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Intermodal Supply Chain Risk Management

Abstract

Efficient and secure global supply chains contribute to the improvement of the competitiveness of the products traded on international markets by reducing their costs and delivery time while increasing the reliability and security. Global supply chains are unthinkable without transport integration, which is usually accomplished through the form of intermodal transport systems. Intermodal transport systems are much more complex than the unimodal ones due to the number of stakeholders, included transportation resources, infrastructure and processes, which in case of poor coordination in the planning, organization and implementation of transport chain logistic activities can lead to increased supply chain vulnerability. Therefore, the main challenge in the functioning of intermodal transport operations in supply chains is to increase their efficiency taking into account the problems of associated risks. The current initiatives on the topic of identification and management of risks in the intermodal supply chains do not provide a complete and clear picture of the potential problems which the intermodal supply chains are exposed to. Hence, the purpose of this paper, which is based on the literature review of the model of the intermodal transport system structure and models of risk management in supply chains in general, is to provide a framework for a holistic consideration of risks in intermodal supply chains, which can lead to the improvement of their efficiency and competitiveness.

Key words: intermodal transport, intermodal supply chain, risk, risk management

1. Introduction

Transportation is one of basic economic branches upon which the quality of overall economic development depends. The transportation sector employs more than

10 million people and participates with about 5% in the total GDP of the European Union (EU) [16]. On the other hand, a great number of issues are related to transportation such as environmental pollution and global warming, traffic congestion, reduced safety etc. For example, from the total quantity of CO_2 freed in the EU, 26% accounts for the transportation sector [16]. Therefore, the transport sector is placed in a paradox situation; on one hand, it means constant undertaking of initiatives for the development of transportation in order to meet the increasing demand for transportation services, while on the other hand the increased scope of transportation causes a large number of adverse impacts on the way of life and health of people. Decision making in transport, manifested through transport policies, is directed toward solving this paradox and creating a more efficient, safe and environmentally acceptable transportation, with one of the measures being the promotion and stimulation of the increased usage of intermodal transport. Intermodal transport, which means the usage of two or more different forms of transporting goods in standardized loading units, where the content does not change during transfer from one mode of transport to another, is an indispensable part of global supply chains of which the practical reality started by the integration of transportation chains and production systems and the transition from the „port-to-port“concept to the „door-to-door“concept in the management of transportation processes.

In literature, transportation is often presented as “the glue which connects members of a supply chain” on the efficiency of which the effectiveness of the whole chain depends [23]. Due to its nature, the intermodal transport is more complex than the unimodal transport, since more forms of transportation means are used, which are usually controlled by more different participants, the transportation structure is more diverse and complex (requiring points of transhipment), which further creates more complex processes and mutual relationships of the participants in a chain. The greater the number of participants, “connections”, and “nodes” in a chain, the greater the probability for an undesired event to occur, and thus the risks to which such chains are exposed also increase. [12]. The fact that in an intermodal transport chain a large number of processes have to be realized successively by different participants may lead to decreased efficiency which is manifested by increased total time of delivery and reduced flexibility and reliability of delivery [11]. Because of the above mentioned, the main challenge in the planning, organizing and managing intermodal transport activities in supply chains is how to increase the efficiency, which results in the constant search for new methods of solving the mentioned challenge. In the context of increasing efficiency of intermodal transport chains, it is necessary to take into account and to consider more closely the issue of risk which, among others, may appear as the consequence of initiatives for enhancing efficiency. Generally, the increased interest in risks in supply chains represents a unique trend in the logistics which is followed by a large number of scientific and professional papers. Risks in supply chains are most often defined as events which have an adverse impact on the chain in the sense of causing delays, interruptions, disturbances or complete break up in the realization of the whole process. Therefore, the diapason of risks that supply chains are exposed to

is quite wide and varies from disturbances within one process or a member in a chain, to natural catastrophes which may lead to the disruption of the whole chain.

Risks are one of the basic factors (beside costs, environmental protection and users' attitudes) which have influence on the choice of transportation service [15], and this is the reason why many existing works on the topic of risks in intermodal transport chains deal predominantly with the choice of a cost-efficient and risk-free variant of the realization of a transport chain [31]. Also, the existing works on the topic of risk in intermodal supply chains do not offer an adequate and full picture of all the potential dangers that intermodal supply chains are exposed to, which is the purpose of this paper. The main result of this work is the proposal for a general framework for holistic defining of the intermodal supply chains risk which should provide decision makers with a wider insight into the risks that these chains are exposed to, in addition to a good basis for an initiative for the improvement in the transport and supply chains efficiency.

2. Intermodal Supply Chain Concept and Related Terminology

Globalization of markets and the improvement of information and communication technologies occurring almost on a daily basis have led to the creation of global supply chains, the functional integration of which cannot be imagined without intermodal transport chains which enable an efficient (first of all, in terms of cost, time and reliability) transportation of goods among members in the chain. The intermodal transport development has an impact on further economic globalization, so that its significance in the future shall be considered through defining directions for further development of the overall transport system based on the principle of intermodality. The intermodal supply chain can be defined as a network of consumers, retailers, distributors, transporters, warehouses, suppliers and producers among which transportation of goods is performed by two or more modes of transport [4]. According to [27], this represents the first basic characteristic of intermodal supply chains, while the second one is the existence of specialized places for the transfer of load units from one mode of transport to the other, which are the most critical points in the whole chain.

