MANAGEMENT OF INTERMODAL INTEGRATION OF RAIL TRANSPORT

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Abstract: *This paper presents the main positive effects of intermodal integration management especially in times of crisis, such as the covid-19 pandemic and not only, intermodal transport proving to be one of the safest systems, with which large quantities can be transported of goods on long, fixed, and controlled routes, with less staff. Intermodal transport plays a strategic role, but there are also certain problems encountered, which will be presented. In the context of intermodal integration, rail transport is the main player in protecting the environment and conserving energy resources. The study presents an analysis of the main notions, differences, barriers, solutions to increase quality and stimulate interest in intermodal transport.*

Keywords: *intermodal transport, management, terminals, globalization, hub-and-spokes.*

JEL Classification: *L92, O10, R40*

1. Introduction

One of the most important aspects of the times we live in is the notion of globalization which involves the international integration of markets for goods, services, capital, free and unrestricted access, on a commercial basis, to raw material and energy resources.

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As a consequence, as a result of globalization, there is a major increase in the marketed finished products, due to foreign investment in areas with cheaper labor, which will increase in the coming years. With regard to the transport system, the main effect of globalization is the connection between economic growth and the growth of freight and passenger transport.

The development of transport is directly proportional to the international economic development, which has imposed an exponential increase in the volume of goods transported.

This leads to an increase in the number of road freight vehicles, additional costs, pollution, accidents and adverse social effects. The need to disconnect economic growth from increasing transport volume, in order to further reap the benefits of economic growth while reducing adverse effects, can be done by promoting greener and safer modes of transport.

The notion of intermodal transport has developed since 1960, with the emergence and evolution of large cargo units (containers). This development has led to a rapid and continuous growth of containerized transport, facilitating the development of international trade.

According to the definition accepted by mutual agreement by the main national and international entities, *intermodal transport is that transport system which involves the successive use of at least two modes of transport and in which the intermodal transport unit is not divided when changing modes of transport* (Organizația Națiunilor Unite, 2001).

Intermodal transport is also found in the literature and under the name of transport **"point to point"** characterized by the integration of at least two modes of transport.

The transport system is an essential factor of the economy of a state, being the basis of production processes, distribution, consumption operations, making it possible to move raw materials, products and people. In recent years, studies have shown an imbalance between different modes of transport, especially to the detriment of rail transport.

Changing the balance between the different modes of transport must aim to increase interest in railways through the development of intermodal transport, mainly by combining road/rail modes, the effects of which have a positive impact on several factors, either economic or from the point of view of road safety, the environment, the globalization process and mobility. Despite all the measures taken, strategies and directives, etc., more and more journeys are made by road and the use of this mode of transport is constantly increasing, the consequences of this approach being more and more serious, namely: congestion, pollution, increasing the number of road accidents and more.

The transfer of transport operations to the rail or naval sector, where possible, reduces the negative effects of road network congestion, this process also requires serious investment in intermodal infrastructure, construction and operation of intermodal freight or passenger terminals.

The efficiency of operations in intermodal terminals (transshipment/ transfer, transit, etc.) is very important for the development of intermodal transport, requiring a serious approach and research on intermodal transport networks, location of terminals, etc. For the design of an intermodal transport terminal, it is necessary to apply mathematical and simulation models to solve the following points:

- determining the location of the terminals where the transfer between the transport modes is made;
- determining the requesting for modal networks;
- determining the capacity of the terminals (Costescu, 2012).

The elements analyzed and presented in this paper refer to the intermodal railway-road transport. The structure of this mode of transport includes the following elements:

- collection / distribution of goods in the hubs of origin, respectively destination (use of road transport mode);
- transport terminals to ensure the transshipment of cargo units between the different modes of transport, each terminal is a point of collection and distribution of cargo units;
- long-distance freight transport by rail.

