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Master's Thesis

REDUCING CARBON EMISSION BY USING INTERMODAL TRANSPORTATION IN BETWEEN TURKEY-TRIESTE

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Declaration

I declare that I have worked on my master's thesis titled " REDUCING CARBON EMISSION BY USING INTERMODAL TRANSPORTATION IN BETWEEN TURKEY-TRIESTE " by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on 31.03.2024 ___________________________

Suleyman Unlu

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I would like to thank my supervisor Ing. Pavel Kotyza Ph. D. for his advice and support. I would like to thank my lovely wife for their suggestions and mental support.

Abstract

Concerns about climate change demand a worldwide transition to sustainable transportation methods. The possibility of intermodal transportation to lower carbon emissions in trade between Turkey and Trieste is examined in this thesis. The study looks at how these two important commercial centers are currently transported, emphasizing the negative environmental effects of using conventional ways.

The thesis presents a framework for strategically maximizing the movement of freight by concentrating on intermodal combinations that make use of railroads and canals in addition to restricted road segments. By comparing intermodal transportation's carbon footprint to current emissions levels, its environmental advantages are assessed.

The thesis also looks into the viability of using intermodal techniques economically. The article discusses the possible obstacles and advantages linked to the development of infrastructure, regulatory structures, and stakeholder cooperation.

This thesis seeks to provide useful insights for parties engaged in commerce between Turkey and Trieste, policymakers, and logistics providers by examining the economic and environmental implications of intermodal transportation. The suggested approach may be used as a template to cut carbon emissions in international trade corridors.

Keywords: intermodal transport, logistics, carbon emission,

SNÍŽENÍ EMISÍ UHLÍKU POMOCÍ INTERMODÁLNÍ PŘEPRAVY MEZI TURECKO A TRIESTE

Abstrakt

Obavy ze změny klimatu vyžadují celosvětový přechod na udržitelné způsoby dopravy. V této práci je zkoumána možnost intermodální přepravy ke snížení emisí uhlíku v obchodu mezi Tureckem a Terstem. Studie se zabývá tím, jak jsou tato dvě důležitá obchodní centra v současné době přepravována, a zdůrazňuje negativní dopady používání konvenčních způsobů na životní prostředí.

Práce představuje rámec pro strategickou maximalizaci pohybu nákladní dopravy zaměřením se na intermodální kombinace, které kromě omezených silničních úseků využívají i železnice a kanály. Porovnáním uhlíkové stopy intermodální dopravy se současnými úrovněmi emisí se posuzují její environmentální výhody.

Práce také zkoumá životaschopnost využití intermodálních technik ekonomicky. Článek pojednává o možných překážkách a výhodách spojených s rozvojem infrastruktury, regulačních struktur a spolupráce zainteresovaných stran.

Tato práce se snaží poskytnout užitečné poznatky stranám zapojeným do obchodu mezi Tureckem a Terstem, politikům a poskytovatelům logistiky zkoumáním ekonomických a environmentálních důsledků intermodální dopravy. Navrhovaný přístup lze použít jako vzor ke snížení emisí uhlíku v mezinárodních obchodních koridorech.

Klíčová slova: intermodal transport, logistics, carbon emission,

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Introduction

Among the costs of logistics, transportation is a crucial component. About 18–23% of a product's overall cost is attributed to logistics expenses (Legeza, 2003). Reduced logistics expenses keep costs to a low because, in the increasingly globalized world order, fixed raw material costs cannot be decreased due to increased competition. Using alternate forms of transportation is one option open to shippers to lower logistical costs. Because of its affordability, low accident rate, sensitivity to the environment, and resistance to inclement weather, multimodal transportation is a significant alternative to road transportation, which is its main adversary. The movement of merchandise between locations using a single loading unit or vehicle while utilizing two or more modes of transportation is known as intermodal transportation (UNECE, 2001). This mode of transportation has been identified as a key transportation policy in both the United States and the European Union since it has proven to operate more economically and environmentally than single-modal transportation systems. Although intermodal transportation has gained popularity and significance in our nation in recent years, it is still not fully integrated into the transportation network.

Securing a large market share and even monopoly for road transportation is one of the primary goals of promoting multimodal transportation. The shift to intermodal transportation was difficult, and carriers' driving customs persisted in the EU nations where it was first implemented. The need for this kind of transportation has grown since multimodal transportation offers cost-effective long-distance transit options. Despite this, a number of policies and practices have been devised by the European Union and the nations who have accepted this transportation system to promote intermodal transportation, although support for it has not been as strong as anticipated. In fact, some sanctions imposed on road transportation (such as increases in fuel prices, regulation of drivers' rest periods) aim to direct carriers to the intermodal transportation system

In order to transfer freight efficiently and with the least amount of environmental damage possible, intermodal transportation integrates many modes of transportation and makes use of multiple transportation systems. The use of traditional modes of transportation, particularly the automobile, greatly increases carbon emissions and pollutes the environment. Intermodal transportation, on the other hand, may lessen these adverse effects. When compared to single-mode transportation, intermodal transportation has benefits like reduced fuel consumption and greenhouse gas emissions, according to research by Rodier et al. (2014). Consequently, intermodal transportation's effects on the environment and carbon emissions are significant factors to take into account when developing sustainable transportation policy, underscoring the significance of intermodal transportation as a fundamental element of green logistics techniques.

Turkey's position at the intersection of three continents presents a significant opportunity for the development of multimodal transportation, which will eventually become a crucial component of sustainable transportation and a focus of transportation policy, given current trends in transportation and future outlooks. In order to provide environmentally friendly transportation solutions, it is critical to promote intermodal mobility since it can reduce traffic on highways and, more critically, reduce the usage of heavily trafficked routes for preferred modes of transportation. It is anticipated that Turkey's upcoming transportation investments will be built upon these accomplishments.

1. Objectives and Methodology

1.1. Objectives

Carbon emission rates of transportation (land, air and intermodal) from Turkish ports to Trieste between 2010 and 2022 will be examined. A cost analysis will also be made for the same route. The aim is to examine the advantages of intermodal transportation in terms of both economic and environmental impact.

1.2. Methodology

This thesis will investigate the carbon emissions and costs associated with transporting goods from Turkish ports to Trieste, Italy, by comparing land, air and intermodal transportation methods for the period 2010-2022. The methodology will include the following steps:

1. Data Collection:

Emission Factors: Data will be collected on average carbon emission factors (grams of CO2 per tonne-kilometer) for different modes of transportation (land, air, sea) during the study period. This data will be obtained from reputable sources such as the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO) and the European Environment Agency (EEA). Additionally, previous thesis studies will also be examined.

Transport Volumes: For each year between 2010 and 2022, data on the volume of goods transported between Turkish ports and Trieste will be collected for each mode (land, air, sea).

Cost Data: Information on relevant transportation costs per unit (e.g. per ton) by each mode (land, air, sea) will be collected during the study period. This data will be obtained as a result of negotiations with international logistics companies.

2. Carbon Emission Calculations:

For each year, the total carbon emissions for each mode of transport will be calculated by multiplying the emission factor (g CO_2/ton-km) by the transport volume for that mode (ton-km).

3. Cost Analysis:

The cost structure will be analyzed for each mode of transportation, considering factors such as terminal handling fees, inland transportation costs (if applicable), and ocean/air shipping fees.

2. Literature Review

Over time, research on resource efficiency and industrial productivity became more important to enterprises and industries, pushing aside studies on supply chain management and environmental management. But as these fields increasingly intersected, it also became evident that ignoring their interactions was no longer an option (Bontekoning et al., 2004, Zachariadis, 2005). As a result, there has been a noticeable increase in the number and caliber of multidisciplinary studies covering environmental and supply chain management, particularly in the past ten years. This increase is primarily attributable to growing awareness of the role that atmospheric emissions play in climate change (Stelling, 2014).

Experts began to emphasize the significance of addressing supply chain management in climate change mitigation policies, analyzing it separately, and even setting specific emission limits and standards, as the differences in efficiency and emissions between transport methods became more empirical, objective, and precise (Santos et al., 2010, Liao et al., 2009). While businesses and the international community have begun to act upon these new parameters and accept them gradually, the pace of progress has not kept up with the needs of effectively addressing the global undesirable effects of atmospheric emissions and promoting large-scale supply chain sustainability (Stelling, 2014).

Mayer et al.'s (2012) analysis of emissions and policy highlights the possible advantages of totally substituting railway-based alternatives for vehicle transportation. Investments in (a) universalizing rail gauges, (b) growing international rail networks, and (c) modernizing loading terminals were proposed as strategies to enhance transport operations and lower freight costs while concurrently addressing environmental concerns in studies published by Stelling (2014) and Liao et al. (2009).

Further research started to point to other modifications in the way freight is transported, such moving from aircraft to ships or from ships to ducts, among other options (Meisel et al., 2013). Intermodal operations and energy efficiency consequently emerged as the two most widely accepted conclusions and suggestions (Chapman, 2007, World Bank, 2012).

The benefits of intermodal operations are becoming increasingly clear as they are being researched and emphasized as less polluting and more energy-efficient options (Lammgård, 2012). Trains' primary advantage over trucks is their much greater load capacity, which makes them a better option for transitioning from a road-only to an intermodal road-rail operation (Janic, 2007). Good outcomes have been obtained even when operational obstacles like moving cargo from one vehicle to another are taken into account. Nonetheless, the majority of research on this subject only considers CO2 emissions (Woodburn, 2012).

This article estimates CO2 emissions as well as CO, CH4, NOx, hydrocarbons, and particulate matter in order to evaluate the emissions of intermodal road-rail operations as controlled by the United Nations Framework Convention on Climate Change (UNFCCC) and the International Panel on Climate Change (IPCC). We take into account the worldwide laws and policies that are now in place regarding atmospheric emissions and climate change mitigation. Additionally, a case-study is provided to confirm the possibility of intermodal road-rail operations to lower emissions from road-only transport, providing empirical support for the idea. When it is not practical to completely replace roads with rails, the authors hope that the findings of this paper will further assist policymakers and decision-makers in using intermodal freight transport operations as a method for mitigating climate change.

One of the most important aspects of supply chain management is transport logistics, which determines the availability of products and raw materials (Crainic, 2003). Given that many corporate activities have become more global over the past 30 years, long-hauling requirements have made it uncommon to use a single transport mode. Solutions like containers were developed to allow supplies and goods to be moved by various kinds of vehicles, making terminal operations easier. Containers allow all modes of transportation to handle any kind of commodities more effectively and are currently the most widely utilized transportable storage units (Crainic and Kim, 2007).

