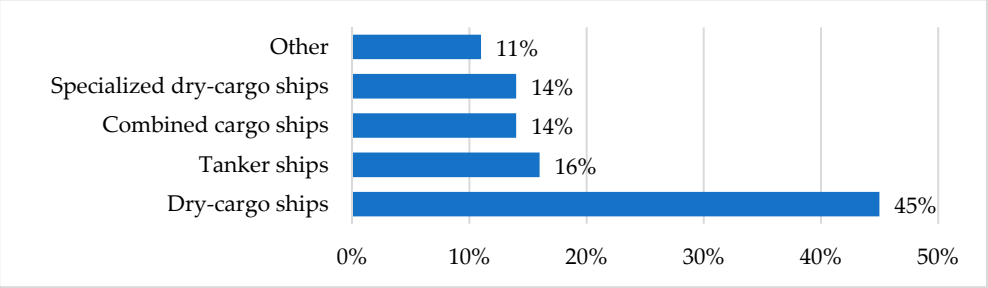

Figure 5. Most commonly used means of maritime transport.

Figure 5 reveals that dry-cargo ships are the most popular among respondents, with 45% of the respondents having chosen this answer. Tanker ships (tankers, gas vessels) (16%), combined cargo ships (14%) and specialized dry-cargo ships (refrigerators, Ro-Ro, bulk carriers) were a less popular choice, which allows the conclusion that the most popular ships are those for carrying containers, which in turn contributes to the organization and simplification of transport interoperability. It was also important to find out what respondents thought about the level of development of maritime and rail transport interoperability (Figure 6).

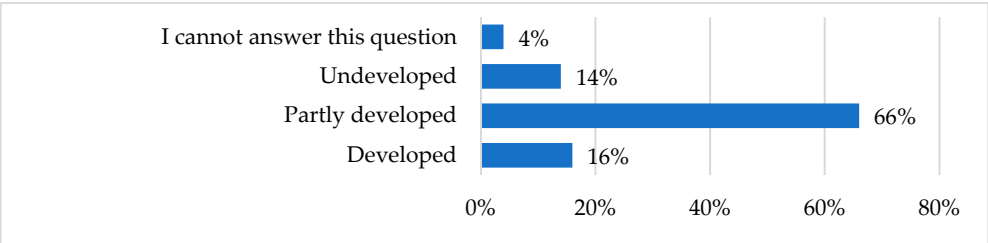

Figure 6. Level of development of maritime and rail transport interoperability.

Respondents' answers show that the majority of respondents (66%) said that maritime and rail transport interoperability is partly developed, which allows the conclusion that it

is underdeveloped. Having made such a conclusion, it was important to assess the factors that make this interoperability less appealing (Figure 7).

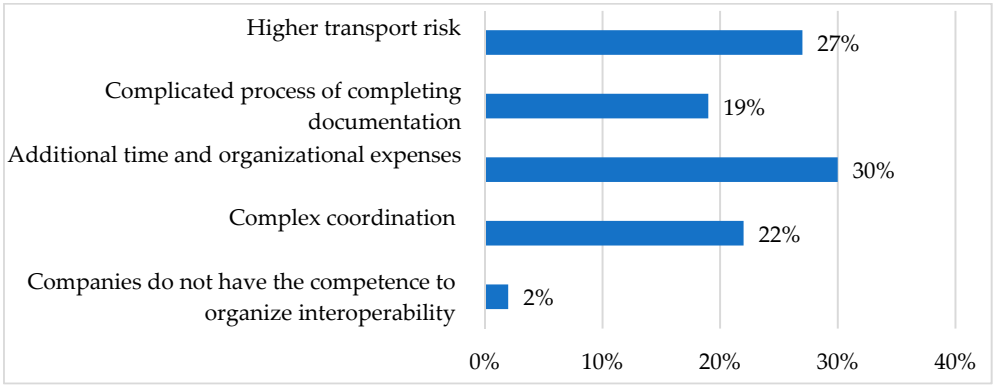

Figure 7. Factors that make maritime and rail transport interoperability less appealing.

The research found that the main factors that make the interoperability of maritime and rail transport unappealing are additional time and organizational costs (30%) and higher transport risks (27%). Respondents also noted that the coordination of this interoperability is difficult (22%) and the process of completing documentation is complicated (19%). After assessing the reasons for the low appeal of interoperability, the search for measures to increase its appeal became an important factor (Figure 8).