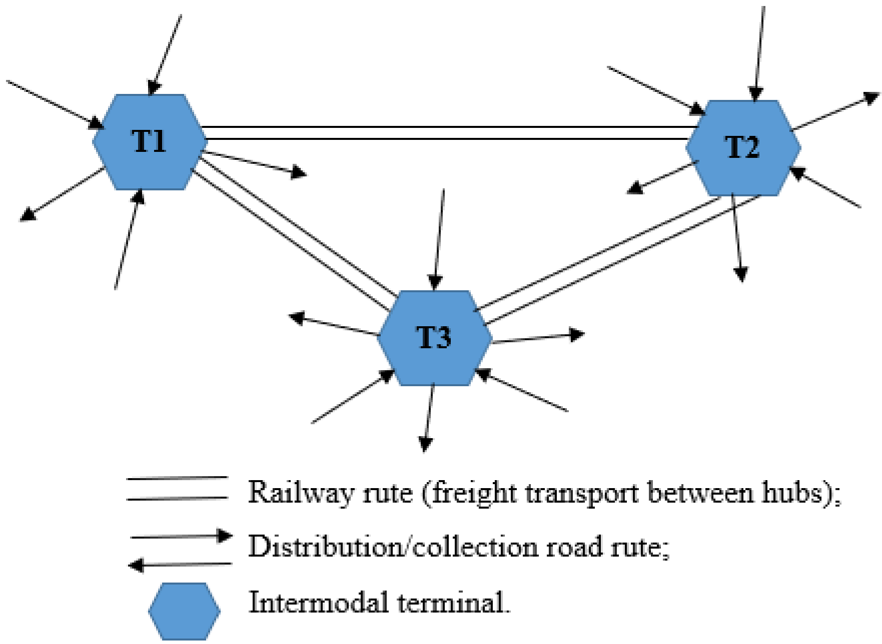


Figure 1. Examples of structures.

In the intermodal railway-road transport are used road, railway networks and special infrastructures located in the intermodal terminals. The competitiveness of this system depends on the location of the terminals and the transfer costs. Most terminal location models presented in the literature aim to find the end point of an objective function, defined for the requirements of the transport system (Owen & Daskin, 1998).

The intermodal transport process consists of several stages:

- loading/collection process;
- transshipment/grouping of freights;
- rail freight transport;
- sorting/transshipment of freights;
- distribution/delivery of freights.

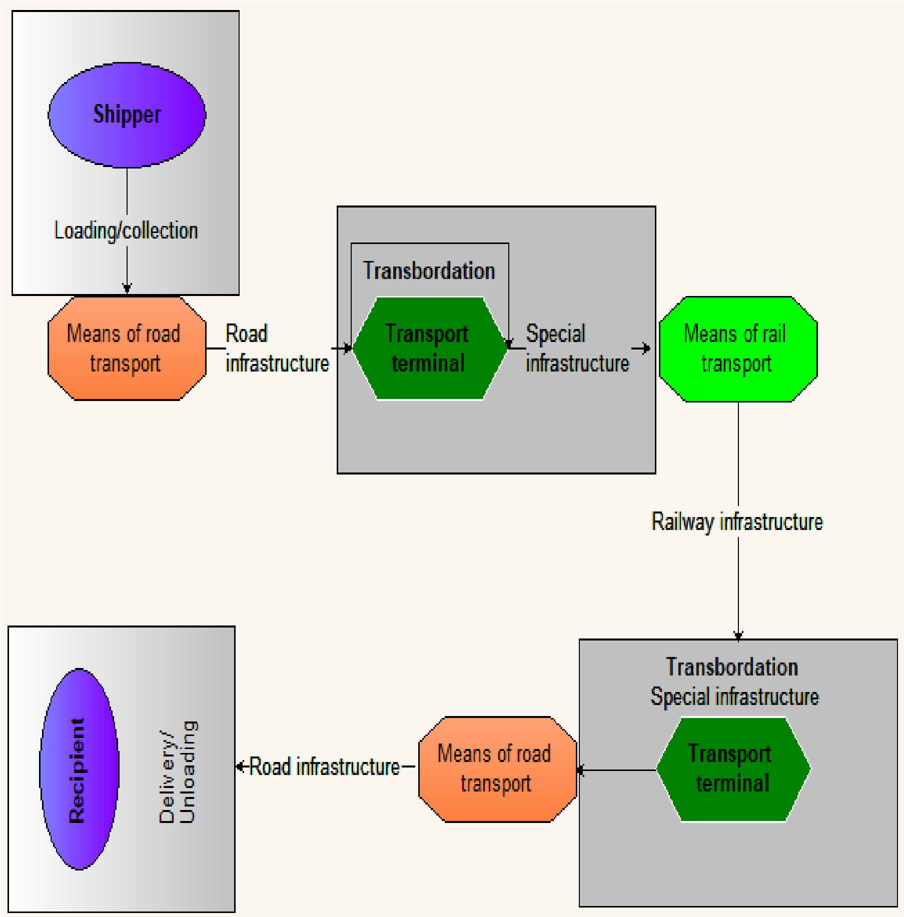


Figure 2. The operations of the road-rail intermodal transport process.