One such chain of mutually connected and integrated different business subjects is characterized by sequential interdependence, spatial vastness and complex technical-technological basis. The basic challenge that the intermodal supply chain meets is the seamless integration and rapid transit [17]. As the same author states, the issue of integration in intermodal supply chains can be observed from physical, economic and organizational aspects where the imperative of faster flow of goods through intermodal transport chains means maximum control and coordination along the whole supply chain. In continuation of this section, terms supply chains and intermodal transport shall be defined more closely.

2.1. Supply chain

Supply chain represents a cluster of physical elements, their activities and processes through which their mutual interaction takes place, with the aim of making the flow of material goods from the initial supplier to the end user possible [32]. Similarly, another definition of supply chain also gives [26], where the term supply chain is understood as flow of matherials, information and finances which pass through and among organizations connected by a certain number of factors such as relationships, processes, activities and integrated information systems (Figure 1). It should be stated that Figure 1 represents the picture of flows global direction, and that in the real systems both the flow of materials and finances could be two-way. Typical elements which compose a supply chain are suppliers, producers, distributors, wholesalers, retailers and end users. These physical elements form the structure of a chain and represent its fixed part, i.e. its basic infrastructure. Forming a given structure is the issue of strategic nature. The executable part of a supply chain is made of certain modes and rules for the realization of some logistic activities and processes and it is by its nature more tactical or operational. Management of the executable part and designing of a fixed part of the supply chain together make the management of the supply chain, or supply chain management.

According to [28], the term supply chain management was used for the first time in practice during 80-ties in the past century with the aim of developing a vision of demolishing functional silos which meant independent functioning of production, marketing and distribution. [29] defines supply chain management as a group of approaches used for efficient integration of suppliers, producers, distributors and retailers so that the right goods are delivered in the right quantity, to the right destination and at the right time with the aim of minimizing total costs and simultaneously satisfying the required service level. According to [32], supply chain management, where the accent is on the importance of integration of activities, represents the function responsible for transportation and warehousing of material goods on their journey from suppliers, over intermediary operations to end users.

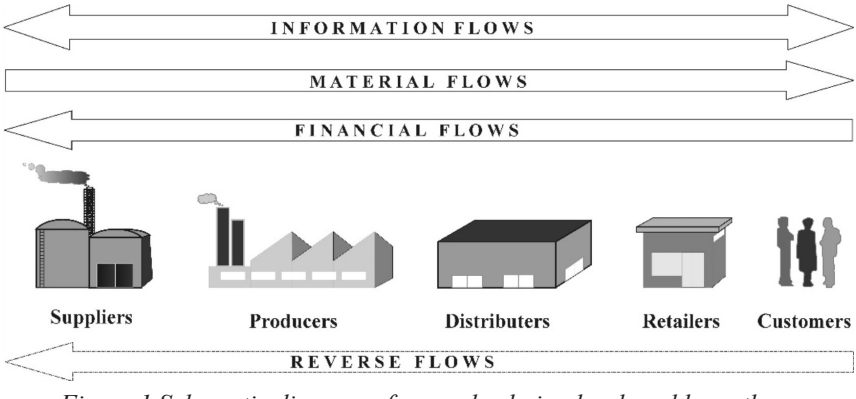

Figure 1 Schematic diagram of a supply chain, developed by authors

In providing maximum available, flexible and reliable transportation services in a supply chain, intermodal transport systems have become of essential importance. Intermodalism is the basis of advanced logistic strategies which the biggest transportation companies in the world apply. Because of this, the efficient supply chain management requires understanding of basic technologies and intermodal transport systems, basic characteristics of its services as well as advantages which may be achieved by its appropriate application. It is highly important to know the intermodal transport terminology itself as well as any elements of which the intermodal transport system is composed and types of connections present within the system [17].

2.2. Intermodal transport system

The intermodal transport terminology is not unified and consistent [5]. Different participants in the intermodal transport system use different names (terms) and different definitions of the terms. In literature and in practice, beside the term 'intermodal transport', terms such as multimodal, combined, integrated transport also appear. Even though all these terms in fact mean usage of two or more different modes of transport in performing a transportation task, and as such they can be considered synonyms [2], the usage of some terms and understanding of their meaning differs in dependence on subjects in the supply chain and on the context of observation (legal, operational, methodological) In this paper, the term intermodal transport shall be used, of which some definitions are given below. Thus, [10] defines intermodal transport as the transportation of goods or people from initial to end destination by at least two modes of transport while the transfer of goods or people from one mode to another is performed in intermodal terminals. An almost identical definition is given by [34], who also states that during the past years the term intermodal transport has been identified more and more with the term container transport. The European conference of ministers of transport defined intermodal transport in the document from 2002 as moving of goods in the same load unit or road vehicle which uses two or more modes of transport without touching the load during transshipment from one transportation mode to another [5]. [35] defines intermodal transport through three basic conditions which have to be fulfilled for a transportation to be considered intermodal: (1) existence of standardized load units in which goods are transported from initial to end destination; (2) basic load units have to be in the form of ISO containers, swap bodies, semi-trailers and specially designed containers; and (3) load units have to change at least two modes of transport during realization of a transport chain. Therefore, it can be concluded that the first basic characteristic of intermodality is a multiple transportation during the transport of goods from initial to end destination, while the second characteristic is related to the form of transport of goods which represents standardized load units such as containers, swap bodies and parts or whole road vehicles. Intermodality can be observed as a qualitative indicator of the level of integration of transport modes in the sense that

greater intermodality means greater integration and complementarity among transport modes which ensures better conditions for efficient functioning of the transport system.