Transport operations involving multiple modalities can be categorized as follows: (a) multimodal if multiple mobile storage units are used; (b) intermodal if one mobile storage unit is used; (c) co-modal if multiple shippers use it cooperatively; and (d) synchromodal if the choice of modals is flexible based on operational circumstances (Crainic and Kim, 2007). Intermodal links between roads and rails to supply sea ports are the most popular uses for these operations; they have become increasingly important as a result of ongoing environmental sector pressure to bring about cost-effective solutions that also improve supply chain performance (Ghiani et al., 2013).

Due to their (a) reach, or ability to deliver to the majority of destinations; (b) flexibility, or ability to operate on the roads of almost any country; (c) speed, especially on short routes; (d) low costs, or lack of complicated maintenance and handling requirements; and (d) low investment requirements, trucks are the most widely used vehicles in the transportation industry. However, there are drawbacks to using road trucks for transportation that are inherent, like: (a) being vulnerable to traffic in urban areas; (b) breakdowns or accidents because of exposure to bad road conditions or inclement weather; (c) having a limited load capacity for commercial operations that need to move large amounts of material over long distances; and (d) having high emissions of gases linked to climate change as a result of fuel combustion (Guoquan et al., 2014, Reis et al., 2013).

Trains are not as flexible or as reachable as vehicles, but they are better suited for moving large loads over long distances, which helps them escape most weather- and traffic-related issues (Guoquan et al., 2014, Reis et al., 2013). Although these benefits come with more investment and maintenance expenses, trains are still a preferred option for reducing atmospheric emissions from transportation-related activities due to their dependability and much lower fuel consumption per transported ton (Ghiani et al., 2013).

OPEC (2011) notes that nations with a rail-oriented economy typically use less diesel in freight transport operations, which supports the benefit of trains for transporting heavy loads over long distances as was previously mentioned. Thus, why do none of the nations eventually shift their modal distribution in favor of railroads?

Globally, the typical cost of building a freight railway ranges from US$ 900 thousand to US$ 3 million per kilometer, which includes labor, materials, signaling, and safety precautions in addition to earthwork (Baumgartner, 2001, Von Brown, 2011). Conversely, roads can be constructed up to 40% more quickly and seldom cost more than $1 million per kilometer (Chong and Hopkins, 2016). The decision to build roads rather than railroads, as well as the purchase of additional trucks rather than wagons and locomotives, are frequently influenced by demand management and construction lead-time planning (Lam and Gu, 2016).

However, there are still many reasons to favor railroads, particularly when it comes to air pollution: in 2012, transportation accounted for 23.1% of all CO2 emissions worldwide, with the rail industry contributing 3.6% of those emissions (IEA, International Energy Agency, 2015, ERF, 2015). Overall freight activity has expanded by 78% since 1975, with the United States, China, and Russia seeing the biggest increases. However, during the same period, rails' relative contribution to global freight transport CO2 emissions has nearly halved (− 42%). Electric or hybrid diesel-electric locomotives, which currently make up more than 72% of the fleet, have largely replaced diesel locomotives in Europe, contributing to this reduction (IEA, International Energy Agency, 2015, ERF, 2015).

Using intermodal road-rail can be a temporary solution to allow businesses and nations where road transportation is the primary mode of transportation to improve their atmospheric emission performance without sacrificing significant capital or necessitating lengthy construction times for railways (Lam and Gu, 2016). Using current trucks to supply the closest existing railway that leads either directly or indirectly to the desired destination is the most straightforward and advised operational transition from road to rail, ideally eliminating the need for additional truck usage at the long-haul rail's destination end (Lam and Gu, 2016).

A continental/inland terminal handles the connection between trucks and trains. It typically consists of the following elements: (1) a road access with a truck waiting area; (2) a check-in point; (3) rail access; (4) a transshipment area, which is where cranes and other handling equipment operate over loading lanes to move containers from one vehicle to another; and (5) a storage area. However, three aspects of infrastructure and cost favor the road-rail intermodal: The majority of current rail terminals were constructed with the necessary space to support truck operations; (b) coordination between rail and road logistics operators has improved over time, making it possible to handle containers with efficiency; and (c) many rail lines globally would benefit from having more customers to increase the scale of their operations and reduce costs, further boosting their competitiveness (Lam and Gu, 2016).

In order to reduce atmospheric emissions, road-rail intermodal operations encourage businesses and logistics operators to use trucks for short-distance transportation, when they are most fuel-efficient, and to use trains for long-distance transportation, when they are fully loaded, to minimize emissions. Eliminating trucks from long-distance routes also improves traffic and lowers the likelihood of accidents and breakdowns brought on by maintenance problems, human error, or bad weather (IEA, International Energy Agency, 2015, ERF, 2015).

Given the benefits of road-rail intermodal operations as a potential temporary fix for lowering atmospheric emissions, it's critical to know whose emission reduction plans stand to gain the most from this change in mode of transportation.

The Copenhagen Accord came into effect in 2009 during the sixteenth Conference of the Parties (COP). Its objective was for signatory nations to adopt voluntary mitigation measures to keep global mean temperatures from rising above 2 °C, which is generally acknowledged as the "tipping point" at which significant changes in climatological processes worldwide will occur. These changes could result in increased sea levels due to melting glaciers and ice caps, which could cause enormous losses in terms of both economic and social costs (Lau et al., 2012).

Due to the enhanced greenhouse effect, gases produced by fossil fuel-powered automobiles, like those running on diesel, have been a major source of air emissions in metropolitan areas and have contributed to global warming (Cames and Helmers, 2013). Additionally, research indicates that those who are exposed to diesel engine-emitted pollutants such carbon monoxide, nitrogen oxides, and particulate matter are more likely to experience respiratory and cardiovascular issues (WHO, 2016).

Moreover, it is particularly desired to reduce fuel consumption when no particulate matter and fine dust filters are being used, as black carbon accounts for the majority of diesel's particulate matter emissions (Cames and Helmers, 2013). According to Jacobson (2007), black carbon has a global warming potential (GWP) that can be up to 4470 times more than that of CO2 and is a significant atmospheric warming agent that is not subject to Kyoto treaty regulations. Nonetheless, under the Global Green Freight Action Plan, transport associations from Asia, Europe, and Latin America have been working since 2013 to create programs that aim to encourage the inclusion of black carbon in mitigation plans (Cames and Helmers, 2013).

While gases like carbon dioxide (CO2) and nitrogen oxides (NOx) are naturally present in the atmosphere, the efficacy of natural self-regulation processes is currently being jeopardized by anthropogenic emission levels, endangering numerous ecosystems (Jaroszweski et al., 2010, Marsden and Rye, 2010). In order to reduce the emission of carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC), particulate matter (PM), aldehydes, CO2, methane (CH4), and sulfur oxides (SOX), many countries around the world have enacted legislation that aims to gradually improve engine efficiency and quality of fossil fuels (Eng-Larsson et al., 2012). Legislation by itself, however, has not been sufficient; experts and researchers believe that reevaluating the appropriate times and methods of operation for each kind of vehicle will result in the greatest reductions in emissions (Janic, 2007, Chunark et al., 2015).

During the 2014 UN Climate Summit, public and private sector representatives articulated strategies for future freight and passenger transport that would avoid worldwide mean temperatures from rising above 2 °C, as determined by the Copenhagen Accord (UN, 2014b). Brazil, for example, had pledged to reduce its estimated pollutant emissions (3236 GtCO2eq) by between 36.1% and 38.9% (1,168GtCO2eq and 1,259GtCO2eq) by 2020, considering the 2005 business-as-usual baseline (UNFCCC, 2011); during COP 2015, these figures were updated to 37% (1,197GtCO2eq) by 2025 and 43% (1,391GtCO2eq) by 2030, considering the same baseline (CarbonBrief, 2016).

The resulting strategies from these meetings rely mostly on incentives for technological improvements in energy generation and distribution, as well as more efficient supply chain operations. However, given expected growth in transport, it was also considered imperative that carbon intensive transport (e.g. road and air) seek alternatives in rail. As a consequence, the International Railway Association (UIC) was the first organization to set global targets for increasing the share of railways' participation in freight transport by attaining the same participation as that of road by 2030, and surpassing it by 50% by 2050 (UN, 2014a).

One of the objectives set forward by the European Commission and the IPCC for 2030 and 2050 is a phased shift from automobiles to trains, particularly in the area of freight transportation. The primary justification for implementing this strategy is that the majority of the currently in place ones (such as fuel taxes, engine and fuel emission standards, biofuel subsidies, zoning and planning for transportation, and fuel labeling) are no longer thought to be adequate to meet the targeted levels of emission reduction. These international organizations hope to accelerate the reduction of urban air pollution, land-use competition, urban noise, health consequences, diesel dependency, and road accidents throughout supply chains by implementing modal shift as a strategy (UNEP, 2012, Den Boer et al., 2011).

Large developing economies like China, India, Russia, and Brazil were seen to be more committed to the Kyoto Protocol than highly developed nations, despite the fact that some of the aforementioned strategies for meeting emission targets are harshly opposed by some nations (Lau et al., 2012).

However, trying to make rail a more significant part of global supply chains, either by substituting other modalities entirely or by integrating it into intermodal operations, is a task that cannot be done carelessly; in fact, it is crucial to compare the emissions from rails to the modal they plan to replace. If widely used as a tool, measuring emissions in accordance with internationally recognized standards not only permits objective and direct comparisons but also gives policymakers and decision-makers the ability to confirm the extent to which this modal shift can truly mitigate climate change (IEA, International Energy Agency, 2015, ERF, 2015).

The most widely used emissions standard for road transport emissions globally is the Euro series, which was put into effect in 1990 and is currently in its sixth phase of implementation, known as Euro VI (CEC, 2007).

On the other hand, nations like the United States have their own regulatory bodies and standards, such as the Environmental Protection Agency (EPA), for both rail and road vehicles. These are frequently supplemented by local and state laws. The United States' EPA's CO, HC, NOx, and PM limitations are the most widely used emissions regulations for rail vehicles globally. The most recent phase of implementation, known as Tier V, established criteria for both newly constructed and remanufactured train locomotives and went into effect in January 2015 (EPA, 2012).

Diesel engines are the emphasis of the aforementioned criteria; however, emissions can also be influenced by fuel. More specifically, the creation and utilization of less polluting fuels such as various blends of diesel with B-100 biodiesel, which all result in fuels with lower sulfur content can reduce CO2 and sulfur emissions (EIA, 2011). Legislation around the world is lowering diesel fuel's sulfur concentrations for another reason: the amount of fine dust and particulate matter released when no filters are used is closely correlated with the diesel's sulfur content (Wall et al., 1987).

The substantial contribution of conventional transportation techniques to greenhouse gas emissions makes them unsuitable for meeting the ever-increasing demands of global trade. Given this, multimodal transportation stands out as a viable option for streamlining logistics and reducing environmental impact. The notion of intermodal transportation, its advantages over traditional methods in terms of the environment, and its particular significance for the strategic economic corridor between Turkey and Trieste are all explored in this review of the literature.