The quality of the intermodal transport service consists in the synergy of all the operations that make up the process and the management of the organization of the interactions between the different modes of transport and the organization of the participating factors.

2. Management of the intermodal integration process and problems encountered

Management in the transport sector can be defined as the need to both manage available resources and conserve existing ones through efficient and effective use, as well as to cope with existing changes and challenges.

The intermodal transport process is a complex system, all parts of the transport process, including the exchange of information, must be effectively connected and coordinated. It can be defined as a set of interconditioned activities that use resources (personnel, means of transport, infrastructure, information, etc.) to deliver a proposed result, the transport service, to meet current needs and challenges. The transport activity is a factor with a strong impact on the quality of life, the concerns are oriented towards measures aimed at developing environmentally compatible transport systems.

In this context, the intermodal integration of rail transport leads to an efficient use of transport capacity, with beneficial effects on energy consumption and pollutant emissions. Railway-road intermodal transport is a strong axis of the European Union's sustainable development policy.

The development of intermodal transport depends on the location of terminals and transfer costs. Solving the problem of the location of intermodal terminals requires a lot of potential location points, as well as the flow and cost matrix (Costescu, 2012).

In the case of a large transport network, the number of potential points is high, making it impossible to solve the location problem by a deterministic method. Therefore, the problem of selecting potential points for the location of terminals must be solved (Arnold, et al., 2004). After determining the potential points, the demand matrix and the cost matrix are estimated, data that will represent inputs to location issues.

The main steps that lead to solving the problem of terminal location are:

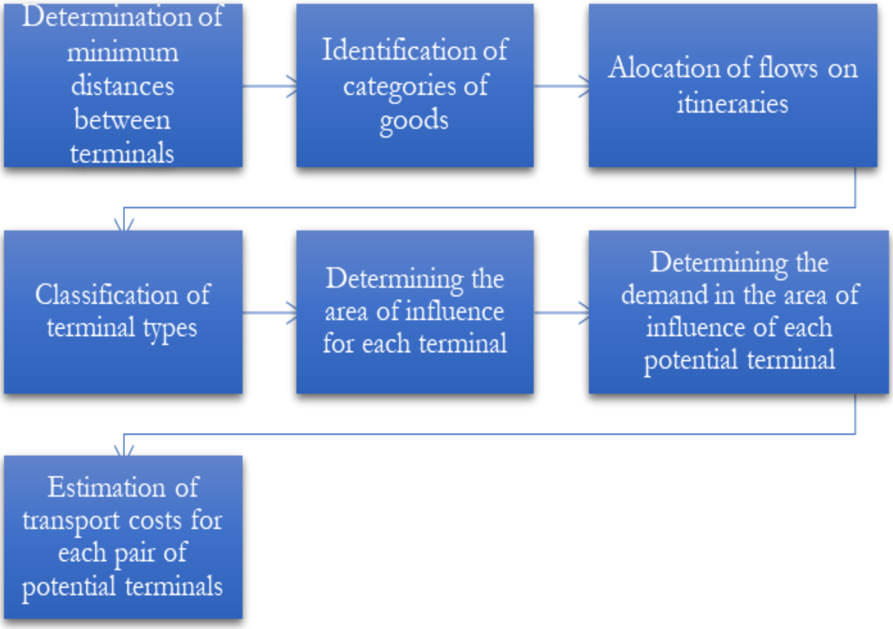


Figure 3. The stages of determining the location of the terminals

A transport network with a larger number of terminals may lead to a reduction in the initial and final road transport distances for the concentration and distribution of goods in/from the terminals. Due to the processes taking place in the railway-road transport terminals (transshipment, etc.), in order to be able to apply procedures for determining itineraries and allocation of flows and to take into account the additional durations and costs incurred in terminals, intermodal transport networks are formalize as virtual networks.