The economic basis for intermodality means the usage of certain advantages of basic transport modes and their combining into an integrated transport "door to door" chain, with the aim of improving the whole transportation system.The integration is needed both at the level of infrastructure and at the level of operative procedures and legal relationships among the participants [37]. Therefore, intermodal transport chains require the existence and development of appropriate infrastructure and technological solutions which should ensure seamless realization of goods flow. Besides, in the realization of an intermodal transport chain, a great number of different types of subjects (participants) take part with different mutual relationships, which all together makes the intermodal transport system a highly complex system.

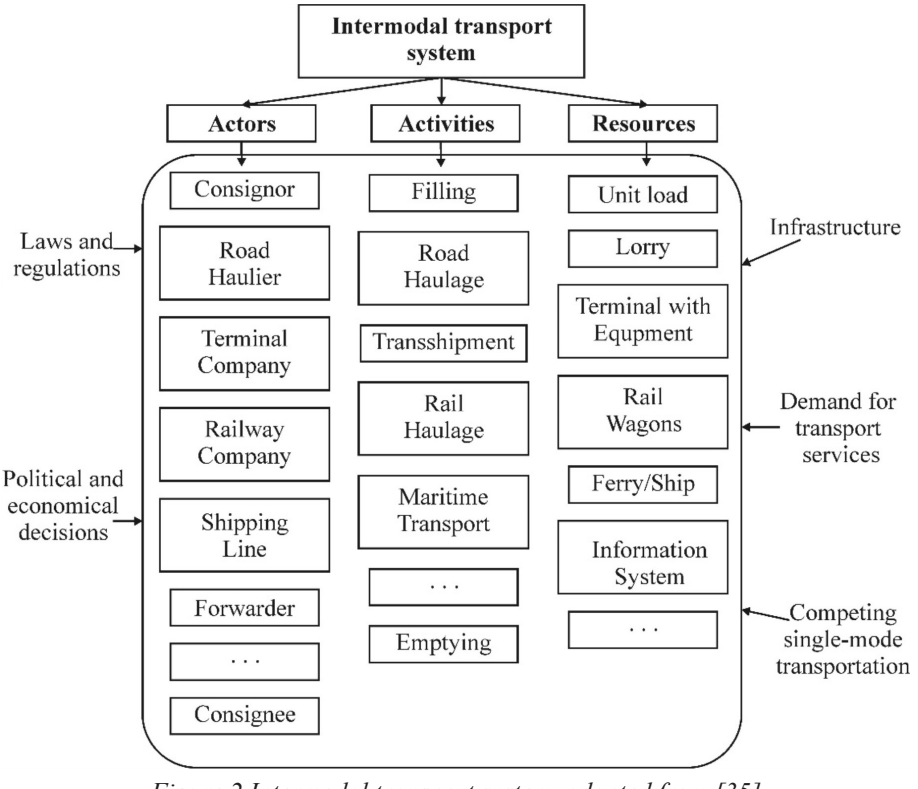

Figure 2 Intermodal transport system, adapted from [35]

The aim of this paper is to create a methodological framework for the systematization of risks in intermodal supply chains. Risks in intermodal supply chains are not possible to recognize and systematize without the knowledge of adequately defined

elements of the intermodal transport system and their mutual relations. Intermodal transport system can be observed, e.g. as: technical system, system of rendering transport services, system of logistics (distributive) channels, system of marketing channels or a system that serves for the reduction of impact of transportation to the environment [13]. In the paper [35], the intermodal transport system is observed from three aspects: (1) technical – considering the intermodal transport system as a technical system with hierarchically connected elements which do not have the characteristics of independence; (2) network – where the intermodal transport system is characterized as a sequential transportation of goods among the nodes mutually connected by bonds and thus forming a transportation network, and (3) aspect of chains – within which the intermodal transport system can be considered as a sequence of repeated connected activities. The result of such an analysis of the intermodal transport system is the model which represents a unique synthesis of the three mentioned approaches (Figure 2) which shall serve in this paper as a basic element of the methodological framework for the systematization and risk management in intermodal supply chains.

3. Risk management

3.1. Definitions of risk and risk management

The concept of risk appears in all spheres of human activities which is the reason for its intensive treatment from different aspects and perspectives. Generally, the risk is most often observed as the product or the function of several components. According to [32], the risk represents a probability that some unexpected event shall do harm to a business organization and it is defined in the function of the level of uncertainty (given through probability or frequency) and the size of impact (consequence) of such an event. The International organization for standardization (ISO 31000) also defines the risk by two basic components: the consequence and uncertainty of the realization, while consequences can be both positive and negative. From the financial aspect, probably the oldest one since used for hundreds of years earlier for insurance of trade ships, the risk is regarded as a probability of the expected result [20]. From the strategic aspect, the risk is used for adjustment of the amount of capital return on investments [7]. From the marketing aspect, the risk comprises the nature and significance of purchasing goals and failures in satisfying psychological and qualitative goals [9]. In the paper [25], the initial definition of the risk means the existence of three types of questions (dimensions) which the author calls a "triplet": "What may happen?", "What is the probability that it shall happen?" and "If it happens, what are the consequences?". Similarly to the mentioned risk concept, in the paper [3] the risk is defined as an unexpected situation where end results do not correspond to the set goals, while it is emphasized that defining of the risk concept requires a certain measurability of the risk and risk factors. When the risk qualification itself is in question, then the standard formula considered by most authors

assumes risk (R) as the product of probability of the occurrence of some undesired event (L) and consequence of the occurrence of the event (I), that is: R = L x I [20].