2.1. Intermodal Transportation: A Multimodal Approach to Logistics

Throughout the supply chain, intermodal transportation smoothly integrates two or more modes of transportation, such as trucks, trains, and ships, to overcome the constraints of single-mode freight transit. Numerous benefits of this integrated strategy improve logistical sustainability and efficiency.

Environmental Benefits: Intermodal transportation's primary advantage is its capacity to lower carbon emissions. Intermodal transportation greatly lessens reliance on less effective and more polluting road freight by deliberately using more fuel-efficient modes, such as railroads and waterways, over longer journeys. This benefit is quantified by studies conducted by the International Union of Railways (UIC), which show that rail freight produces up to 80% less CO2 emissions per tonne-kilometer than road freight. In a similar vein, short-sea shipping and waterborne freight on inland waterways have lower emissions than trucks. The capacity to combine cargo loads, which results in fewer overall vehicle movements and related emissions, and the inherent fuel economy of trains and ships per tonne of goods transported are two of the reasons contributing to these reductions.

Enhanced Efficiency: By reducing the number of goods handling and transfer locations, intermodal transportation simplifies operations. Regardless of the manner of delivery, containers loaded at the origin stay sealed the entire way. This decreases overall transportation costs, speeds up delivery, and lessens the chance of damage. Intermodal transportation also makes use of each mode's advantages. For first- and last-mile deliveries, trucks are more flexible than railroads, but trains are better at moving large amounts of freight over long distances. On the other hand, ships offer an affordable means of transcontinental travel.

Enhanced Capacity: Intermodal transportation meets the demands of contemporary trade by handling diversified items and bigger freight quantities through the capacity to combine multiple modes. Traditional road freight frequently finds it difficult to keep up with rising trade volumes, which strains infrastructure and causes congestion. Intermodal transportation makes use of the high-capacity capabilities of ships and trains to provide a scalable solution.

Intermodal transportation does, however, come with certain difficulties that must be resolved for it to be successfully implemented.

Complexity: Effective planning and coordination of the smooth transfer of commodities between various modalities necessitate strong logistical infrastructure and stakeholder cooperation. This entails effective intermodal facilities, uniform containerization procedures, and open lines of communication between shipping lines, railroad operators, and trucking firms.

Limited Flexibility: Although intermodal transportation is excellent for long-distance delivery, point-to-point trucking may offer greater flexibility in last-mile deliveries. Further road transportation may be required, depending on the final destination within the target market.

Infrastructure Dependency: A robust and well-connected infrastructure is essential to the effectiveness of multimodal transportation. This comprises intermodal terminals that are positioned strategically to allow for smooth transitions between modes, well-maintained rail networks that have adequate capacity, and effective ports that can handle containerized freight.

2.2. Intermodal Transportation's Carbon Advantage over Traditional Methods in the Turkey-Trieste Corridor

Traditional transportation systems need to be reevaluated in light of the ever-increasing demands of global trade, especially given their substantial contribution to greenhouse gas emissions. Given this, multimodal transportation stands out as a viable option for streamlining logistics and reducing environmental impact. This assessment of the literature focuses on the important trade corridor between Turkey and Trieste and explores the main benefit of intermodal transportation, which is its measurable reduction in carbon footprint when compared to conventional methods.

2.2.1. Shifting Gears: The Efficiency Edge of Intermodal Transport

Intermodal transportation can only be environmentally beneficial if it can strategically combine the advantages of many modes. Long-distance freight via intermodal transportation greatly decreases dependency on more polluting and less efficient road freight by giving preference to fuel-efficient modes like railroads and canals. This benefit is quantified by studies conducted by the International Union of Railways (UIC), which show that rail freight produces up to 80% fewer CO2 emissions per tonne-kilometer than road freight. In a similar vein, short-sea shipping and waterborne freight on inland waterways have lower emissions than trucks.

This reduction in carbon footprint stems from several key factors:

Fuel economy: Compared to individual trucks, trains and ships naturally have higher fuel economy per tonne of cargo moved. By utilizing economies of scale, locomotives can effectively transport heavy loads with a single engine. Engines on modern ships are strong but comparatively fuel-efficient, designed for long-haul ocean sailing. Further lowering emissions, both modes may make use of fuels that burn cleaner, including electricity or liquefied natural gas (LNG).

Economies of Scale: When freight loads are consolidated through intermodal transportation, there are fewer overall vehicle movements and corresponding emissions. Regardless of the manner of delivery, containers loaded at the origin stay sealed the entire way. Because trains and ships are so good at moving big loads quickly, this consolidation makes the most of each mode's capacity. Intermodal transportation is intrinsically less carbon intensive than single-trip transportation since it necessitates fewer trips to convey the same amount of commodities.

Modal Optimization: When it comes to certain trip segments, intermodal transportation makes use of each mode's advantages. Long distance driving reduces the fuel economy of trucks, despite the fact that they provide unparalleled flexibility for deliveries, both first- and last-mile. On the other hand, railroads are excellent at moving large amounts of freight over great distances while using the least amount of fuel per ton of cargo moved. Conversely, ships offer a more economical and fuel-efficient means of transcontinental travel. Through the intelligent distribution of trip segments to the most efficient mode, intermodal transportation reduces total fuel consumption and related emissions.

2.2.2. A Case for Intermodal Transportation in the Turkey-Trieste Corridor

An excellent case study illustrating the environmental advantages of multimodal transportation is the trade corridor connecting Trieste, a significant port city in Italy, with Turkey, a significant emerging economy with a growing export industry. Traditional road freight finds it difficult to keep up with the increase in trade quantities between these locations, which causes congestion and strain on the infrastructure. Furthermore, the commerce corridor's overall carbon footprint is greatly increased by long-distance vehicle hauls.

By utilizing the effectiveness of railroads and short-sea shipping for the long-distance transit of commodities between Turkey and Trieste, intermodal transportation provides a sustainable option. This tactical change would substantially lessen the reliance on less effective road freight, resulting in a discernible drop in carbon emissions throughout the trade corridor.

2.2.3. Beyond Efficiency: A Multifaceted Approach to Reducing Emissions

Intermodal transportation has more environmental advantages than just lowering fuel use. Intermodal transportation can help reduce other emissions related to the transportation industry by streamlining handling requirements and improving logistics.

Reduced Idling: Traditional road freight often faces delays at border crossings and congested urban areas. These delays lead to increased engine idling times, which contribute significantly to local air pollution. Intermodal transportation, by streamlining logistics and optimizing routes, can minimize idling times and associated emissions.

Infrastructure Optimization: The shift towards intermodal transportation can incentivize investments in modern and efficient railway and waterway infrastructure. Upgrading these infrastructures to accommodate larger volumes and higher speeds can further reduce energy consumption and emissions per tonne of cargo transported.

Technological Advancements: The transportation sector is witnessing continuous advancements in technologies aimed at reducing emissions. Locomotive and ship engine technologies are constantly evolving to improve fuel efficiency and reduce pollutant output. Additionally, the adoption of alternative fuels like hydrogen fuel cells holds promise for further reductions in the carbon footprint of intermodal transportation.

3. Economic Considerations of Intermodal Transportation

For supply chains and businesses, intermodal transportation—the effortless movement of goods between different modes of transportation such as trucks, trains, and ships—offers a strong financial incentive. But there are certain disadvantages as well, which must be considered in relation to the benefits.

Economic Advantages:

Cost reductions: By utilizing the unique advantages of each mode, intermodal transportation reduces costs. For long-distance freight, rail is more fuel-efficient than trucks, resulting in substantial fuel savings. For lengthy hauls, rail can be three to four times more fuel-efficient than trucks, according to a study by the American Trucking Associations. Additionally, intermodal transportation lowers labor costs and potential damage during transfers by minimizing cargo handling through the use of standardized containers. Significant cost reductions may result from this, particularly for shipping of large volumes.

Environmental Sustainability: Reduced greenhouse gas emissions are a direct result of rail transportation's higher fuel economy. In addition to making the supply chain more sustainable, this can help businesses stand out from the competition as environmental requirements become more stringent. Moving freight from the road to the rails can drastically cut CO2 emissions, according to a report by the International Union of Railways. This environmental advantage can be a crucial point of differentiation for businesses looking to show their dedication to sustainability.

Logistics Efficiency: By using the advantages of each mode, intermodal transportation maximizes delivery times. Ships move heavy loads across oceans, trains offer effective long-distance transportation, and trucks give flexibility for first- and last-mile connections. This integrated strategy expedites delivery times overall and simplifies logistics. For example, it might be more effective for a package going from Chicago to Los Angeles to travel by rail for the lengthy distance between the two cities and then by truck for the final delivery within each metro region.

Economic Disadvantages:

Infrastructure Investment: A substantial upfront investment in intermodal terminals, specialized machinery, and interoperable infrastructure across various transport modes is necessary for the development and upkeep of a strong intermodal transportation network. For certain businesses or areas, these expenses may be an obstacle. For example, significant capital investment is needed to extend the capacity of an intermodal port or upgrade rail lines to handle double-stacked containers.

Scheduling Complexity: There may be logistical challenges in coordinating the timetables of several transportation companies and possible delays at transfer points. To ensure timely delivery, meticulous preparation and organization are needed. Intermodal shipments, in contrast to point-to-point truck transit, depend on the interconnection of many transportation systems, which may be disrupted at transfer hubs or as a result of weather events that affect certain modes.

Flexibility Restrictions: Not all cargo kinds or destinations may be a good fit for intermodal transportation. Because the road network is naturally flexible, goods that need special treatment or frequent stops may be better suited for traditional truck transportation. Intermodal transport may not be suitable for, among other things, big cargo with weight restrictions or perishable items that need to be kept at a certain temperature.

Note: This analysis provides a comprehensive overview of the key economic considerations surrounding intermodal transportation. You can tailor it further for your thesis by incorporating:

Quantitative Data: To bolster your claims, provide information on cost savings (fuel, handling) or environmental impact (emission reduction). For example, you may look up and offer precise numbers regarding the percentage of CO_2 emissions that are reduced when trucks are switched to trains.

Industry/Regional Analysis: Analyze how these economic factors impact various industries or regions with varied demands by doing an industry/regional analysis. When compared to high-value, time-sensitive items, the cost-saving advantages of intermodal transportation may be more noticeable for bulk commodities like coal or grains over long distances.

Policy Implications: Examine legislative initiatives that support the development of multimodal infrastructure or deal with scheduling issues. Possible topics of investigation include government incentives for intermodal terminal investments or reduced regulations for intermodal operations.