Another feature is that each terminal is treated as a complex node, which is associated with a graph (Raicu, 2007). The graph associated with the complex node allows the description of the processes performed within it, by introducing additional arcs, which are assigned costs, durations or other variables. For each type of operation performed in the node (loading, unloading, transshipment) a virtual arc is created, thus constructing a graph for each node (Costescu, 2012).

Figure 4. Example of a road-rail transport terminal.
Source: (BONTEKONING, 2006).

3. „Hub-and-spokes" networks in intermodal road-rail transport

The current trend in terms of intermodal transport and rail operators is to improve activities that result in an optimal value of the cost-benefit ratio in the point-to-point system.

This system assumes that the entire load unit in the origin terminal has the same destination.

This model is only effective if there is a constantly large amount of cargo being transported to the same destination. Traditional freight markets for intermodal transport usually consist of large flows transported over considerable distances, in ports and flows between factories and their warehouses (Cardebring, et al., 2000).

Hub-and-spokes networks in intermodal rail freight are considered a potential solution to contribute to the intermodal integration of the railway sector. In Europe, there are a number of hub-and-spokes intermodal networks that have been operational since the 1990s.

Trains are operated or cargo units are transshipped to network hubs. Maneuvering, sorting or transshipment operations are relatively time consuming and reduce the advantages of hub-and-spokes networks, in this sense a new type of terminal has been designed, specially designed for the hubs in the "hub-and-spokes" networks. In these terminals, standardized loading units (pallets or containers) are efficiently transshipped from one train to another, thus avoiding maneuvering and sorting operations at the terminals (WIEGMANS, et al., 2007).

The transport system, such as freight, passenger, parcel or even tele-communications, often requires the use of a "hub-and-spokes" network that has a proper design and a balance between price and quality of service.

A hub-and-spokes network is defined by the fact that trains with loading units are sent from the stations of origin to the stations of destination passing through a hub (central node), place where the flows of goods are reorganized (by shunting operations, or in predetermined flows in which the goods are loaded on wagons with a predetermined destination) in trains depending on the final destination. This hub has the role of an exchange operation that takes place between groups of trains. Arrivals and shipments are synchronized over a period of time according to the needs of the freight forwarder and the rolling stock available to the railway operator (Kreutzberger & Bontekoning, 1999).

These exchange hubs are equipped with equipment and organized for the execution of unloading/loading operations of standardized units for different modes of transport. For example, rail-road, rail-rail and so on can be carried out in these hubs (transshipment of goods) (Bontekoning & Kreutzberger, 2000).

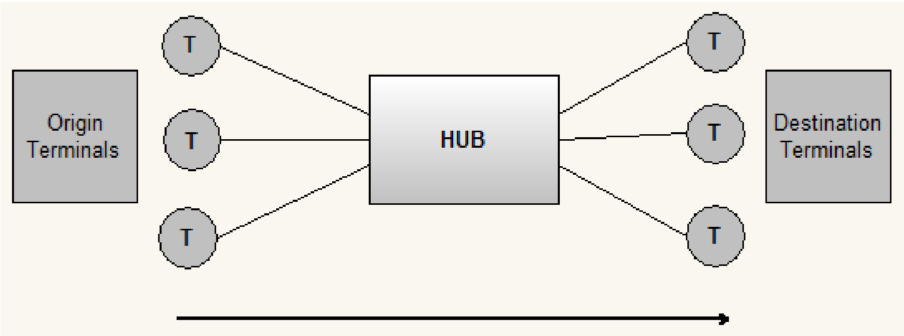
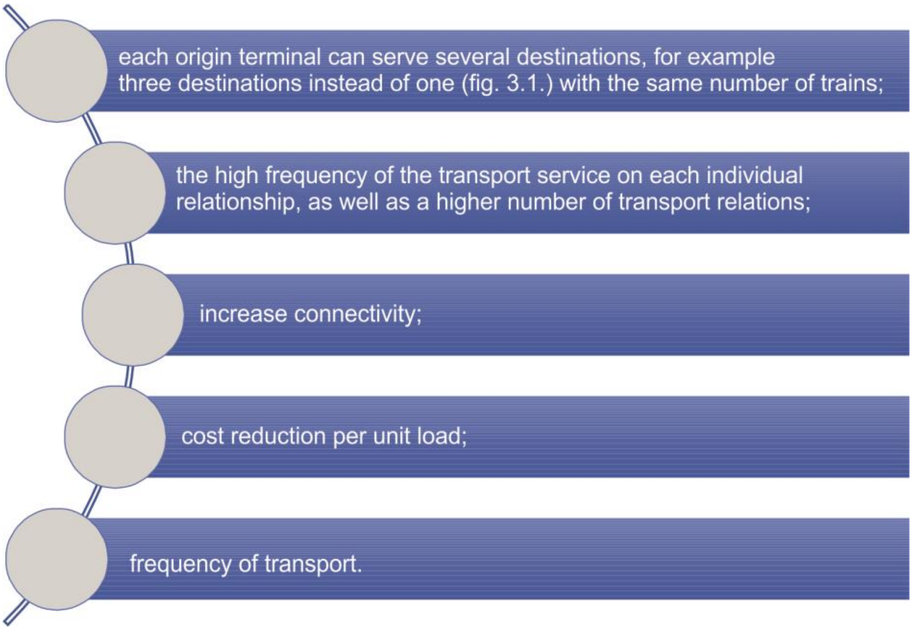