The general characteristic of all the mentioned paradigms related to the risk includes unexpected event, decision-making and potential losses. Therefore, the risk can generally be defined as a product of probability of the occurrence of undesired situations and size of their consequences, which result in a deviation of actual results from the planned ones [21]. Defining the risk is made easier by its recognition, that is, identification. Once the existence of a risk is established, certain (re)action is to be undertaken. Therefore one should bear in mind that bringing a wrong decision may lead to greater problems or even to complete collapse of the system. Therefore, the understanding of risk characteristics, and above all, its structure and mutual causal-consequential relations with other groups or risk categories is of utmost importance for its efficient management. Generally, reaction to risks is known in literature under the term risk management. The shortest definition of risk management includes an integrated process of identification, assessment, prioritization and risk control. Generally, risk management represents an appropriate process of decision-making defined differently by different authors. According to [24], risk management represents a process in which decision is made on acceptance of known or assessed risks and/or implementation of actions with the aim of mitigating consequences or probability of their occurrence. [32] defines risk management as a process of systematic risk identification, analysis and control. [14] defines risk management as a process responding to the existence of uncertainty (and thereby the risk) through the control of deviation from the set goal, the aimed specification or standard.

The method of implementation of the risk management process is defined by a certain number of key elements or phases of the process. The number and context of these phases (steps) defining the risk management model differ in dependence on authors and institutions mentioning them [21]. In literature and practice, a great number of risk management models can be found and in most of them similar elements are present as stated in [24], ranging from identification/analysis (or assessment) of a risk, through assessment (or evaluation) of a risk to different ways of risk management and control. Therefore, it can be concluded that almost all models are identical regarding the basic processes they are made of, while only the names of those processes differ. Confimation of such a conclusion and statement can be found in the paper [32], according to which each of the existing risk management models is characterized by three basic processes: (1) risk identification; (2) risk analysis; and (3) risk control (Figure 3). For the realization of each of these phases, a certain number of techniques and methods are used, some of which have found their application in the supply chain risk management.

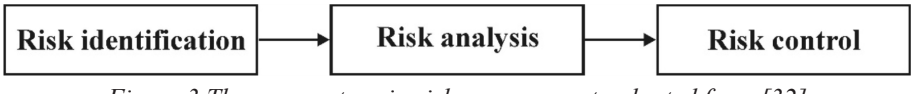

Figure 3 Three core steps in risk management, adapted from [32]

3.2. Risks and risk management within the supply chain context

There is not a uniform and generally accepted definition of the risk within supply chains. The concept of supply chain risks can be defined as exposure to different events which have adverse effect on the operative capacity of a supply chain, and thereby to its performances such as the service level to end users, costs or possibility of quick response [30]. Supply chain risks represent everything that can endanger the capability of a supply chain in the fulfillment of its goals [23]. One of the most comprehensive and pragmatic definitions was given by [18], according to which supply chain risks include all the risks of information, material and financial flows from the source of raw materials to end users, represented by the probability of discrepancy (non-uniformity) between the supply and demand. The spectrum of risk events may have an impact on the operational capacity of the supply chain and it has a wide range from the external (from the environment of the supply chain) to the inter-organizational and intra-organizational ones, while their consequences can be categorized within the range of short term (of less intensity) and long term ones (greater intensity) [22]. The key factor of an efficient risk management includes its understanding and classification. In literature, several ways of supply chain risks classification can be found where different types or categories of risks are proposed. In the paper [22], it was concluded on the basis of literature reviewing that there are more than 30 different proposals for risk classification. Generally, most of the existing supply chain risk classification models can be lined up in one of the following three characteristics [33]:

- Risks with high impact-low probability, high impact-high probability, low impact-high probability and low impact-low probability as proposed by [19].
- Supply, demand, operational and external risks as proposed by [8].
- Risks from the aspect of organization, network and environment as proposed by [18].

In the paper [23], it is stated that risks, risk level and risk management within supply chains are three very important concepts and the supply chain risk management (SCRM) is defined as a method of identification, analysis, monitoring and control of consequences of events which might endanger logistic activities in the supply chain. Risk management requires a well planned and organized cooperation of all members in the supply chain with the aim of responding to risks in order to ensure continuity and efficiency of supply chain functioning. As there is neither a unique formally accepted definition of the supply chain risk nor a generally accepted definition of the supply chain risk management, [6] states, on the basis of 60 works reviewed, that the most frequently quoted definition of SCRM is given by [18], according to which SCRM represents identification of potential sources of risks and implementation of appropriate strategies by coordinated action of members in the supply chain in order to diminish vulnerability of the supply chain. SCRM represents a multi-dimensional phenomenon with a wide spectrum of circumstances influencing it, including very complex procedu-

res and methods of their implementation [21]. However, as stated by [32], it is possible to extract several basic principles on which the SCRM stands:

- The Principle of balance (*trade-off*) between the desire for a greater efficiency and the increasing supply chain vulnerability;
- The Principle of pro-activity, since risk management must ensure readiness of a company for occurrence of risky events;
- The Principle of circularity, since the process of SCRM never ends but plans for its improvement are constantly made taking into consideration new conditions (SCRM is a cyclic and not a linear process).

The SCRM process should include all the activities directed to quantification and qualitative analysis of risky events which are created as the result of uncertainty. That is, the SCRM represents a unique process of decision-making which includes activities of identification, analyzing, assessment and forming appropriate measures as presented in Figure 3, which represents a general model of the SCRM process. [32] supplements this model with several more phases (Figure 4) creating the SCRM model which is very often quoted and used in literature. Therefore, the process of defining and implementation of the SCRM represents a closed cluster of progressive tasks whose actual realization depends on the context of application. In the following section, the risk management process shall be presented the tasks of which and ways of their realization are, as believed by the author, suitable for intermodal supply chains.