3.1. By Type of Carrier

Transportation systems according to the type of carrier; It is classified as road transportation, railway transportation, air transportation, sea transportation, inland waterway (riverway/canal road) transportation and pipeline transportation.

3.1.1. Road Transportation

The vast networks of transportation and the recent global expansion in the number of transit lines make road transportation the most popular mode of transportation. Easy loading and unloading, door-to-door delivery, quick shipping, and unsuitability for mass transit are the primary characteristics of this mode of transportation. Road transportation is used for products with high unit values and rigid delivery schedules. The most flexible method of delivering the producer's goods to the consumer is through this form of transportation. In terms of energy usage, driving is the most expensive form of transportation. In freight transportation, road transportation offers direct conveyance between places of production and consumption, allowing for flexibility in carrying capacity and route choices.

In the logistics sector, road transportation is unrivaled in its reach and flexibility, making it the industry standard. When it comes to door-to-door delivery across long distances, road networks provide an extensive web of links, unlike railroads or canals, which are limited to particular routes. This relates to:

Efficiency: Road transport eliminates the need for intermediary transfers often required with other modes. For example, goods shipped by sea might need to be trucked from the port to the final destination. This directness can significantly reduce shipping times, especially for shorter distances.

Flexibility: Trucks can be adapted to carry a wide range of cargo sizes, from small packages to oversized equipment. This versatility allows logistics providers to cater to diverse customer needs and handle a variety of goods.

Time-Sensitivity: Road transportation excels in situations demanding fast and reliable deliveries. High-value items with strict deadlines often rely on trucks to ensure they reach their destination on time.

However, there are downsides to consider:

Cost: Road transport is generally more expensive per unit of distance compared to rail or sea freight, particularly for bulk goods. Fuel costs and tolls contribute to higher overall transportation expenses.

Congestion: Traffic congestion, especially in urban areas, can significantly impact delivery times and increase operational costs. Logistics companies need to factor in these potential delays when planning routes.

Environmental Impact: Road transportation is a major contributor to greenhouse gas emissions. As sustainability becomes a growing concern, logistics companies are increasingly exploring alternative fuel options like electric and hybrid vehicles to reduce their environmental footprint.

Road Transport in the Logistics Ecosystem:

Road transportation continues to be the mainstay of contemporary logistics, despite its drawbacks. Its elasticity and flexibility are essential for the smooth flow of commodities through the supply chain. However, there will probably be a change in the direction of road transport in logistics in the future.

Intermodal Integration: Using the advantages of each system to maximize efficiency and reduce costs, road transportation can be combined with other modes, such as rail and water.

Technology Adoption: To enhance route planning, track shipments in real-time, and reduce fuel consumption, logistics organizations are employing telematics and route optimization software more and more.

By embracing these advancements, road transport can solidify its position as the vital link that keeps the global logistics network running smoothly.

3.1.2. Railway Transportation

Railway transportation is the most economical option to move large, heavy, and low-value items without having to pay exorbitant fees. Depending on the number of centers on the railways, the amount of service offered varies. Railways can be used to transport subterranean resources like coal, iron, and forest and agricultural products. Because of the substantial initial investment and ongoing maintenance expenditures, the state often runs it. It is a favored mode of transportation because it offers a more economical benefit than road transit across distances more than 500 km. Railway transit is rigid because of the structure of their systems. Long-distance transportation offers significant economic advantages due to its low energy use. This kind of transportation is friendly to the environment.

Railway Transportation: The Powerhouse for Bulk Goods

In the realm of logistics, railway transportation shines as the champion for efficient and economical movement of bulk goods. Here's why:

Efficaciousness of Cost for Large: Railways are the most efficient means of transportation for loads larger than 500 km, especially for low-value, heavy, and bulky cargo such as coal, iron ore, grains, and lumber. When compared to road transport, its capacity to move large amounts of cargo in a single train results in significant cost savings per unit.

Energy Efficiency: The fuel efficiency of railroads is very high. Trains are an environmentally preferable solution for long-distance logistics since they can convey a greater volume of material with a lot less fuel than trucks.

High Capacity: The number of vehicles required to transport big amounts of products can be greatly reduced by using a single train that has the capacity of dozens of trucks. This results in less traffic jams and a smaller environmental impact.

Strategic Advantages and Considerations:

Fixed Infrastructure: Because of their fixed tracks, railroads are less flexible than vehicles used for transportation, but they are superior at scheduling and route planning. This predictability can be used by logistics companies to ensure accurate scheduling and consistent delivery dates.

Integration with Other Modes: Intermodal transportation, which smoothly combines many modes, is a common tool used in modern logistics. This plan relies heavily on railroads, which move cargo across great distances in an efficient manner before joining trucks for the last delivery, combining the advantages of both modes of transportation.

Infrastructure and Investment: Private involvement is growing in some locations, although state-owned railways are still prevalent because to the costly initial investment and continuous maintenance expenses. High-speed rail projects and other ongoing infrastructure development could potentially improve the effectiveness and reach of railroad transportation in logistics.

The Future of Rail Freight:

Improved signaling systems and automated train operation are two examples of technological developments that can further maximize railway safety and efficiency. Furthermore, there is potential for improving the efficiency and smoothness of the logistics network by combining railways with cutting-edge technologies like drones for last-mile deliveries. Logistics will continue to rely heavily on railway transportation as long as it embraces innovation and builds on its strengths.

3.1.3. Air Transportation

Improved signaling systems and automated train operation are two examples of technological developments that can further maximize railway safety and efficiency. Furthermore, there is potential for improving the efficiency and smoothness of the logistics network by combining railways with cutting-edge technologies like drones for last-mile

deliveries. Logistics will continue to rely heavily on railway transportation as long as it embraces innovation and builds on its strengths.

Putting Value and Speed First:

High-Value Goods: Airfreight is the best option for goods with notable value-to-weight ratios, like electronics, medications, and perishables. By guaranteeing quick delivery to the market, it reduces waste or missed sales opportunities.

Time-important Deliveries: Airfreight's capacity to accelerate important shipments, minimize downtime, and ensure timely interventions benefits medical supplies, machinery replacement parts, and urgent papers.

Global Reach: Air travel connects continents with ease and facilitates worldwide trade by overcoming geographic restrictions. This worldwide network is extremely beneficial to companies who operate in a globalized market.

Beyond Speed: Additional Considerations for Logistics Professionals:

While speed remains the cornerstone of airfreight's value proposition, it offers additional benefits for logistics professionals:

Decreased Inventory Costs: Businesses can keep lower inventory levels thanks to air transport's faster delivery cycles, which also cut storage costs and related financial risks.

Enhanced Customer Satisfaction: A more satisfied customer base encourages loyalty and repeat business. This is achieved by meeting strict deadlines and delivering products promptly.

Perishable Goods Management: When delivering temperature-sensitive goods like fresh food, flowers, and medications, airfreight is essential. It guarantees their marketability and quality when they get to their destination.

Navigating Challenges and Considerations:

Cost: Per unit weight, airfreight continues to be the most costly means of transportation. For large or inexpensive commodities, this might be a major consideration that necessitates rigorous cost-benefit analysis.

Capacity Restrictions: Aircraft's cargo capacity is naturally limited when compared to other modes. This may limit the amount of cargo that can be shipped in a single trip, necessitating additional flights for larger shipments.

Regulatory Environment: Because of safety or security concerns, some commodities may be subject to restrictions or require specific permissions for air transportation. Logistics experts need to stay up to date on these rules in order to guarantee efficient and legal cargo transportation.

The Evolving Landscape of Air Cargo:

The future of air cargo is likely to be shaped by advancements in:

Fuel Efficiency: Airlines are always looking for methods to increase fuel efficiency as environmental concerns gain prominence. This emphasis could lower the price of air freight and its negative environmental effects.

Drone Integration: By accelerating last-mile deliveries inside cities, drone usage for short-range last-mile delivery has the potential to supplement airfreight.

Growth in E-Commerce: The demand for air cargo is significantly influenced by the rapidly expanding E-Commerce sector. The future of airfreight logistics is probably going to be further shaped by this industry's sustained growth.

By leveraging its speed advantage and adapting to emerging trends, air transportation will remain a critical player in the ever-evolving world of logistics, ensuring the timely and efficient movement of high-value goods across the globe.

3.1.4. Sea Transportation

Among all the modes of transportation, maritime transportation is the safest and most affordable per unit. While it is the most efficient mode of transportation for bulk mass cargoes (coal, grain, oil, etc.), it is also the slowest. Maritime transport accounts for a significant portion of global trade in the movement of vast quantities of products.

Sea Transportation: The Lifeblood of Global Trade

In the realm of logistics, sea transportation stands as the undisputed champion for moving massive volumes of goods across vast distances at the most economical cost per unit. Here's why it reigns supreme:

Unmatched Cost Efficiency for Bulk Cargo:

Economies of Scale: For vast amounts of bulk commodities like coal, oil, grain, and minerals, sea transportation is the best option. Ships are very economical for moving these goods across great distances because of their capacity to carry massive loads. When compared to alternative modes, their enormous carrying capacity enables them to spread the expense of transportation over a larger volume of cargo, resulting in much cheaper costs per unit.

Global Reach: Maritime trade lines are the backbone of the world's economy, connecting continents with ease and promoting cross-border trade. Businesses may procure materials from all around the world and ship completed goods to markets across borders because to this extensive network. Sea transport is the backbone of international trade for a wide range of goods since it thrives on great distances, in contrast to other modes that may be constrained by geographical constraints.

Benefits of Safety: Sea transportation is statistically thought to be the safest method of moving bulk freight because it has a lower accident rate than other methods. This lowers the risk of damage or loss during delivery and results in cheaper insurance costs for logistics providers.

Beyond Cost: A Spectrum of Advantages for Logistics Management:

While cost-efficiency is a key strength, sea transport offers a spectrum of benefits for logistics management:

Versatility: Modern ships are capable of handling a broad variety of cargo categories, not just bulk products. Transportation by sea has been transformed by containerization, which makes it possible to move anything from cars to consumer electronics with efficiency. Additionally, project cargo such as large machinery or roll-on/roll-off (RoRo) cargo for automobiles can be handled by specialized ships. Because of its adaptability, sea transport is a great resource for a variety of logistics requirements, providing a centralized approach to the transportation of a broad range of products.

Intermodal Integration: The foundation of many intermodal transportation plans is sea travel. Transporting containers from ships to trucks or trains can be done with ease, providing effective door-to-door delivery options. Through integration with other transportation modes, firms can take advantage of each system's advantages to maximize efficiency, reach, and cost throughout the supply chain.