Figure 5. The configuration of a simple "hub and spokes" network.

The main advantages of hub and spoke networks compared to the classic point-to-point system are:



Due to hub exchanges, each train that is shipped from the home terminal can be loaded with standardized units for all destinations on the network. Thus, instead of a single route directly to the destination station, made with a single special train assigned for this purpose, several stations located in the terminal area could be served, without the need to increase the frequency of trains. Trains with a larger number of wagons can also be used to reduce costs. The only disadvantage of this system is:

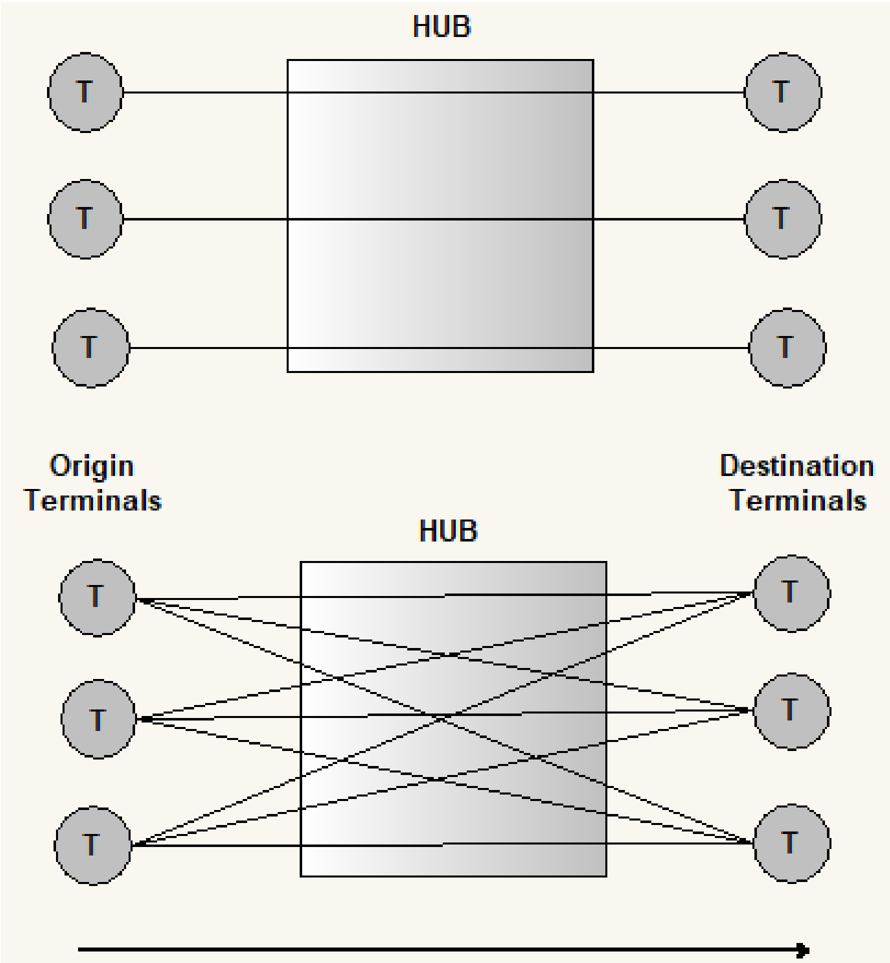


Figure 6. Creating a "hub and spokes" network from a "point to point" network.