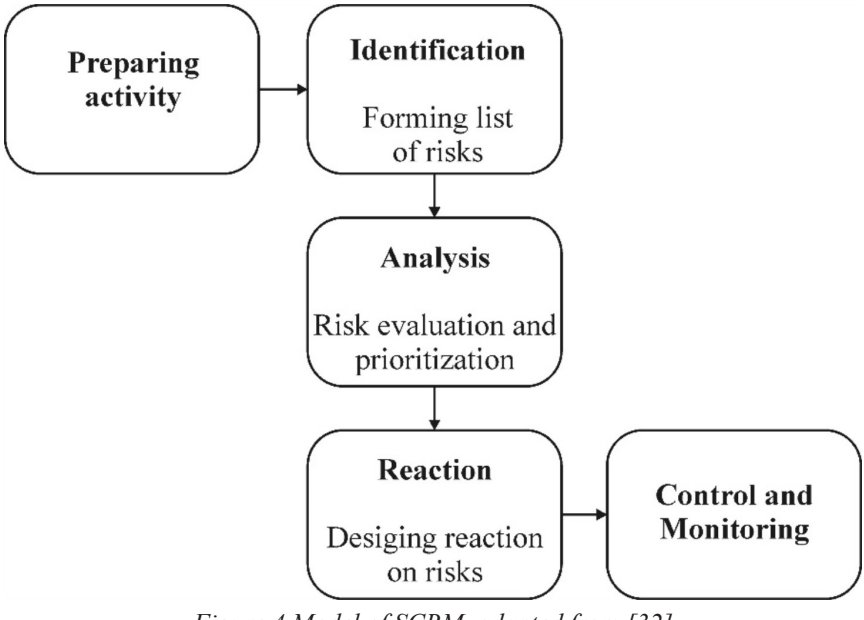

Figure 4 Model of SCRM, adapted from [32]

4. Developing framework for the intermodal supply chain risk management

4.1. Previous research on risks in the intermodal supply chain

Researches on the topic of risks mostly start with their classification which should help in precise identification and further efficient risk evaluation and control. Risk classification in intermodal supply chains is most often performed in the context of the existing risk classifications within supply chains, generally presented in the previous part of the paper. Lacking in standards regarding risk classification both in supply chains generally and in intermodal chains is the consequence of insufficiently defined risk concept and structure, that is of vague boundaries of the concept of risk and concepts of uncertainty, risky event, vulnerability, resilience, risk source etc.

Due to the complexity of the system, as already stated, which is represented by a large number of different activities, participants, technical means and managing systems and practices, intermodal transport chains are more exposed to risks than unimodal ones. Also, due to the complexity of relationships among participants in the intermodal transport system, concerning responsibility above all, risk management processes are also quite complex. Regarding risks that may appear in the intermodal supply chain, as stated in the paper [12], risks to which goods are exposed as well as deliverers, receivers and all other partners in the supply chain may be distinguished, as well as risks to which technical resources, shippers and logistics service providers, human labor force, information risks etc. are exposed. The same author, considering first of all safety of intermodal transport chains as the basic source of risks, mentions: goods, transportation devices and people, after which he gives the risk classification: transportation devices risks, load units risks, risks of different points for transfer of load units and personnel risks. Regarding the methods for risk management and control, above all in a pro-active manner, [12] points out to the necessity of usage of procedures and rules (both national and international), then a homogenized usage of modern information technologies and training staff for timely reacting to occurrence of risk events.

Analyzing risks within container supply chains, [36] mentions four basic sources of risks: processes, labor force, organization and environment. Regarding processes, the author considers risks from an engineering perspective in the context of passing goods through the supply chain composed of different technical means, infrastructure and other technical objects. The second group of risks is related to labor force, that is to deviations in their actions (errors, health, misapplication) which may lead to lesser or bigger disturbances in the chain. The third group of risks is related to the business strategy and micro-economic context, while the fourth group of risks has its source in macro-economic, political and climatic conditions. In [36], it is further stated that identification of all risks in a chain is extremely difficult and therefore only examples of potential hazards are mentioned and threats which appear in the context of container ships and ports. Examples of potential danger in the domain of ships are as follows: collisions, fire and explosions, stranding, malfunctioning of ship machines, load dam-

age, dangerous loads etc. Regarding ports, some of dangerous situations are collision of ships, malfunctioning of technical equipment, loss of load, explosions and fire, etc. Some of threats are: human errors, health and safety of employees, strikes, terrorist attacks, war, economic crisis, financial break down, illness, poor weather conditions, etc. The risk management process within container supply chains proposed in [36], beside the identification phase, also includes risk screening (their evaluation and prioritization on the basis of a risk matrix) and risk control (a list of counter measures which include solutions based on training of employees, change in procedures and new technical solutions).

In the paper [17], inter-organizational relationship is observed between two segments of the intermodal supply chain: the container terminal and drayage trucking operations in the context of the amount of weakness of this connection that can cause risks in relation to the whole supply chain. In [1], risks in the inland waterway transport on the middle Danube were investigated, above all in the context of sailing, and they have defined the framework for categorizing risk in inland waterway transport (IWT) chains (Figure 5). The same authors propose the risk management process based on the one already existing in literature, which is composed of six phases: risk identification, consequence analysis, risk estimation, risk assessment, risk mitigation, and risk monitoring. The given risk management process represents a part of the three-dimensional approach to the risk issue in IWT chains which, beside the managerial context, also captures different types of risks and the unit of analysis positioned along three perpendicular axes (Figure 5).