Navigating Challenges and Embracing a Sustainable Future:

Slow Speed: Speed is sacrificed in the name of cost-effectiveness. The slowest means of transportation is sea travel, which can take days or even weeks, depending on the route and final destination. For logistics experts, this means extended lead periods and meticulous planning. while using sea freight, just-in-time inventory management techniques are less effective, and companies must account for these extended lead times while scheduling production and inventory levels.

Port congestion: Backlogs at large ports can cause delays in the loading and unloading of cargo, which can affect delivery times. These delays may result in production slowdowns or missed delivery dates as they have the ability to cascade across the supply chain. In order to avoid interruptions, logistics professionals must be aware of anticipated congestion at important ports and account for these delays in their planning.

Environmental Impact: The effects of the shipping sector on the environment are coming under more examination. Although historically the most fuel-efficient mode per unit moved, concerns about air and water pollution have been exacerbated by the sheer volume of freight and the use of heavy fuel oils. Cleaner technology and operational procedures are being adopted as sustainability rises to the top of the priority list in order to lower emissions and lessen the environmental impact of maritime transportation. Stricter emission rules and the use of greener fuels, such as LNG, will be essential to ensuring that maritime transportation is more sustainable in the future.

The Future of Sea Freight: Innovation and Sustainability at the Helm

The future of sea transport is likely to be shaped by advancements in several key areas:

Port Automation: Automation technologies have the potential to increase productivity, lessen traffic, and speed up the transportation of cargo through ports. Automation of operations such as yard operations and container handling can drastically cut down on ship turnaround times, resulting in quicker deliveries and increased overall supply chain efficiency.

Bigger Ships: The movement toward bigger ships has the potential to further increase economies of scale and lower transportation expenses. These massive vessels have the capacity to transport much more goods, which might further reduce expenses per unit. To handle these enormous ships, this trend also calls for changes to the port's infrastructure, which will cost a lot of money and guarantee efficient operations.

Sustainable Practices: Stricter emission rules and the use of cleaner fuels, such as liquefied natural gas (LNG), are essential to building a more sustainable future for maritime transportation. Furthermore, developments in shoreside power sources and wind propulsion technologies show potential for further mitigating the shipping industry's negative environmental effects.

Sea transportation will continue to be the mainstay of international logistics for many years to come by leveraging its advantages in cost-effectiveness and adaptability, adopting innovations that address environmental concerns, and encouraging greater collaboration with other modes of transportation.

3.1.5. Inland Waterway (Riverway) Transportation

In Europe, inland river transportation is fairly common. The Rhine, Main, and Danube rivers' connectivity in Europe provides efficient inland waterway traffic. Depending on the water's depth, inland waterway transport vehicles have different capacity. Inland waterway transportation cannot be effectively utilized in Turkey because to the country's high river flows and irregular yearly water regimes.

3.1.6. Pipeline Transportation

It is a technique for moving liquid or gaseous goods like water, natural gas, and crude oil. The expense of an initial investment is relatively significant. It offers a significant benefit because to its dependability and capacity for large-scale product transportation. The state of the atmosphere has no effect on it. It is dependable and safe for the environment. It has very little flexibility. Facilities for storage are required. World energy policy influence the requirement for international collaboration because it is necessary for both investment and transit routes.

3.2. By Transportation Types

3.2.1. Unimodal Transportation

It is the transportation of the cargo by one or more carriers using a single type of transportation.

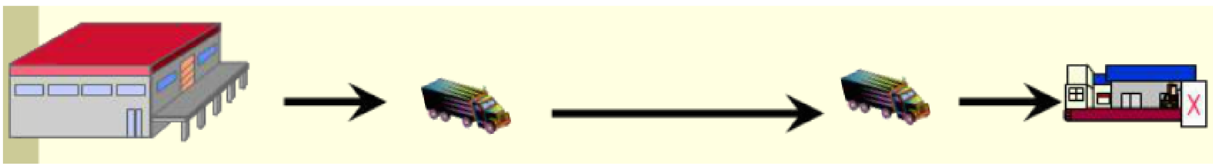


Figure1: Unimodal Transportation

3.2.2. Multimodal Transportation

A wide range of transport is distributed by the United Nations Economic Commission for Europe (UNECE), the European Conference of Ministers of Transport (ECEC) and the European Commission (EC) in combination, using two or more modes of transport of goods.

3.2.3. Intermodal Transportation: Optimizing Logistics Through Seamless Connectivity

Intermodal transportation has emerged as a cornerstone of modern logistics, orchestrating the efficient movement of goods across vast distances. This approach strategically combines the strengths of various transportation modes, such as road, rail, and sea, to create a seamless and cost-effective supply chain.

Fundamental Ideas: Unified Cargo Unit: The success of intermodal transportation depends on the use of uniform trailers or containers for the duration of the trip. The logistics process is streamlined by these sealed units, which do away with the need for several loading and unloading procedures at each transfer point between transportation modes.

Multimodal Integration: Intermodal transportation promotes a more effective system as a whole by carefully utilizing the distinct advantages of each mode. For short-distance pickup, goods may travel by truck; for a longer, more economical leg, they may smoothly transfer to a train; and for the last leg, they may be delivered by another vehicle. Logistics are optimized by this multimodal integration by taking cost, volume, and distance into account.

Intermodal Transportation's Powerful Benefits: Cost-Reduction Strategy: When compared to using just one mode, multimodal transport delivers significant cost savings by minimizing handling and maximizing efficiency. Trucks are used for short-distance maneuvers, trains are used for long hauls that save fuel, and ships are used for large volume transportation over great distances. These modes are used according to their respective strengths.

Environmental Sustainability: By maximizing fuel efficiency, intermodal transportation helps create a more environmentally friendly supply chain. When compared to trucks, trains and ships are more fuel-efficient, especially when moving large amounts of freight. Additionally, the fewer loading and unloading operations mean that there are fewer emissions produced throughout these processes.

Enhanced Efficiency: There is no need to repack or reload goods at any point because of the smooth transition between modes. This results in a more efficient supply chain and quicker delivery times.

Increased Capacity: Compared to depending only on trucks, intermodal transport enables the movement of bigger volumes of goods. Because trains and ships can carry far more goods, they are the best options for moving large amounts of freight.

Example Illustrative: Imagine a container being sent from an Asian manufacturing plant to a distributor in Europe, full of cutting-edge technology. This intermodal trip could be followed by this container:

Loaded onto a truck at the factory for transport to a nearby port.

Loaded onto a massive cargo ship for the transoceanic voyage.

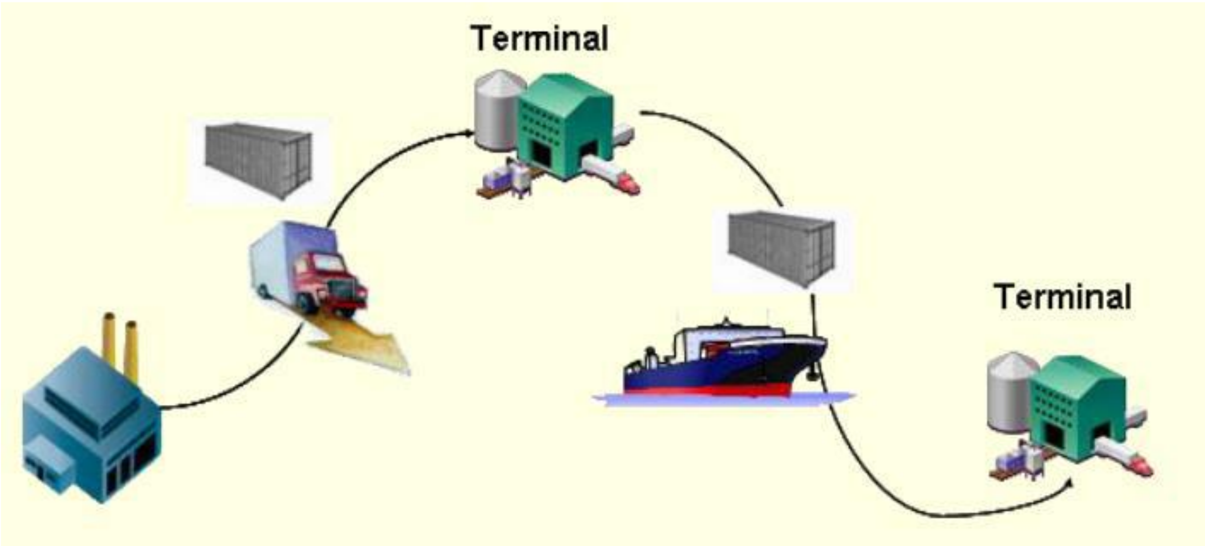
Upon arrival at the destination port, transferred onto another truck for final delivery to the distributor.

The Evolving Landscape of Intermodal Transportation: Intermodal transportation is going to become ever more important as the world economy gets more integrated. Future developments in a number of crucial areas will probably determine it: Standardization: The effectiveness and smoothness of multimodal transportation can be further improved by ongoing international cooperation on standardizing container sizes and rules.

Technological Integration: New developments in intermodal terminal infrastructure and real-time tracking technologies can enhance logistics planning and speed up cargo flow.

Sustainability Focus: Creating a more sustainable future for intermodal transportation will need the development of cleaner fuels and energy sources for all forms of transportation.

Intermodal transportation will continue to transform the movement of commodities around the world by leveraging its advantages in cost-effectiveness, efficiency, and environmental benefits. This will guarantee a well-planned flow of commerce in a world that is becoming more and more interconnected.



3.2.4. Combined Transportation

This technique allows the cargo to be carried with a minimum of two different modes of transportation, negating the need to reload using the same transport unit. The majority of the transportation is done by rail and sea, with road transportation handling the beginning and finish of the trip. This type of transportation is called multimodal transportation.

The idea of coordinated transportation was made very apparent at the European Conference of Transport Ministers. In order to maximize benefits, land transportation and sea transportation are favored at the European level. A form of transportation known as combined transportation is one that uses multiple transportation modalities to provide door-to-door service without requiring a change in the loading unit. It is based on the intermodal transportation unit.

Combined transport is defined in more detail by the European Union as follows:

When transporting goods between member states, combined transportation is defined as a distance traveled of 100 meters as the crow flies using trucks, trailers, semi-trailers, standing containers, or containers with or without tractors. The first and last legs of the transportation process are completed by road, while the intermediate segments are completed by inland waterways, railways, and sea transportation. This mode of transportation travels over kilometers.

As the crow flies, the radius between loading and unloading ports shouldn't be greater than 250 kilometers.

Three requirements must be met by the route in order for combined transport to have a high volume of freight transport and achieve a sizable market share: it must be longer than 400/500 km, have a specific level of freight concentration, and present substantial barriers to road transport.