The choice of transport network design affects the performance levels that must be fulfilled by the transport terminals and consequently the choice of transshipment technology.

The main feature of the hub and spokes model is that all load units pass through the hub terminal and therefore it must give maximum efficiency. It is very important that the hub terminal has a large capacity and is extremely reliable, because the whole system is affected in case of a blockage at this point. The hub terminal is obviously critical for the "hub and spokes" model (Woxenius, 2007).

The operational conditions required in this case are the capacity of the terminal (hub) and the distinction between the load units and their volume characteristics. The number of trains per lot and the number of lots must also be taken into account.

Operational performance is defined by the parameters that speed, flexibility and operational costs. Speed refers to the speed with which a train or batch of trains can be served. Flexibility refers to the ability to adapt to changes in cargo volume or to changes in the train's arrival schedule. The following are some of the factors that influence the current transport network:

- at this moment intermodal transport is considered a competitive mode of transport, which can be used as an alternative to unimodal transport;
- the existence of a specific equipment industry, necessary for intermodal transport;
- in the 1980s and 1990s, intermodalism in general became important as a technical issue, and since 1990, a large number of specialized publications have addressed this issue of transport (BONTEKONING, 2006).

4. The main performance characteristics of a hub

System analysis is a technique in which the objectives, components and elements of the system and the interactions between components and elements, and between the system and the environment are congruent. The difference between a component and an element is that a component describes the system at a higher level than an element. A component consists of several elements (Clementson, 1988). The components and elements of a system can be evaluated from several points of view, taking into account the research and its objectives. This leads to a selection of system features that will be described and analyzed, which excludes components and elements of the system that are not relevant to the purpose of the study.

In conclusion, a hub can be defined as a component of the whole system, in which several operations are performed, an interaction between the different elements resulting from the following performance criteria for that hub:

- **the safety of operations,** loading units and rolling stock should not suffer;
- **punctuality,** transshipment operations must not delay the dispatch of a train, which may lead to delayed arrivals of rolling stock (and implicitly of the goods) to the destination;
- **competitive costs,** value for money;
- **the speed of the operations** that take place, the service of the trains as fast as possible can lead to a higher utilization rate of the hub and implicitly to a higher efficiency and profit;
- **flexibility** of operations, a hub must be able to meet a variety of requests with late train arrivals and shipments.

The analysis of the system demonstrated the level of complexity of the "hub and spoke" network and led to a better understanding of the problems encountered. The most relevant elements of operations in a hub are the environment and the performance criterion.

Conclusions

In conclusion, the intermodal integration of rail transport is an important step in maintaining flexibility and reducing externalities. However, terminal operations are often costly and time consuming and involve a risk of damage to the goods. One way to reduce these problems is to load goods into standardized intermodal transport units (ITU), also called unit loads, for example, containers, semi-trailers or mobile boxes.

The development of intermodal transport increases the chances of a modal rebalancing in close connection with the railway transport system. This reduces social and environmental negative externalities. Intermodal transport leads both to an increased yield for goods, people and to a yield for society as a whole (in terms of socio-economic and total costs). The modal choice and the increased efficiency balance the existing capacity problems of the transport modes. The integration of railway transport also consists in identifying the locations of the terminals, aiming for them to be places characterized by accessibility, attractiveness, intermodality and nodality, which will lead to a developed transport system with less impact on the environment.

In order to analyze and plan intermodal transport, it is necessary to develop virtual networks, which include not only the formalization of geographical networks, but also operations in terminals. The development of intermodal transport depends on the availability of efficient intermodal terminals.

The main objectives of integrating intermodal transport are economic growth and social cohesion, but at the same time reducing congestion and pollution.

Decoupling environmental degradation from economic growth has become the main goal, and the internalization of external transport costs must be the main working tool. In the long run, it is necessary for both road and air transport to reduce in intensity and for rail and maritime transport to increase in volume.

Lastly, notions were presented about the "hub and spokes" type networks in intermodal rail freight transport, as a potential solution to contribute to the intermodal integration of the railway sector, representing a solution in order to increase the demand for intermodal transport.

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