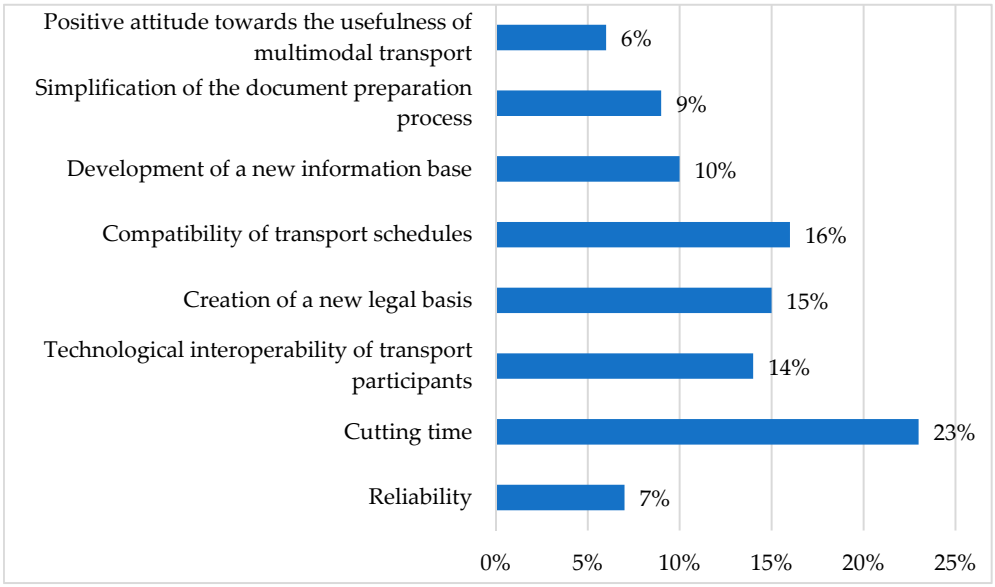

Figure 8. Factors that would ensure that maritime and rail transport interoperability is chosen more often.

Respondents believe reducing time to be the most important factor (23%), many respondents indicated compatibility of transport schedules (16%), creation of a new legal framework (15%) and technological interoperability of transport participants (14%) as important. Less popular but also important options were the development of a new information base (10%), simplification of the document preparation process (9%), reliability (7%) and a positive attitude towards multimodal transport (6%). In addition to these factors, a greater support from the state was also expected. Therefore, it was important to assess which additional state measures would have an impact on promoting the use of maritime and rail transport interoperability (Figure 9).

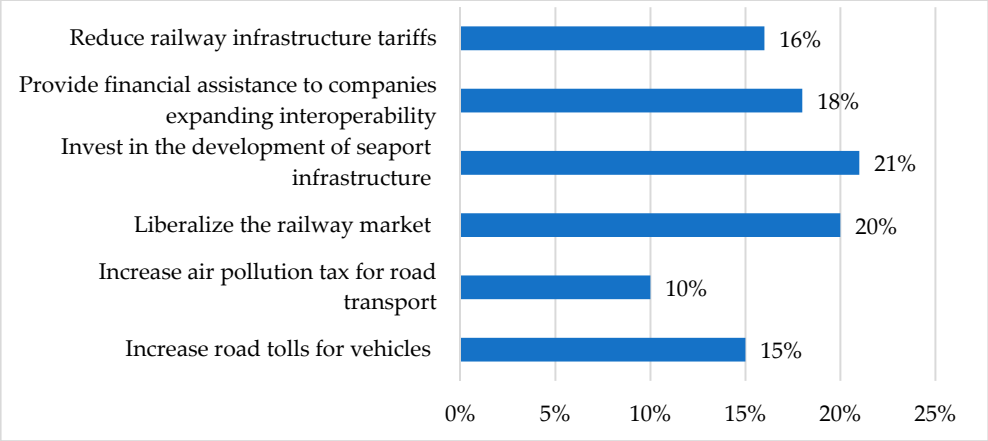

Figure 9. Additional state measures to be taken to promote maritime and rail interoperability.