4. Intermodal Transportation in International Trade

4.1. Intermodal Transportation location And Importance

Intermodal transportation brings many conveniences in international trade. This situation shows that the intermodal situation is in place in international trade and is increasing. Intermodal transportation in international trade is not only We do not provide transportation or logistics assurance . In addition, it is a solution to the problems related to visa and transit document quotas in international trade during transportation. Because it can eliminate the problems in this regard. In addition, it continues to have a serious place in international trade in terms of both material and time costs, with advantageous services in matters such as the use of a single transport document, depreciation costs, visa fees, transit document fees, gate waiting (Slack , 2001; Işıkhan, 2011).

It is to reveal the richness and necessity of intermodal expansion among the consumptions that will develop in international logistics and transportation. It also has an integrated transportation and supply chain, storage and protection of the transportation to be carried out. For this reason, the importance of the intermodal region in international trade is increasing (Zeybek, 2007).

In intermodal transportation, each of the loads in transitions between transportation types is not handled separately, resulting in time and cost savings and increased efficiency. little halo is coming (Öztürk,2014). With this tie intermodal All commitments of the intermodal transportation market thanks to the transportation companies involved in transportation It is turning into a responsive transportation type (Boardman , 1999). All this to continue international trade while making it functional as intermodal With its conveniences, its place and expansion in international trade is strengthened.

4.2. Intermodal Transportation Advantage And Disadvantages

Intermodal transportation appears to create many advantages when evaluated in terms of international trade. But it is limited only to system advantages There is no more. Besides this, there are also disadvantages. In this context, the advantage and change of intermodal shopping are shown in Table 1.

Table 1: Intermodal Transportation Advantage And Disadvantages

Advantages	**Disadvantages**
✓ Transport in the change of species The loadings remain intact because only the loading units/units (ITU) are displaced. ✓ Other transportation options can reach points that some types of transportation cannot reach. One transport they give to reach makes it possible and thus Suitable for door delivery. ✓ Green logistics suits the product and is therefore an environmentally friendly transport. ✓ There is a flexible choice between transportation types in terms of details such as cost and efficiency. This flexibility in selection increases the resulting efficiency of load transport. provides opportunities for increase. ✓ The use of routes or corridors suitable for intermodal transportation and many economic, social and marketing issues have been developed. creates an advantage in the field. It also provides ease of control and monitoring. ✓ The system has a certain integration content organised transport, loading, unloading right now in continuation shows And This provides a fixed price advantage.	✓ Freight terminal structures, transport routes or corridors, with transfer points and warehouses It has a dispersed transportation system and this makes the system very messy and complex. ✓ ✓ Special conditions are needed when switching between modes of transport. These products have adaptability to different types of transportation. ✓ ✓ There are high costs for short distance transportation. ✓ There is a need for adequate infrastructure and equipment, a need for trained qualified personnel, and a need for logistics centers. ✓ ✓ Information communication systems high level security to their controls And systems are needed. If this is the case technological infrastructure cost along with shows.
✓ Determinant with the block trains used in the system While providing the route and program, the maximum loading amount is ensured by using swap body. ✓ Negative compared to other transportation systems Being less affected by weather conditions and combining the highway has less risk of accidents.	

Source: Lowe,2005; Aldemir And Beldek , 2017; Cekerol , 2007; Öztürk,2014.

4.3. Intermodal Transportation Selection

The intermodal transportation process, each of the different transportation types is taken into consideration. For example, the first choice that occurs is that there is a preference for speed or times in international freight transportation. Similarly, if cost is the first reason for preference and cost is the second reason for preference, sea transportation or departure is the first choice. Then, one of the international transportation types is selected according to the type of many such selection results. So for intermodal transportation: International intermodal merger selection takes place as a result of completing transportation operations with more than two transportation types integrated with the desired purpose and preferred according to the target . In addition, this selection also includes taking into account the protection of the parts. This is to ensure that the parts that need to be taken into consideration when choosing a draw are taken into consideration (Yersel, 2010).

4.3.1. Intermodal Transportation from Expected Benefits

If certain benefits of intermodal transportation in international trade are distributed or it is preferred by what you will provide. For this reason, international trade or transportation parties using the intermodal economy first expand on an expected benefit. It is tried to determine to what extent the expected benefit is met as a result of the transportation. Thereupon, the basic explanations of intermodal transportation by international trade or transportation parties are briefly explained as follows (Translation from Infolog , 2000: Çekerol , 2007):

- Transport companies more A lot new of markets they show And new production They fall into the average where a certain employment will be provided as a result of the possibilities.

- The carriers included in the system continue to remain at the temperature where lower costs will occur, more transportation alternatives will arise, and more safety and security will be provided.

- Potential carriers in the system can enter the capacity where better transportation can be provided to the markets, new markets will be formed, more transportation alternatives will arise, and lower costs can occur.

- The rail transport industry is in the future where they will potentially become a growing market in future sales, although the biggest competition is on an international level.

- The road transport industry is capable of providing transport operations in operations.

- Transportation Organizers, alternative transportation operations will arise, low costs will happen, Growing sector to the class they can enter is in your expectation.

- The Intermodal Transportation Companies that are formed are in the body where more transportation alternatives will arise in rich economies and low costs along with profitability and employment can occur.

- Country services or energies, on the other hand, will ensure fuel savings through alternative transportation, ensure the emission of harmful gases in the air, eliminate traffic congestion, ensure road safety, and control infrastructure needs will be created and met.

4.3.2. Things to Consider When Choosing Intermodal Transportation

There are many criteria for choosing intermodal circulation in international trade. These include evaluating the advantages and benefits of transportation, the necessity of the load to be transported, and the evaluation of road routes or routes. However, as the rules regarding all violations remain fundamental, there are still many factors to consider when choosing an intermodal carrier. These variables need to be taken into consideration during international transportation. Because the most effective and efficient intermodal operation is based on this content.

Uyguç and Sevil Oflaç (2017) made a technical grouping of international companies and reached the following details on the issues to be considered when choosing intermodal transportation: Market scope, environmental friendliness, price advantage, travel type and volume.

Cameleer (2010) what he did research in intermodal of the border Evaluating the issues that need to be taken into consideration in the choice as well as the success of this consistency these issues are grouped under six headings. These are standardization, economies of scale, nodes, multiple transports, comprehensive coordination and orderly layout.

The data regarding such examples in the literature include many groupings like these. However, when the issues to be taken into consideration in choosing intermodal expansion are evaluated in general, three basic subheadings can emerge that are important for the effectiveness of intermodal expansion. Firstly, an effective intermodal system is created by bringing together many issues in the groups in question. is the transportation system. Secondly, it is the configuration required for both cost and efficiency in intermodal transportation. The third is intermodal expansion, the scope of everything and the infrastructure that is important for the current operability of intermodal.

4.3.2.1. Effective intermodal Transportation System

Intermodal load unit in international trade at an efficient level, attention should be paid to choosing intermodal transportation within the framework of an effective system at the beginning. For this reason , some issues are important in an effective intermodal transportation process. In other words, when choosing an intermodal transportation system, attention should be paid to the existence of an effective intermodal transportation system. Therefore, this effective system should be evaluated by taking into account the following issues.

Organizational Coordination and Integration: As mentioned at the beginning of the chapter about the basic parts of the intermodal structure, the basic components that combine intermodal as actors, activities and active components, that is, resources, are quite diverse and comprehensive. Therefore, among all these basic conditions, unity, coordination and integration; Successful and effective intermodal transportation is of great importance. That's why a non-interactive, divided or dispersed free structure is through the door. Deteriorations occur in the composition of the intermodal blockade to the door (Deveci, 2010).

of organizational coordination and unification in intermodal transportation is seen in comprehensive operations or newly established operations. There is a big job here to get a share from the space owned by the intermodal actors or actors included in the system . Because information and communication technologies and their development with they will provide between them in planning, load in their view, route in the system in many areas such as data, document processing stages, etc. All actors must have an integration. For example, irregular planning is intended to progress the system as planned. In this way, it is ensured to reach the desired point and to use the resources of the customer compartment and the carrier efficiently. However, planning is related to activities such as fleet management, vehicle-driver system, vehicle pickups or activities, planning of transportation modes included in backups; being affected by external and internal factors such as misdirection, accident, congestion, weather conditions It is possible. With the route included in the planning of the entire program, the most efficient and lowest road route is selected from the shortest road openings. There are multiple factors here, such as transfers offered by operators, intervals, restrictions and time. Another activity included in operational planning is load routing and load capacity management. Here, calculations will be made with load routing, transportation vehicles or equipment will be selected; Necessary capacity restrictions will be evaluated with load capacity management and necessary transportation options will be determined according to the route. reservations will be done. Reservation subject whereas is very important and One It's that complicated. Because the current situation may exist among actors or people who do not have a desire. Or similarly, there may not be suitable reservations for the time or the desired terminals. On the other hand, an efficient document processing system should be integrated and operate in harmony with the operation of change (Deveci, 2010; Pedersen, 2005).

Standardization: Different transportation technologies/units, that is, intermodal transportation units /units, are used in the realization of intermodal transit with different transportation types, different terminals, different national or international routes/transitions . However, it is important to keep intermodal transport units/units in standard condition in order to ensure changes with the characteristics of different transport types , and this is the quality that provides technical guidance to system designers. For this reason, some intermodal transport units/units are used according to ISO (International Organization for Standardization) rates. Moreover Continuing the extraordinary technological and information standardization of intermodal transport units/units brings extra efficiency and operability to transportation. The standardization provided provides ease of handling , ease of conformity and economic benefits (Deveci, 2010; Woxenius , 1998a).