In the paper [31], supply chain risks were analyzed in the Gulf of Finland in order to understand how the studied supply chains are affected by risk. Also, the study addresses the risk management possibilities by investigating the risk visibility and control perspectives as well as the cooperation of the focal actors. The study started by first discovering the intermodal supply chain process phases, after which risk identification followed performed from the aspect of activities (processes) within the intermodal supply chain (Figure 6), where after, on the basis of an interview and collection of statistical data, risk identification was performed for each of the activities within the considered intermodal supply chain.

In this way, the study [31] identified a wide range of risks for the actual case study, which differ among themselves according to the probability of occurrence, size of consequences caused by them and possibility of their detection. After identification of risks, their classification was performed according to the proposed model by [20], as presented in Table 1.

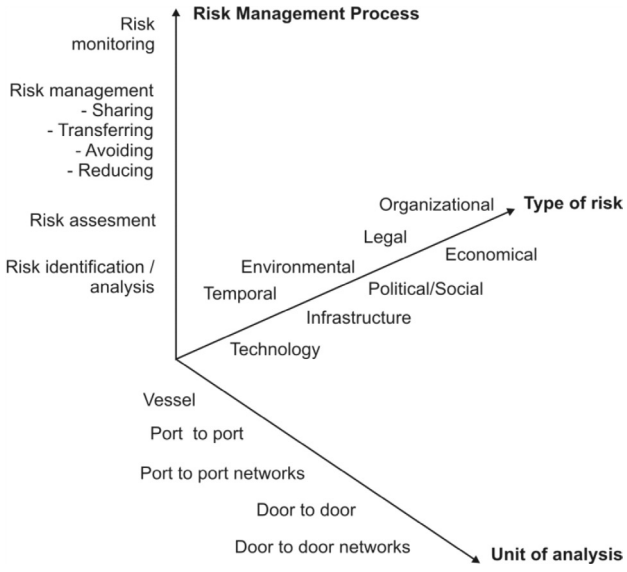

Figure 5 Framework for categorization of risks in IWT chains, [1]

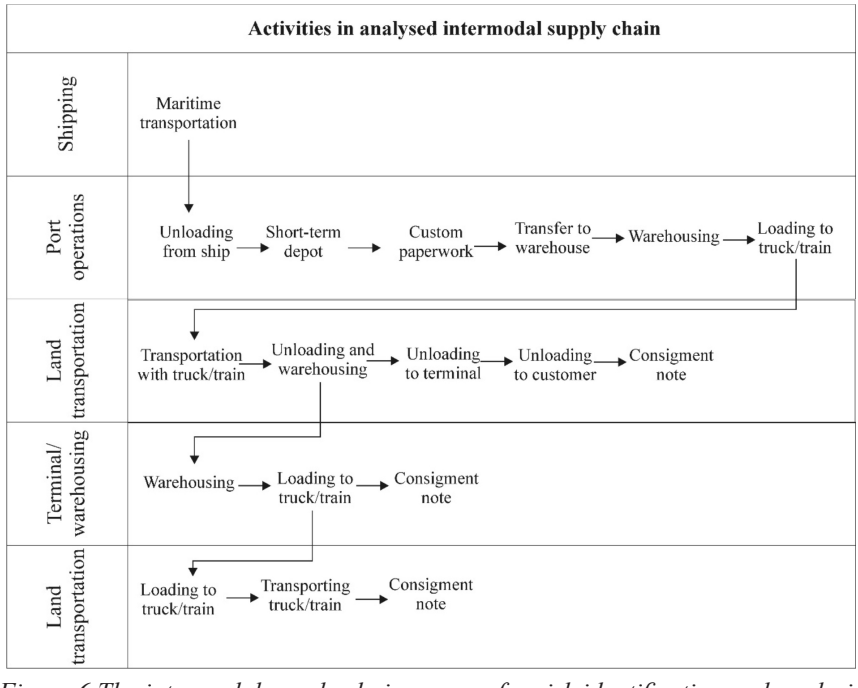

Figure 6 The intermodal supply chain process for risk identification and analysis adapted from [31]

Risks, identified by activities of the intermodal supply chain and classified in the way as presented in Table 1, are further analyzed in the context of their probability, size of consequences and possibilities of detection and control. The result of the risk analysis is their prioritization which represents the basis for determining measures for their control (treatment). The model of risk management applied in this study is based on the model presented in Figure 4 and, as the basic resource for the risk management, a quality interchange of information among all the participants in the chain is mentioned, which should allow for timely response to risks in terms of decreasing probability or size of consequences of their occurrence.

Table 1 Categorization of identified risks developed in [31]

Risk category	Supply Risks	Security Risks	Operational Risks	Macro Risks	Policy Risks	Environmental Risks
Identified risks	Hazardous materials; Stoppage made with cargo onboard; Lack of intermodal equipment; Bottlenecks in transport routes; Capacity problems in railway; Problems in customs clearance; Employee strikes; etc.	Organised crime; Smuggling of people; Information system breakdown; Drunk drivers; Traffic law negligence; Spying and espionage; Ownership of the merchant fleet; Energy supply; Eco-terrorism; Water supply, Problems in telephone connections; Terrorism; etc.	Ship collision near port; Lack of skilled workers; Problems with equipment handling; Workers' accuracy and motivation; Interpretation problems with documents	Financial crisis; Small markets; Fierce competition in transport sector.	Customs; Railway operators' attitudes.	Nuclear disaster in nearbly plants; Ice conditions in wintertime; Fire; Regional infectious diseases; Climate change; Natural forces; Long distances; Toxic waste; Fog in the shipping line; Geographical position; Slipperiness in wintertime.

