Enhancing Supply Chain Efficiency through Railway Logistics for the Industrial Regions in Saudi Arabia

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Abstract

Railways logistics have been developed since the 19th century; however, until today, utilizing the characteristics of the railway to provide a sustainable supply of raw materials has not been fully Exploited. To the industrial regions, the logistics hub increases the efficiency of its supply chain.

Supplying raw materials from the logistics hub to the industrial areas grants cost reduction, reliability of the manufacturer's material supply, positively affecting production capacity, restocking interval time, and social and environmental responsibility. This study aims to highlight the benefits of railway logistics to enhance the economy and improve operational capacity. This research used a mixed method to highlight critical elements of railway freight characteristics and compared them to truck freight characteristics to view the limitation of each approach to decide the optimal solution for the case via cost, environment, social economy, and future potential. The outcomes of this study will be valuable to both the industry manufacturers and the economy.

Keywords
Railways, Logistics, Supply Chain, Sustainability, and Saudi Arabia.

1.0 Introduction

The industrial sector flourished in Saudi Arabia as it is one of the leading countries in the oil industry and its subsidiaries. Transportation has always been the backbone of the economy, enabling the movement of materials and goods from one place to another. Currently, the most transportation modes used are sea freight and truck transportation. This research presents the potential of using railways to support the industrial sectors due to the need for a high-capacity vessel for long distances and a relatively lower cost. Each mode of transportation has unique advantages that can benefit the industrial sector. Multi-modal transportation modes will utilize each mode's advantages and compensate for its limitations. This research will study the feasibility of adding the railways' transportation and compare it with the other used methods in the industrial sector. When evaluating

comparable research, it is crucial to consider the different variables that impact choosing transportation.

2.0 Literature Review

A similar study was conducted to compare different transportation methods on various factors, mainly on cost and pricing. It showed that truck transportation had more access Flexibility than railways due to railways being subjected to fixed routes (Forkenbrock 2001). However, on the external cost, railways transportation was found to be significantly lower regardless of the transportation distances and a more environment-friendly solution and sustainable. However, some limitation was identified for both transportation modes as based comparison with the fullness ratio and the distance (Sahin 2007), showing that when utilizing the high capacity of the railways, the longer the travel distance, the more cost-effective become, also tuck consider an ideal transportation mode for the ease of managing and loading time on short to medium distance. The fixed cost of the railways was considered higher than the truck as it required structuring infrastructure, raising the fixed cost. Taking the comparison of Railways and truck transportation on the Green Supply chain studies proposed through the technological advancement in railways, and overall, trucks were the leading cause of emissions of carbon dioxide, noise pollution, and fossil fuel consumption, in overall more efficient logistics eco-friendly sustainable freight transportation align with the railway.

2.1 Railway logistics in the supply chain

The railway system has been one of the earliest transportation methods used for moving goods and people, playing a significant role in the economy of countries like the USA, with a usage rate of 40%. Russia and China have 12% and 8% utilization rates, respectively. ("Russia's RZD speeds up rail service to attract cargo 2017) (Japan times 2018) (Federal Railway administration, 2018)(Meng 2018).

The process of railway logistics involves the careful planning, coordination, and execution of transporting goods and materials by rail. This encompasses the management of cargo movements from their point of origin to their end destination, as well as the scheduling of trains, tracking of shipments, and coordination of different stakeholders such as shippers, carriers, and rail operators. (Abdurazzokov 2023)

Railway logistics plays a crucial role in the overall logistics industry, especially for industrial businesses requiring large quantities of goods and materials over long distances. Unlike trucks, trains can easily handle high-density and bulky materials like raw materials, construction equipment, and finished goods. Additionally, train cargo can be customized to accommodate various goods and materials. This detachability feature provides flexibility to transport a wide range of products, from sensitive medical goods to strategic stocks for industrial manufacturers. (Sobirov & Eshonqulov 2023)

2.1.1 Advantages of Railway Logistics

Railways logistics have witnessed various advantages: efficiency, cost saving, mitigating risk, commodity flexibility, and being environmentally friendly.