Respondents believe that in order to additionally promote maritime and rail interoperability, the state should invest in the development of seaport infrastructure, improve carriageways, the condition of railways, install more powerful cranes, and liberalize the railway market, thus enabling private companies to engage in carriage and cooperate with maritime transport companies. In the opinion of respondents, it was also important to provide financial assistance to companies developing maritime and rail interoperability, to reduce railway infrastructure tariffs, and to increase the road transport fee. However, with the development of information technology, compatibility of the two different modes of transport is just as important in their interoperability. Therefore, the research aimed to find out whether information systems would help to develop the interoperability of maritime and rail transport.

The research found that the majority (72%) of respondents believe that information systems would really help to develop the interoperability of maritime and rail transport, and 21% of respondents believe that this would help only in part.

In summary, it can be said that in Lithuania the interoperability of maritime and rail transport is insufficient, therefore carriage by individual vehicles or by including road transport is usually chosen. The choice of other modes of transport is also determined by the fact that rail and maritime transport work schedules are uncoordinated, which increases the time spent, as freight is often left waiting. There are also incompatibilities between technological and information systems, lack of common documentation and infrastructure.

It is important to emphasize that Lithuania does not yet have a developed model upon which the interoperability between rail and maritime transport could be efficient and smooth. A model for organizing interoperability of these modes of transport has been developed based on the results of the research.

3.2. Model of Organization of Maritime and Rail Transport Interoperability in Carrying Freight Internationally

The research revealed that so far, maritime and rail transport interoperability is insufficient. The analysis of results of scientific literature and the survey allowed the distinction of the following issues:

1. The creation of a better and more convenient maritime and rail system would help to cut transport costs carrying large freight in long distances.
2. The integration of maritime transport would help to expand the markets where companies operate, which would make them more competitive internationally.
3. There is a lack of maritime terminals that would allow efficient movement of maritime containers to trains. This situation is due to the lack of demand itself.
4. Integrating maritime and rail transport is difficult, as vehicles used in these modes of transport have different operating schedules and this sometimes means delayed delivery of goods.

5. The system for registering customs and import data must also be improved.

These and other aspects are important not only for Lithuania, but also for other countries, which must ensure a smooth interaction between maritime and rail transport. Therefore, four main steps must be taken to ensure the integration of maritime and rail transport systems (Figure 10).

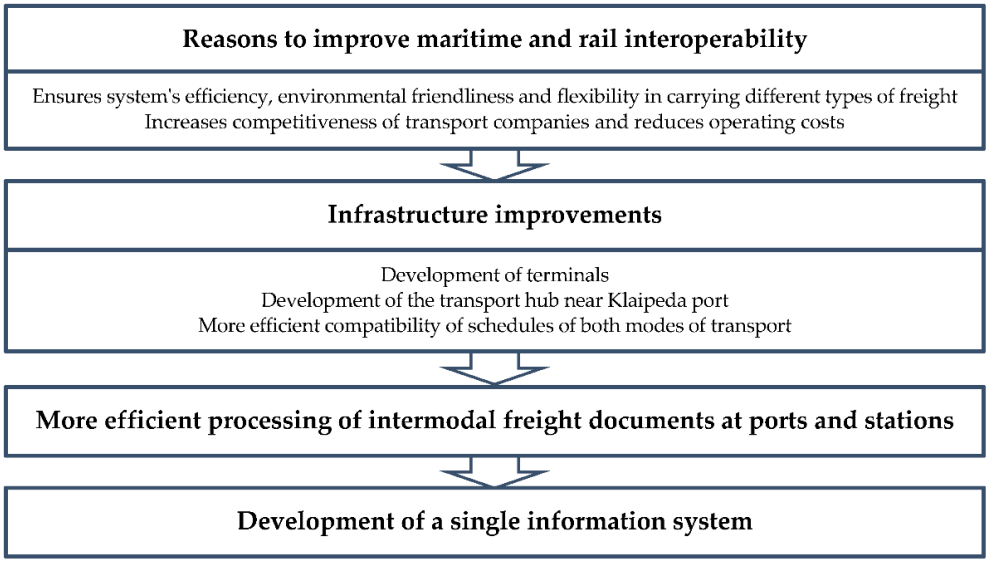

Figure 10. Integration of maritime and rail transport systems (source: compiled by the author).

The above scheme illustrates that efficient integration of maritime and rail transport is important both for private transport companies and for the improvement of the overall national transport system. Integration of different modes of transport and the development of an intermodal system would help to increase the competitiveness of companies in carrying different types of freight, reduce environmental pollution, and ensure development into new markets where transport operations must be based on maritime transport.