4.2. Proposed framework for the intermodal supply chain risk management

Intermodal supply chain risks could be a consequence of one or more stohastic and unpredictable events or performed activities, and they range, as already mentioned, from daily delays to catastrophic events caused by man-made failures or natural disasters. The basic prerequisite for an efficient management of those risks is their identification, categorization and clear understanding. There is a lack of a standardized and widely accepted intermodal supply chain risk management model in the current literature and practice, lacking even a single and unified model for their classification, which is, among others, the result of a lack of a clear understanding of the underlying risk factors (risk structure). Hence, the main idea of this paper is to propose, first of all, the model for identification and classification of risks in intermodal supply chains, based on the basic elements of the intermodal transport system.

The research strategy based on a deductive research approach has been applied in this paper. Since only limited research works on the intermodal supply chain risk management has been found, a qualitative methodology based on the explorative approach and literature review has been chosen. That is, based on content analysis of the existing literature about intermodal supply chain risk management models and models of the intermodal system structure, a new conceptual framework for identification and categorization of risks in intermodal supply chains has been defined. In that way, the final aim of the proposed model would be to create an as detailed list of risks as possible that intermodal supply chains are exposed to. This paper does not include the verification of the proposed framework since it has not been applied in a real system and this should serve as the main direction of further research.

The proposed model for the intermodal supply chain risk management is based on the general supply chain risk management models given in [23] and [32], as well as the intermodal system structure model proposed in [35] (Figure 2) which is used as the basis for the intermodal supply chain mapping (supply chain screeening), as a basic requirement of the quality risk identification. As illustrated in Figure 7, the process used to create and implement the proposed intermodal supply chain risk management system follows the progression of tasks, arranged in a manner to suit the context of the intermodal supply chain risks especially in terms of their identification, which will be briefly explained in the following part of the paper.

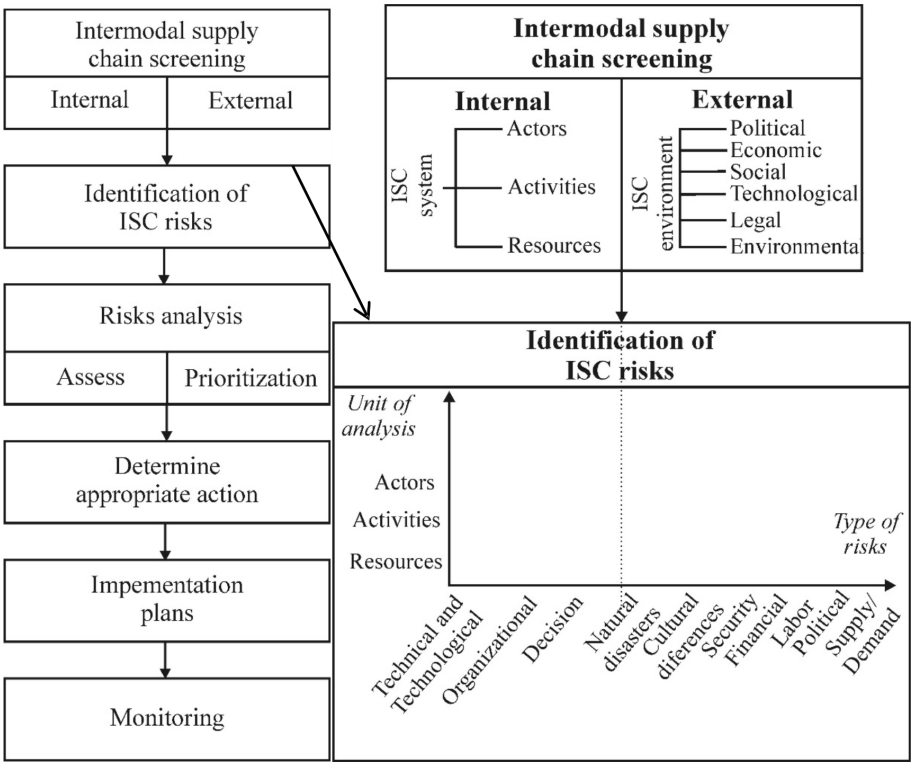

Figure 7 Proposed framework for ISCRM, adapted from [23]

The main taks of the "pre-identification" phase is the mapping of the intermodal supply chain and scanning of basic internal and external components of the intermodal supply chain environment. The analysis of the internal components involves screening according to the basic elements of intermodal transport systems (activities, actors and resources). This is the main difference compared to some of the existing papers in the field of intermodal supply chain risks, which usually analyzed only one of the main groups of the intermodal transport system elements (usually activities, as presented in [23]). The external factors that could be analyzed are almost endless. The specific list of these factors depends on the particular intermodal supply chain. Here is proposed, similar to the paper [23], the PESTEL analysis method as a general way of analysing the external components of the supply chain environment based on six factors: *political*, *economic*, *social*, *technological*, *environmental* and *legal*. The above mentioned factors are largely consistent with the environmental factors set out in the adopted model of intermodal transport system structure (shown in Figure 2).