The railway is the most efficient transportation method on land; 40% of US, long distance logistic uses railway, the Association of American Railroads(2023). loading capacity accompanied by a relative travel speed compared to the other transportation methods, which are the trucks and the air freight, which form a middle combining the advantages of both ways. Low cost is a vital factor in

the economy and gives an advantage to any business. The indicator for the transportation cost of a method is cargo or passenger per route(Sahin, 2007). Through the increasing demand and global inflation, the railway provides an ideal cost saving for any industrial organization with large Manufacturing output with a precise arrival time. (Cernichiaro Reyna 2022).

The railway can be considered the lowest risk method from different prospective as there is no uncertainty for the estimated delivery date reducing the risk of delays with dedicated tracks, immune to damaging the goods or material which is sealed in the cargo containers safe from theft and damage, less demanding malfunctioning and maintenance. Although it is a fact that truckload is without a doubt the most flexible method in logistics, it has a limited capacity for the volume and size of commodities it can hold. Railway scale of accommodation is on a ton's scale which vastly increases the flexibility range of materials and goods it can transport over a long distance.

A trade-off exists between the efficiency and sustainability in the supply chain, using railways to transport goods and materials replacing quite a few trucks due to the cost saving and the high-capacity cargo cart, without fuel and the dioxide emission and overloading the roads (Garica-Alvarez ETL 2013) Lin et al. (2017) found that highway freight transport's total carbon emission is 7.89-10.45 times more than railways freight transports. An environment-friendly solution to meet the increasing demands and with the technological advances many types of train are available in the markets such as electric trains. One of the advantages of railway logistics is its efficiency in transporting large volumes of goods over long distances. Rail transport is also more environmentally friendly than other modes of transportation, such as road transport, as it produces fewer emissions per ton-kilometer. However, railway logistics can also face challenges such as congested rail networks, limited capacity, and the need for specialized infrastructure such as loading and unloading facilities. Effective railway logistics requires careful planning, coordination, and communication among all stakeholders involved in the transportation process.

The rail freight industry has seen significant advancements in technology and innovation in recent years, improving efficiency, safety, and sustainability. One central area of innovation has been in developing autonomous rail technologies. These systems use sensors and advanced algorithms to enable trains to operate without a human driver, increasing safety and efficiency. For example, in 2020, Rio Tinto became the first mining company to run a fully autonomous rail network, which has already delivered significant improvements in productivity and safety. Another area of innovation has been using big data and analytics to optimize rail freight operations. By collecting and analyzing data on everything from train schedules to weather patterns, rail companies can make more informed decisions about route planning, resource allocation, and maintenance management, increasing efficiency and cost savings. (Li et al. 2020). In addition, significant advancements have been made in developing sustainable rail technologies, such as hybrid and electric locomotives. These technologies can help reduce emissions and improve the overall environmental footprint of rail freight operations.

Blockchain technology is also being explored in the rail freight industry. By creating a secure and transparent digital ledger of all transactions and movements, blockchain could enable better tracking and tracing of goods and improved supply chain visibility and efficiency. (Thakur 2023). These technological advancements and innovations are helping to transform the rail freight industry, making it more efficient, sustainable, and safe.

2.1.2 Connect railway networks with the seaport.

Connecting railway networks with seaports is an essential aspect of logistics planning, as it allows for the efficient movement of goods between different transportation modes. This connection can be achieved through rail links or dedicated rail lines connecting the seaport with the railway network. Which will have several benefits as follow:

Improved efficiency, Reduced costs, Increased access, and Environmental benefits.

Railway transport is a more efficient mode of transportation for moving large volumes of goods over long distances. Connecting the railway network with seaports allows goods to be quickly and efficiently transported from the port to inland destinations. (Batarlienė 2020). Rail transport is often more cost-effective than other modes of transportation, such as road or air transport. By connecting railways with seaports, businesses can benefit from lower transportation costs. (Warren & Ieromonachou 2013). Connecting railway networks with seaports can help businesses access new markets and customers. This is particularly beneficial for companies that rely on imports or exports and cover longer distances than traditional freight trucking. Rail transport is more environmentally friendly than other modes of transportation, such as road or air transport, as it produces fewer emissions per ton-kilometer. By connecting railway networks with seaports, businesses can reduce their carbon footprint. (Warren & Ieromonachou 2013). To connect railway networks with seaports, it is vital to have dedicated rail lines or rail links that allow for the efficient movement of goods between the two transportation modes.