It can be noted that two main trends for improving the integration of maritime and rail transport system have been distinguished:

1. Development of infrastructure necessary for integration;
2. Improvement of the data processing system, development of the information database.

A model (Figure 11) which would optimize the process of maritime and rail transport interoperability was developed on the basis of the above information. All the focus in developing this model was concentrated on creating a new information base that could collect all the information needed to carry freight from various related institutions and companies. This would ensure the accessibility of data to the parties involved and a better quality of the analyzed transport interoperability. The following are the key goals of this model:

- to implement a one-stop shop principle for all modes of transport, where information is sent from all the parties involved in the carriage;
- to create a single electronic transport document to carry freight with the possibility of creating common legal regulation;
- to move paper documents to the electronic space;
- to allow all persons involved in freight carriage and objects to monitor freight in real time and to coordinate different operating schedules.

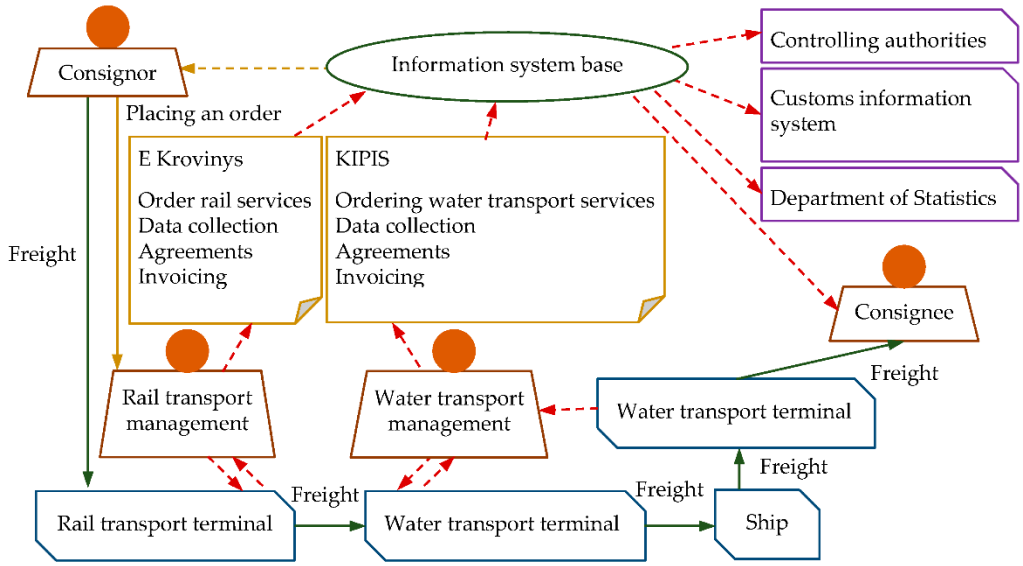

Figure 11. Proposed model of maritime and rail transport interoperability. Source: compiled by the authors.

Moreover, the creation of such a cooperation network is a good step towards increasing the productivity of companies of all stakeholders in order to improve the quality of their provided services.

The information system base will allow accessing information much faster and easier, because it will be collected in real time in one place. This should also lead to better quality of the service and greater appeal to the customer. Collecting all the information in one place would also be beneficial, as it would allow to save time necessary for information to travel, reduce errors, provide quick access and ability to contact persons responsible in certain companies, also allowing to add other modes of transport. Therefore, investments in the development of information technologies are necessary, as they would allow simplifying freight carriage processes.

3.3. Results of the Expert Assessment of the Proposed Maritime—Rail Transport Interoperability Model

The experts willingly participated in the assessment of the developed model answering the questions in the questionnaire, leaving comments that helped to make the final assessment and approve the model. The experts' answer to the first question of the expert assessment showed that the problem under consideration is very relevant. This can also be seen in the chart below.

In the course of the expert assessment, experts assessed the lack of interoperability between maritime and rail transport as a very relevant issue. The incompatibility of these information systems made the assessment of our developed and proposed interoperability model very important.