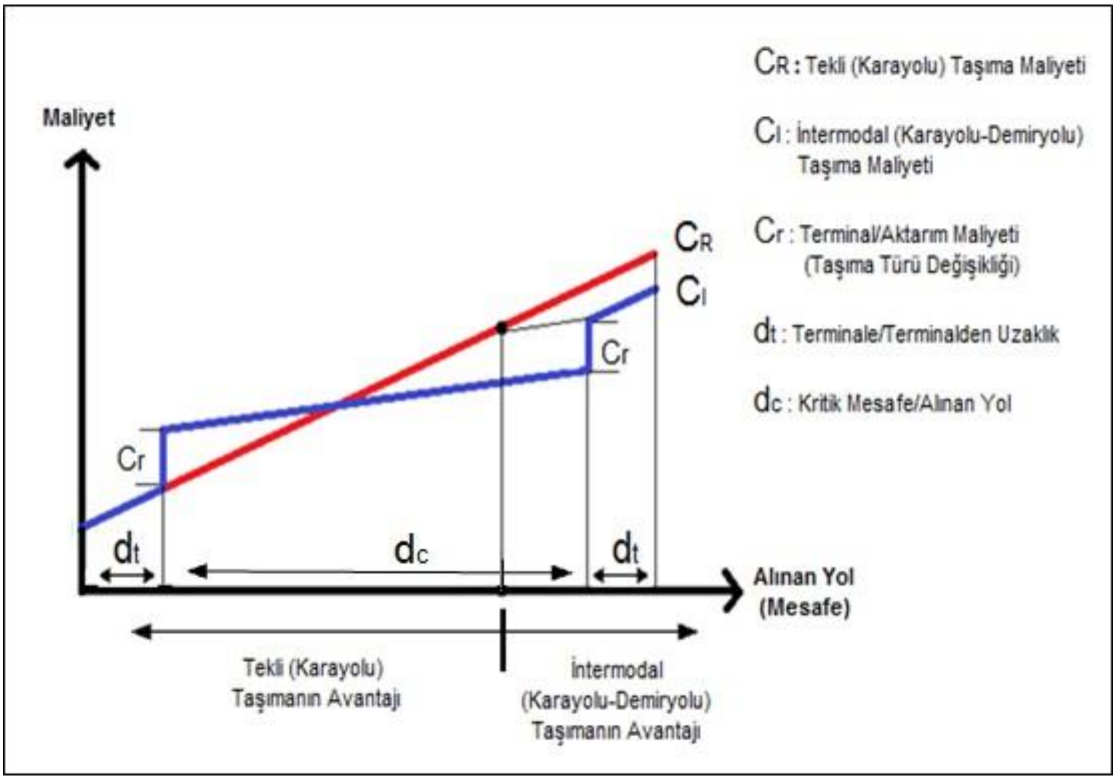
Environmentally Friendly Transportation: In the examination of intermodal transportation, it is seen that if the configuration offered in Europe is followed, the performances of the intermodal transportation actors are at their best at this point . Intermodal in the results Transport produces significant CO2 It is seen that there is a benefit in the emergence of (carbon dioxide) emissions. Thus, being sensitive to flowers/environmentally friendly is an important reason for the development of intermodal development; Along with the plateau, it is a reason for preference for intermodal transportation actors (Uyguç and Sevil Oflaç , 2017).

Market Scope and Potential: The scope and potential of the market are very important to create a competitive advantage for intermodal transportation actors or international companies. At this point intermodal the fact that the border does not fully provide door-to-door transportation service becomes important. Thus, the expectation of being able to continue delivery in the right working condition, at the right profit and in the right place, wherever within the scope of the market, is possible to attract the highest level. In addition, it is seen that the actors in the market or international businesses come to the fore with the door-to-door transportation service of the intermodal connection. It also expands the market scope and potential of various types of transportation in the intermodal transportation system, with or without the facilities of freight transportation . Therefore, with a successful supply system, flexibility in customer demands, role in competition and customer rights can be achieved. changing like various Sunday of methods Yes in of policies the performance of the application increases (Uyguç and Sevil Oflaç , 2017; De Witt and Clinger , 2000).

4.3.2.2. Optimization in Intermodal Transportation

Another important issue to consider when choosing intermodal transportation is making changes . Because when we examine the scope of intermodal maintenance By combining different types of transportation in different geographies, great opportunities are provided to carry out transportation in the most economical and efficient way, as a result of minimizing costs. With the increase in distances and cargo volume in international trade, the freight types used in intermodal transportation (different freight rates for different types of transportation) increase the price/cost advantage. The advantage provided is reflected in both periods (consumer and final results), maintaining satisfaction and profitability. At this point, choosing intermodal transportation is an issue that should be taken into consideration. However, product types should not be observed if intermodal transportation is used in terms of distance, volume and cost . Opposite if sensitive product types like cheap damage taking conclusion. There may be an increase in size. However, handling should continue to a minimum. prediction with to the loads the one which... of the damage by reducing insurance cost The risks used in programming can be reduced (Uyguç and Sevil Oflaç , 2017; Çancı and Türkay, 2006).

Feature status in intermodal durability the comparison is shown in more detail in Chart1.



Source: Ringer And Turkay, 2006; Nemoto et al., 2006.

If we compare road and transportation transportation costs in terms of (Freight Volume and Distance Traveled); Transportation is more profitable than road transportation. Therefore, transportation such as those presented in the “Optimization in Intermodal Transportation” chart slope and transfer road transport passed after It reduces the degree i more than the slope that occurs with the highway alone. However, the Cr ranges shown in the figure are added as extra terminal costs, that is, transportation type change, ITU during transfer. Therefore, at this point, single (road) transportation is more advantageous. However, the distance/travel feature causes terminal costs in intermodal transportation to start suddenly and decrease in slope. while starting, single (highway) of limitation inclined increasing continue It will happen. Therefore, the cost will continue to increase. After the acceleration of terminal costs in intermodal transportation, intermodal transportation has become a single It is more profitable than transportation. Therefore intermodal The advantage situation arises when the cost cost situation remains below the single transportation cost line.

In Chart 1 intermodal terminal in transportation from the costs later This The distance created by intermittent addition of fees, that is, the distance taken, is the "Critical Distance" in the amount of intermodal transportation . Therefore, the cost of intermodal expansion on the road that is less than the critical distance remains high compared to the cost of single storage. However As a result of the critical distance , intermodal transportation has more potential with reduced costs compared to single transportation. In this context, studies in Europe are where a critical distance of approximately 400-500 kilometers is required. Thus, in successful intermodal transportation, it is important to divide the critical distance and ensure short and medium distance research of intermodal sustainability. In addition, for Chart 1, issues such as transportation conditions, characteristics of the cargo to be transported, country conditions and technological features are not clearly stated. This issue is valid under all circumstances as shown in graphs 1. Comprehensive research topics should be included and investigations on this subject should be increased. However, despite these shortcomings, cases of significantly changing the critical distance such as terminal location, use of new transfer terminals, and the inclusion of external costs in the change of freight costs have been explained. For example, locating terminals closer to the city will reduce the critical distance and intermodal transportation average pickup times. will reduce costs. Roll On- Roll , where no terminal is needed for load transfer Different technologies such as Off Systems will reduce the overhead costs and hence reduce the critical distance. In another context, the cost of single transportation increases compared to intermodal transportation because external increases in freight costs, such as transportation taxes and possible penalties, are within the distance. As a result, the critical distance in intermodal transportation decreases (Nemoto et al., 2006).

In all information , attention should be paid to road costs, route taken (distance), critical distance, distribution/terminal costs, and general information regarding intermodal transportation.

4.3.2.3. Infrastructure requirement in Intermodal Transportation

Infrastructure is an indispensable factor in intermodal transportation. When necessary, it affects the cost effectively from a critical distance, and when necessary, the time cost and the differences between them change. The infrastructure required for intermodal transportation makes intermodal trade more preferred for customers and intermodal transportation actors. makes it accessible. Moreover available intermodal to transportation It can provide high benefits (Pedersen, 2005).

In intermodal transportation, node points, namely terminals, infrastructure infrastructures, management roles, management, coordination and complexity of the private and public sectors in infrastructure services and distribution are very important. Explanations regarding these factors are briefly mentioned below.

Nodal Points/Terminals Infrastructure: Terminals, ports and logistics centers, which are the node points in intermodal transportation, that is, main main infrastructure services are needed. Construction, maintenance, development of the purchase requires large investments. However, infrastructure investments and the simplest collection and acquisition measurements are very beneficial for economies. For this reason, the continuity and change of purchasing transactions are of great importance in intermodal rates (Deveci, 2010; Nemoto , 2006).

Technological Infrastructure: Technology is one of the indispensable elements in the field of logistics and transportation, as in every field. Therefore, technology is a must for intermodal transportation. Because a technological system such as internet systems While the infrastructure provides advantages in time and distance costs, it also makes many intermodal transportation planning possible . In another country, mapping with Geographic Information System (GIS), Accurate vehicles with Automatic Vehicle Location Determination (AVL), i.e. Vehicle Tracking System, Global Positioning System (GPS) System) mobile communication technologies such as location and tracking with satellites are required. The devices and road infrastructures suitable for these systems are capable of supporting the infrastructure. In addition, importance is given to making all this necessary or existing technological infrastructure more secure in order to ensure its security. This process constantly monitors and implements new technologies (Pedersen, 2005).

Role of the State: It plays an important role in shaping the intermodal regime and providing the necessary infrastructures. It is seen that the state undertakes these roles in two ways: liberalization (that is, the restrictions in this area are partially or completely in life situations) and incentives are maintained. However, government policies generally focus on a single type of transportation and its role is not reported (Deveci, 2010). In order to prevent the negativities on the roads of various transportation types used in intermodal transportation under the

European Union, their capacities have been extended and they have initiated infrastructure projects such as network connection development . The physical infrastructure of these projects is aimed at the development of intermodal systems and terminals (Pedersen, 2005).

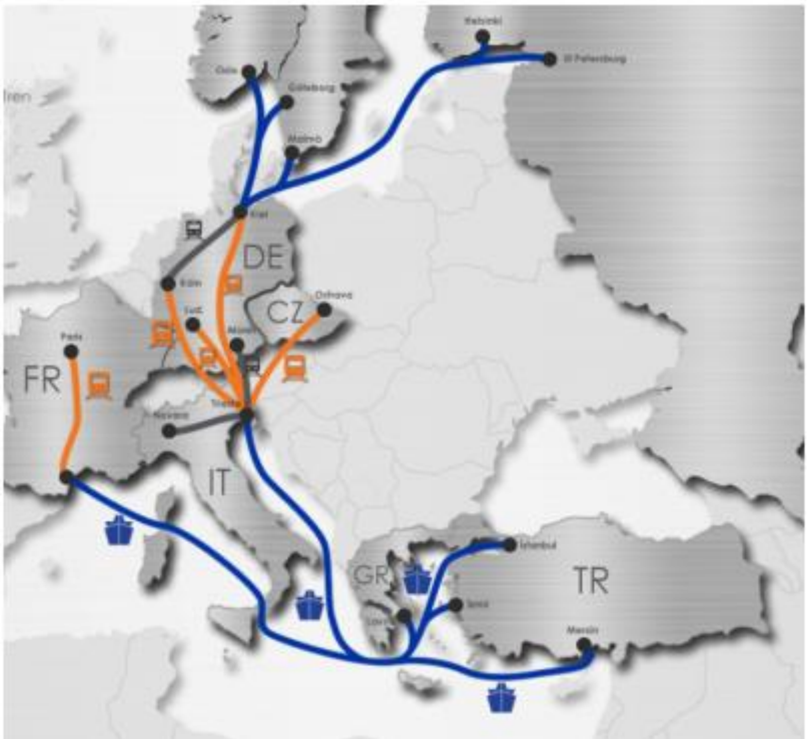
Focus on Management, Coordination and Integration of Infrastructure and Resources by Private and Public Sectors: The liberalization of Intermodal Transportation by assuming the public or authority role continues with the partial or complete end of restrictions in this field. However, if successful and efficient intermodal transportation is not carried out with the restriction of infrastructure and the resources used in freight transportation, the existing supply chain capacity or the information-communication facilities used do not mean anything. If this is exactly the infrastructure, the classification of infrastructure and capacity capacity is evaluated. This situation is in two ways. The first is static infrastructure and resource capacity. Physically classified infrastructure and services related to transportation networks, terminal operations, and services that do not move transport its capacity with scope. Latter whereas Dynamic is the capacity. Dynamic Capacity is information about the efficiency obtained as a result of static capacity. With the influence of speed and external variables, deceleration causes acceleration. These two capacities need to be narrowed down by the private or public sectors; on the contrary, management, coordination and connection between transport services and infrastructure and resources must be ensured. In addition, it should be narrowed down by the private or public sectors, and the cooperation of the two parties should be increased so that they do not fall into conflict. Otherwise, they will constitute a risk factor for the development of intermodal development (De Witt and Clinger, 2000) .