This requires coordination and collaboration between port authorities, railway operators, and other stakeholders involved in the logistics planning process. Connecting railway networks with seaports is an essential aspect of transportation infrastructure. This connection is typically achieved through intermodal transportation, which involves using multiple modes of transportation (such as trains, trucks, and ships) to move goods from one location to another. One example of a railway network connected to a seaport is the Port of Los Angeles in California. The port has a network of railways that connect to major rail lines, allowing for the transportation of goods across the country. This connection has made the Port of Los Angeles one of the busiest ports in the world, handling over 9 million 20-foot equivalent units (TEUs) of cargo in 2019. Another example is the Port of Rotterdam in the Netherlands, connected to an extensive network of railways and highways. The port's railway connections extend to European destinations, making it an essential hub for transporting goods across the continent—the research of Tao (2013) aimed at sea-rail intermodal transport. A subsidy policy could indirectly reduce the shipper's transport cost and thus become an effective means for modal shift.

2.1.3 Railway benefits over truck transportation.

Islam et al. (2016) proposed critical questions: How does rail improve the service quality to attract customers? How can rail offer its customers a competitive price with the road? How can rail strengthen its ability to cope with the increasing demand due to the Modal shift?
Third question, Lin et al. (2017) studied the railway expansion to manage the highway's freight. Railway transportation offers several benefits over truck transportation, particularly when moving large volumes of goods over long distances. Some of the key benefits include:

1. Cost-effectiveness: Railways are typically more cost-effective than truck transportation for long-distance shipping. According to the Association of American Railroads, rail shipping is four times

more fuel-efficient than truck shipping on average, which can result in significant cost savings over time. (Dinneen 2022)

2. Reduced emissions: Railways produce less greenhouse gas emissions than truck transportation, making it a more environmentally-friendly option. According to the Environmental Protection Agency, railways have 75% less greenhouse gas emissions per ton-mile than trucks. (Shoukat, 2022)

3. Reduced traffic congestion: Transpiration activities are the second highest in the world. Carbon dioxide emission from fuel combustion generates 24%. Railways can help reduce traffic congestion on highways, leading to faster and more reliable delivery times for goods. (Wang et al., 2022)

4. Increased safety: Railways are generally considered safer than truck transportation, with lower rates of accidents and fatalities. (Mitra 2016)
5. Volumes capacity: Railways can transport large volumes of goods simultaneously, making them an ideal option for businesses that need to move large quantities of goods over long distances. With an average mix of cars, train cargo caries 90 vehicles with an average of 23-70 tons compared to FTL "Full truckload maximum capacity 24 tons. (Tokhirov & Tashmetov 2022)
6. Cost: The unit cost of railway transport at an average distance of 350 km can be up to three times lower than the truck. Stolarski(2021).

2.2 Advantages of Railway Logistics for Industrial Region in Saudi Arabia

The landscape in the Kingdom of Saudi Arabia presents an ideal environment for a strategic railway network. With a significant distance to cover between the seaport and other logistics hubs and the dedicated industrial cities, it is possible to create an effective and efficient logistic network with desert climate examples such as India and Europe, mainly depending on the railway system for transportation. Connecting the ports and industrial area through the railway will initiate a spike in the production rate, more accurate forecasting, and more effective planning due to mitigating the uncertainties accompanied by other methods, creating more business opportunities to increase market share in areas deemed economically a loss due to the high expenses that come with it. The success of the passenger railway in the kingdom aligning with the vision of 2030 railway logistics will provide rapid development to the mega project across the kingdom with a sustainable supply of materials and goods. More joint ventures between companies and organizations on opposite sides of the kingdom to do joint venture as we have finished goods manufacturers and raw materials suppliers. Adding the possibility to expand the network scale across neighboring counties in the region forms a strategic partnership. The study of Kaack et al. (2018) showed that Model shift could be promoted by policies targeting infrastructure investment and internalizing external cost of road freight, which the kingdom already established with several objectives for a sustainable economy through the 2030 vision.