The experts could assess the presented model on a 5-point scale (where 5 is suitable; 4 is greater than average suitability; 3 is average suitability; 2 is less than average suitability; and 1 is unsuitable). Of the experts, 62.50% of them found the suitability of the model submitted for assessment to be suitable, 12.50% of them considered it to be of greater than average suitability and 25% of experts assessed the model as suitable.

Thus, the experts believe that the application of the model would increase the appeal of the maritime and rail transport interoperability. In their opinion, information systems would definitely or at least partly help to develop maritime and rail transport interoperability.

Therefore, the experts who conducted the assessment of the model confirmed that insufficient maritime and rail transport interoperability in carrying freight internationally was a relevant topic, and that the developed model and the development of an information

base could increase the appeal of this interoperability and contribute to its development. This model could be adapted not only in Lithuania, but also in other countries, where the problem of interoperability is relevant as well.

3.4. Implementation of the Proposed Model: Expected Interaction between Information Systems and Management

The essence of the proposed model is to ensure sustainable freight transport through the interaction of rail and maritime transport. Based on the results of the analysis of the scientific literature and research, a sustainable freight transport process would be possible by creating an efficient exchange of information flows between the participants of railway and maritime transport such as logistics and forwarding companies and connected institutions. As a result, much faster data exchange, data processing and information availability would be achieved. With the help of a common information system, it would be possible to use several systems that interact effectively with each other, which in turn would make it possible to achieve optimal interoperability between modes of transport. It is important to mention the one-stop-shop principle, because when ordering the service through separate programs (KIPIS, "e-Freight"), all data will be sent to a common platform and will be available to the shipper, consignee, transport organizations and necessary state authorities. It would also be important to create a common transport document, a common legal framework that would allow real-time satellite monitoring of the location of cargo, both at loading / unloading points and transport units, to provide customers with additional information and more efficient planning, information to the service user anywhere and anytime, using a computer or monitoring the transportation process, which would include the organization of rail and sea freight. The concept of a common database would allow the customer to easily order the service, obtain information not only about the location of the cargo, but also find out the approximate price of the service generated by the computer according to the algorithm. On the basis of the proposed common rail and maritime transport information system platform, synergies would be possible between the services offered by other modes of transport offered by road and air transport, which would also affect even faster, more flexible door-to-door delivery.

Thus, in order to ensure the interoperability of rail and maritime transport, freight should be invested in the development of advanced technologies, which are still the basis for organizing freight transport processes and their ease of use, but also for obtaining large amounts of information in one place (computer, phone) can attract more customers who would be interested in getting cheaper, less polluting, and convenient communication services.

The most efficient intermodal transport process and high-quality coordination of logistics processes is achieved through coordinated management. Furthermore, by managing the process of transportation by rail and sea, a high level of quality of transportation services can be achieved. In addition to features reflecting the transport process, such as the creation of a logistics system base (the implementation of transport technologies, pricing policy, fleet use), the political dimension is seen as an effective tool to give more bargaining power in strategic negotiation processes. The development of rail and maritime transport services and the creation of new ones on the basis of centralized information exchange show that it is possible to significantly reduce transportation costs, optimize transportation routes, and implement a unified transportation pricing policy.

4. Conclusions

The conducted analysis of scientific literature has shown that the interoperability of maritime and rail transport has a common goal in attracting transit freight and maximizing the use of infrastructure capacity. The key factors that ensure efficient interoperability of maritime and rail transport are strict compliance with the schedule, quality operation of the terminal, qualification of employees and processing of large amounts of information.

Maritime and rail transport were both found to play a key role in the transit chain, as they have common goals to attract new investments, to maximize the use of infrastructure

capacity, and to attract even more freight for carriage in the future having ensured operation of a common multimodal system.

The created model is based on the creation of a new information system database, which will allow access to information much faster and easier, as it will be collected in real time in one place. Collecting all the information in one place will also be beneficial in that it will save time on traveling, reduce errors, ensure a quick access and a possibility to contact persons responsible in certain companies, also allowing to employ other modes of transport.

The assessment of the suitability of the model allowed confirmation that the lack of interoperability of maritime and rail transport in international freight carriage is a relevant topic, and that the developed model could be used to increase the appeal of this interoperability. Furthermore, it confirmed that the adaptation of the model would be important in developing and addressing important interoperability issues related to opportunities of its development not only in Lithuania, but also on a global scale.

In the future, such a model should be approbated by assessing maritime-road and road-rail transport interoperability.

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