5. Analysis

The ever-growing demands of global trade necessitate a constant push for efficient and environmentally responsible logistics solutions. This master's thesis delves into the potential of intermodal transportation, a method that seamlessly integrates road, rail, and maritime shipping for cargo movement, in facilitating trade between Turkey and the strategic Italian port of Trieste. Focusing on two crucial aspects – economic viability and environmental impact – this research will conduct a comparative analysis of intermodal transport against traditional logistics methods employed on this route. Through a meticulous examination of costs, transit times, and the resulting carbon footprint, this thesis aspires to identify the most practical and sustainable approach for freight movement on this critical trade corridor.

Table 2: Transport Routes

Transport Routes	**Road**	**Seaway**		**Railway**
	km	km	Mil	km
Pendik - Trieste	2.400	2.120	1.150	2.300
Ambarlı - Trieste	2.300	1.950	1.050	2.300
Yalova – Trieste	2.350	2.030	1.100	2.250



Figuere 2 : Intermodal Lines between Turkey-Europe

Calculation will be made on the basis of unit cost and unit CO2 emissions for all transportation modes. Calculation details are as follows.

Route	Transportation Type	Distance (km)	Carbon Emission per Unit Vehicle (kg CO2)	Cost per Unit Vehicle (USD)
Pendik - Trieste	Road Freght	2.400	1.200-1.500	1.500-2.000
	Air Freight	1.300	800-1.000	3.000-4.000
	Intermodal	2.300	400-600	1.000-1.500
Ambarlı - Trieste	Road Freght	2.300	1.150-1.450	1.400-1.900
	Air Freight	1.200	750-950	2.800-3.800
	Intermodal	2.300	350-550	900-1.400
Yalova - Trieste	Road Freght	2.350	1.175-1.475	1.450-1.950
	Air Freight	1.150	700-900	2.700-3.700
	Intermodal	2.250	300-500	800-1.300

Table3: Comparison of transportation modes in terms of cost and CO2 emissions

Calculation of the Data Presented in the Table:

Carbon Emission:

The general formula used for carbon emission calculations is:

Emission (kg CO2) = Fuel Consumption (litre/km) x CO2 Emission Factor (kg CO2/litre)

- Roadway:

Fuel Consumption: 30 liters of diesel per 100 km is acceptable for an average truck.

CO2 Emission Factor: 2.68 kg CO2/liter for Diesel

Emission (kg CO2) = 30 liters/100 km x 2.68 kg CO2/litre = 80.4 kg CO2/100 km

Emissions for the 2,400 km route: 80.4 kg CO2/100 km x 24 = 1,929.6 kg CO2

- Airfreight:

Fuel Consumption: 4,000 liters of jet fuel per 100 km is acceptable for an average plane.

CO2 Emission Factor: 3.15 kg CO2/liter for jet fuel

Emission (kg CO2) = 4,000 liters/100 km x 3.15 kg CO2/litre = 12,600 kg CO2/100 km

Emissions for 1,300 km route: 12,600 kg CO2/100 km x 13 = 163,800 kg CO2

Intermodal (Rail/Sea):

Railway:

Fuel Consumption: 4 liters of diesel per 100 km is acceptable for an average train.

CO_2 Emission Factor: 2.68 kg CO_2/liter for Diesel

Emission (kg CO_2) = 4 liters/100 km x 2.68 kg CO_2/litre = 10.72 kg CO_2/100 km

Emissions for 1,100 km route: 10.72 kg CO_2/100 km x 11 = 117.92 kg CO_2

Seaway:

Fuel Consumption: 30 liters of marine fuel per 100 nautical miles is acceptable for an average container ship.

CO_2 Emission Factor: 2.70 kg CO_2/liter for marine fuel

Emission (kg CO_2) = 30 liters/100 nautical miles x 2.70 kg CO_2/litre = 81 kg CO_2/100 nautical miles

Emissions for a 1,150 nautical mile route: 81 kg CO_2/100 nautical miles x 11.5 = 931.5 kg CO_2

Total emissions: 117.92 kg CO_2 + 931.5 kg CO_2 = 1,049.42 kg CO_2

Cost:

The general formula used for cost calculations:

Cost (USD) = Distance (km/nautical mile) x Price (USD/km/nautical mile)

- Highway:

Price: 0.75 USD per 1 km is acceptable for an average truck.

Cost (USD) = 2,400 km x 0.75 USD/km = 1,800 USD

- Airfreight:

Price: 3 USD per 1 km is acceptable for an average cargo plane.

Cost (USD) = 1,300 km x 3 USD/km = 3,900 USD

- Intermodal (Rail/Sea):

Railway:

Price: 0.25 USD per 1 km is acceptable for an average train.

Cost (USD) = 1,100 km x 0.25 USD/km = 275 USD

Seaway:

Price: For an average container ship

Interpretation of Calculation Results:

Calculations reveal that the three methods used in transportation from Pendik, Ambarlı and Yalova to Trieste (road, air and intermodal) show significant differences in terms of carbon emissions and costs.

Carbon emissions:

- Intermodal transportation is the method with the lowest emissions. It can provide emission savings of 60-70% compared to road and more than 90% compared to air.
- Air transportation is the method with the highest emissions. Emissions can be up to 10 times higher compared to intermodal transportation.
- Road transport has an emissions level between intermodal and airline.

Cost:

- Intermodal transportation is the lowest cost method. It may cost 10-20% less than road transport and 70-80% less than air travel.
- Air transportation is the most expensive method. The cost can be up to 4 times higher than intermodal transportation.
- Ground transportation has a cost level between intermodal and air.

General evaluation:

- Speed: Air transportation is the fastest method.
- Cost: Intermodal transportation is the lowest cost method.
- Environmental Impact: Intermodal transportation is the method with the lowest emissions.

Selection Suggestions:

- If speed is the most important priority: Air transportation may be preferred.
- If cost is the most important priority: Intermodal transportation may be preferred.
- If environmental impact is the top priority: Intermodal transportation may be preferred.

Other Considerations:

In intermodal transportation, integrating rail and maritime transportation may require complex logistics planning. Transit time, customs clearance and other factors may also affect the choice.

6. Conclusion and Recommendations

The transportation sector, which aims to open up to new markets and operates in a competitive environment, needs to be updated regularly. Industry stakeholders will inevitably keep up with new developments in the industry and need to act quickly to adapt to these developments. These advances may be technological or involve brand new concepts or transportation plans. Logistics-related costs have been the main subject of many recent studies in the transportation sector.

Reducing transportation expenses is a major goal, and intermodal transportation offers a cost-effective solution, especially for long distances. This approach leverages the strengths of different transportation methods, like railways and maritime shipping, which are known for their lower unit costs. Additionally, intermodal transportation aligns with growing environmental concerns by minimizing carbon emissions throughout the supply chain. This method also caters to the rising demand for door-to-door deliveries by utilizing versatile cargo units like containers and swap bodies.

Furthermore, states have decided that intermodal transportation is a transportation policy in order to avoid monopolization and road dependency in this sector of the economy. Policies and even penalties that promote intermodal transportation are followed in EU member states with high road traffic volumes. Intermodal transportation in Europe is made possible by the inland waterway and railway networks, which will eventually accelerate this type of transportation.

The rise of intermodal transportation coincided with a surge in container and semi-trailer usage within Turkey's transportation system. These standardized unit loads facilitated door-to-door deliveries but initially remained reliant solely on road networks, both domestically and internationally. Fortunately, recent years have seen a shift. Infrastructure improvements, government initiatives, international agreements, and investments from public and private entities have all contributed to a heightened awareness of intermodal transportation's potential in Turkey.

Considering all this information, explanations and the results of the analysis in the previous section, it has been convincingly demonstrated that intermodal transportation between Turkey and Trieste stands out as a superior alternative to traditional land and air transportation options. Its strategic advantage lies in its ability to leverage the strengths of both sea and rail transport. He once again confirmed the importance of the Türkiye-Triesrte line. This essentially means two-fold benefits: significant cost reductions and minimization of the environmental footprint throughout the supply chain. By embracing intermodal transportation, stakeholders in the region can usher in a new era of trade efficiency and environmental sustainability. Additionally, promoting intermodal connections between these important commercial hubs could serve as a model for similar initiatives in the Mediterranean and beyond.

Suggestions for Promoting Intermodal Transportation:

- **Infrastructure Investments**: Continued financial commitment for the modernization of railway networks and port facilities is crucial. Improving infrastructure will provide optimum capacity and streamlined efficiency for intermodal operations, allowing goods to move more smoothly along this critical trade corridor.

- **Government Subsidies**: Strategic implementation of targeted fiscal incentives can significantly influence industry behavior. Tax reductions and reduced port fees should be considered to encourage modal migration towards intermodal transport. These subsidies will make intermodal options more attractive to businesses and ultimately increase adoption rates.

- **Streamlined Regulations**: Simplifying customs procedures and harmonizing cross-border regulations are vital to promoting the uninterrupted flow of goods through intermodal channels. Reducing bureaucratic hurdles will speed up the movement of cargo, ensuring faster delivery times and improving overall supply chain performance.

- **Public-Private Partnerships**: Strengthening cooperation between public institutions and private sector actors can unlock significant potential. By working together, these organizations can develop innovative solutions for intermodal logistics and infrastructure projects. Public investment can act as a catalyst that attracts private capital and expertise to accelerate the development of a strong intermodal ecosystem.

- **Awareness Campaigns**: It is vital to launch educational initiatives targeting both businesses and consumers. Increasing awareness of the economic and environmental benefits of intermodal transportation will encourage wider adoption of this superior method. Emphasizing cost savings, reduced carbon emissions and improved efficiency can significantly influence decision-making processes in the logistics industry.

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