2.3 Feasibility Study for Railway Logistics

A feasibility study for railway logistics would typically consider various factors to determine whether or not a proposed rail project is viable and practical. These factors include the followings:

1. Market demand: The feasibility study would assess the potential need for freight or passenger services on the proposed rail line. This will involve analyzing the current transportation infrastructure and determining if sufficient demand justifies the investment in a new rail line. (Nie et al. 2022)

2. Route analysis: The feasibility study would analyze the proposed route for the rail line, including the terrain, the existing infrastructure, and any potential obstacles or challenges that may need to be overcome. (NDOSSY 2020)
3. Cost analysis: The feasibility study would assess the capital and operating costs of constructing and operating the rail line. This would include land acquisition, construction, rolling stock, and maintenance costs. (Almujibah & Preston 2019)
4. Revenue potential: The feasibility study would estimate the potential revenue that could be generated by the rail line, taking into account factors such as the volume of freight or passengers that could be transported, the pricing strategy, and the competition from other transportation modes. (Sieg & Wessel 2022)
5. Funding sources: The feasibility study would identify potential funding sources for the project, including government grants, private investment, and financing options.
6. Environmental impact: The feasibility study would assess the environmental impact of the proposed rail line, including the potential effects on wildlife, water resources, and air quality. (Gorman 2023)
7. Legal and regulatory requirements: The feasibility study would identify any legal or regulatory requirements for the project, such as permits and approvals that need to be obtained before construction can begin.

A feasibility study for railway logistics would need to weigh these factors carefully to determine whether the proposed rail project is economically and environmentally sustainable and would benefit society.

3.0 Methodology

This paper aims at reviewing railway transportation and discussing its advantages in logistics. This review was advocated by previous case studies, literature, and research conducted in various countries around the world. In addition, the literature review will provide a comprehensive analysis of transportation methods across other industries, specifically seaports. To support the hypothesis of this paper, a comparison is made between the current primary transportation method, truck transportation, and the proposed railway transportation viewing the difference in various factors such as travel distance, fullness ratio, nature of transported material, and landscape discovering the range of use of each method and the limitations. Accordingly, research findings are presented based on formulating the outcome of using the railways' transportation in Saudi Arabia and the feasibility of implementing the transportation method. Additionally, conducting interviews with a focus group consisting of stakeholders such as the government two each, five logistics experts, and three manufacturers for their opinions. These interviews aim at gathering insights on the proposal's impact, potential concerns, and the feasibility of implementation from each stakeholder's experience and point of view. as to possible challenges and obstacles facing the proposal’s implementation and which party would be suited for the management and building of the infrastructure [Figure1].