Risk identification represents a logical continuation of the first phase of the proposed intermodal supply chain risk management model. The basic framework for risk

identification is created by a combination of the unit of analysis and the different types of risks positioned alongh two perpendicular axes (similar to the framework in Figure 5). The unit of analysis are the basic groups of elements of the intermodal transport system, and types of risk are divided into two main categories according to internal and external factors of the environment in which the intermodal supply chain exists. Internal risks are divided into: technical-technological, organizational and decision and they represents risks whose sources lay in the intermodal supply chain structure and which can be controlled by the supply chain decision makers. External risks are classified into the following groups: natural disaster, cultural differencies, security, finance, labor, political, supply and demand. Among others, natural disaster risks could be: earthquakes, hurricanes, floods, drought, etc. The cultural differencies risks include the following: ethical norms, holidays, religious observances, laguages, styles of communication, decision-making processes, etc. Security risks could be: fraud, terrorism, data securty, proprietary data, etc. [23]. The basic principle of the realization of a risk identification process, according to the proposed model, involves the identification of risk according to the basic structural elements of the intermodal supply chain (unit of analysis). That is, for each element of the intermodal supply chain, risk identification is performed (from internal to external categories). The outcome of this model's phase is information about potential vulnerability sources systematized in the form of appropriate risk catalogs.

After the identification process, the next step involves the risk analysis in terms of determining their basic characteristics: the probability of occurrence, duration and severity, which can be defined as risk assessment. The prioritization of risks (the required urgency in risk responding) is something that follows thereafter. That is, after the risk assessment, their categorization is carried out according to the degree of priority and the type of response with the final purpose of specifying the critical risks for the observed intermodal supply chain (allocate the most critical risks in defining countermeasures for their treatment and control). Determining appropriate action means deciding on the most suitable form of reaction to the risks. The main task of this phase is to select the most efficient and cost effective response to risks (according to their priority). The selection of countermeasures is followed by a plan of their implementation. When it comes to the character of those measures, they range from technological and organizational, through educational and knowledge transfer measures to methodological and financial ones. Monitoring includes periodic reviews of the risk catalog, plans for their treatment, as well as other activities related to the implementation of the risk management process. The most important feature of the monitoring phase is their continuity and regularity. Risks are not static; therefore the system used to manage them must be flexible enough to accommodate variability. It is a never-ending task [23]. In that way, all steps within the proposed framework for the intermodal supply chain risk management are defined.

5. Conclusion

In the past decade, risk management became one of the key logistic activities, but its implementation is not simple, especially in the case of global supply chains which are characterized by transportation of freight over long distances, with long delivery times and a large number of participants with various inter-relationships. The lack of awareness of the risks and their management will certainly have an impact on the intermodal supply chain competitiveness. Some of the consequences of disturbance and disruption in global supply chains are: delay or interruption in delivery, increased costs, increased uncertainty and market unpredictability, etc. According to the aim of this paper, the basic research effort was made in the direction of pointing out the importance of an integrated and holistic approach to the problem of intermodal supply chain risks. Since the role of intermodal transport in global supply chains is very important, every risk that occurs in the intermodal transport system may adversely affect the flows of goods, information and finace that are realized through the given supply chains. A literature review revealed the existence of very few papers on the topic of intermodal supply chain risks, which is a proof of the significance of the selected research topic and an evidence of the contribution of the paper to the solving of the problem of defining the methodological framework for the intermodal supply chain risk management (with special emphasis on the most important step of this process-risk identification and classification). Further research on this topic should be related to a more detailed description of other risk management process phases, whereby special attention should be paid to the model verification and to the dynamics or the hierarchy of risk. The sources of risk may be responsible for several risk events, and a single risk event could be the result of impact of various risk sources. Likewise, a risk may act as a source for other risks. Therefore, it is important to identify the cause-and-effect relationship between sources and risk events, as well as between risk events themselves (especially the relationship between external and internal types of risks), because only in that way a high quality intermodal supply chain risk management process could be achieved.

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Upravljanje rizicima u intermodalnim lancima opskrbe

Sažetak

Efikasni i sigurni globalni lanci opskrbe pridonose unapređenju kompetitivnosti proizvoda kojima se trguje na međunarodnim tržištima tako što omogućavaju smanjenje troškova i vremena isporuke uz istodobno povećanje njene pouzdanosti i sigurnosti. Globalni lanci opskrbe su nezamislivi bez transportne integracije koja se najčešće realizira kroz formu intermodalnih transportnih sustava. Intermodalni transportni sustavi su dosta složeniji od unimodalnih zbog sudionika, transportnih sredstava, infrastrukture i procesa, što u uvjetima slabe koordinacije u planiranju, organizaciji i realizaciji logističkih aktivnosti u transportnom lancu može dovesti do povećanja ranjivosti lanca na kašnjenja, zastoje ili kompletne prekide. Prema tomu, osnovni izazov u funkcioniranju intermodalnih transportnih aktivnosti u lancima opskrbe je povećanje njihove efikasnosti, uz uvažavanje problema pripadajućih rizika. Postojeće inicijative na temu identifikacije i upravljanja rizicima u intermodalnim lancima opskrbe ne pružaju kompletnu sliku o potencijalnim opasnostima kojima su intermodalni lanci opskrbe izloženi. Upravo je to svrha ovog rada, gdje se na osnovi pregleda modela strukture sustava intermodalnog transporta i modela upravljanja rizicima u lancima opskrbe generalno, daje predlog okvira za holističko sagledavanje rizika u intermodalnim lancima opskrbe koje može omogućiti unapređenje njihove efikasnosti i kompetitivnosti.

Ključne riječi: intermodalni promet, intermodalni lanci opskrbe, rizik, upravljanje rizicima.