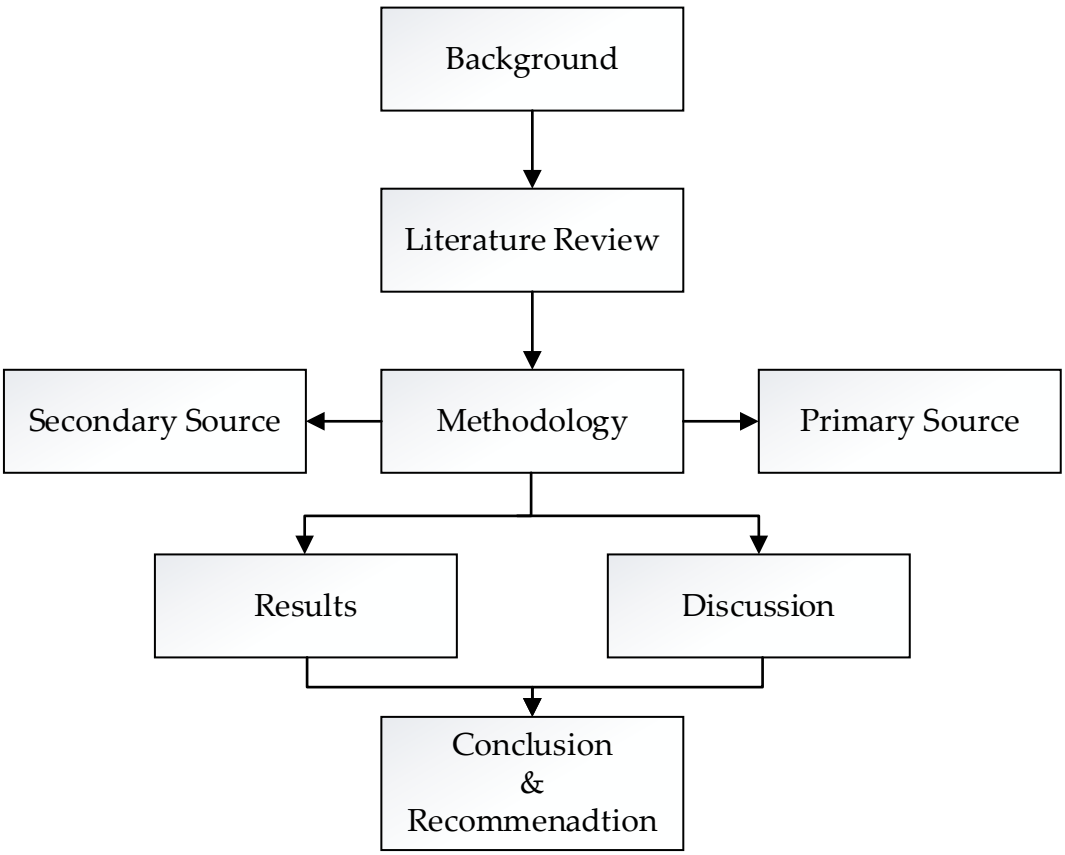

Figure 1. Flowchart of research methodology

4.0 Results and Discussion

Trucks transportation limitations using the urban road, traffic policies, and the small capacity for the industrial region requirement take their toll on their operations, planning and increasing the costs internally and externally, the direction of the global economy toward an environmental responsibility to find alternative solutions affirm that railways characteristic align with the stakeholders. Objective reducing the cost and increasing the effectiveness. An interview of stakeholders and experts in the field of logistics provided their opinion on the proposal answering the following question:

Q1: What is the impact of adding the railway to transportation methods used for the industrial region?

Q2: What are the challenges of using the proposed transportation methods?

Q3: What are the factors to consider when applying railways transportation?

The logistics experts have an intriguing interest in adding the railways as the primary method of transportation due to centralized planning features, lesser trips, and high-cost reduction. Q2: Asset management favors the government sponsor to do the infrastructure as the external cost for railways transportation is high Factors mentioned by the logistics experts are the fullness ratio, the pricing strategy, and the organization to manage and operate the railways private or government.

Manufacturers in the industrial region saw a potential to expand their market share and less workload in inventory with more control in effectively replenishing their stock level. The cost of transportation, asset management, and the stakeholder responsible for private investment or government, pricing, and regulation. Factors mentioned by the Manufacturer's consideration are pricing, stakeholders in transportation management, the facilitation of changing transportation methods from railways hub to trucks to reach their facilities and loading time.

The government sector replies to The proposal to lessen the cost of road maintenance and handling the traffic caused by trucks and new income by placing new regulations and fares for using road transportation, promoting using the railways and contributing to the vision of 2030 for environmental responsibility and more alternative income. The infrastructure cost and the route planning of the rail network, the management of transportation mode under direct government control or put into the private investment of a third party. Factors to consider in implementing new transportation methods: pricing and regulations, limiting road transportation to minimize truck usage.

5.0 Conclusion and Recommendation:

Transportation cost is a vital factor in the economy. The research objective is to highlight the optimal mixture of transportation alternatives to minimize the total logistics cost We have a grand vision for our logistics initiative, where our railway system effortlessly connects every corner of our beautiful nation. By carefully planning and executing our strategy, we can unite diverse communities and unlock new opportunities for all. Collaborating closely with neighboring countries will allow us to unleash even more significant potential, building a brighter future for future generations. As we move forward, we will expand our railway network in phases, with the interconnected phases two and three reaching even further. We also aim to establish mutually beneficial commercial partnerships with our neighbors.

As we begin our logistics initiative, we envision a future where our railway system effortlessly links every part of our wonderful nation. By meticulously planning and executing our strategy, we can unite diverse communities and open new opportunities for everyone. Furthermore, we can unleash even more significant potential through strategic collaborations by working alongside our neighboring countries to build a brighter future.

As our logistics initiative takes shape, we intend to expand our railway network in phases, with phases two and three interconnecting and expanding further. Additionally, we aim to negotiate profitable commercial partnerships with our neighboring countries.

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