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The Viability and Contribution of High-Speed Rail to the Economic Growth and Social Development

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Abstract

The United Arab Emirates, located in the southwest of Asia, and Abu Dhabi, is the largest emirate in the United Arab Emirates (UAE). The emirate comprises a total area of 87% of the UAE. In 2009, The Department of Transport (DoT) announced the Surface Master Plan: A vision for connecting Abu Dhabi in 2030. One of the significant economic objectives of the master plan is to boost economic competitiveness through effective freight and passengers transport services. The rapid development and growth in the emirate will result in a considerable increase in freight movement. Thus, investing in high-speed rail (HSR) projects is crucial to achieving the vision objectives. This study seeks to assess the impact of the Etihad High-Speed Rail (ER) project on the economy and sociability in the United Arab Emirates. In addition, the study will review the HSR project's impact from different studies across the world. The aim will be to synthesize the current knowledge on the subject and draw on the best conditions in which the country can invest in HSR extensions and new projects.

Keywords

High-Speed Rail, Infrastructure Finance, Tourism, Economic Growth, Sensitivity Analysis, Social Impacts

1. Introduction

The Abu Dhabi emirate comprises a total area of 87% of the UAE. In 2009, The Department of Transport (DoT) announced the Surface Master Plan: A vision for connecting Abu Dhabi in 2030. One of the significant economic objectives of the master plan is to boost economic competitiveness through effective freight

and passengers transport services (Dhabi, 2009). The rapid development and growth in the emirate will result in a considerable increase in freight movement. Three specifications define a high-speed rail (HSR); they are:

- Infrastructure—track exclusively built for high-speed travel.
- Speed—with a minimum speed range of 200 km/hr to 250 km/hr (rolling stock).
- Operating conditions—designed rolling stocks that provide safety and compatibility for the infrastructure.

Thus, the need to invest in high-speed rail projects is crucial to support achieving the vision objectives. This study seeks to assess the impact of the Etihad High-Speed Rail(ER) project on the economy and the sociability aspect in the United Arab Emirates (UAE). In addition, the study will review the HSR project's impact from different studies across the world. The aim will be to synthesize the current knowledge on the subject and draw on the best conditions in which the country can invest in HSR extensions and new projects. From the findings, it will be possible to characterize how ER contributes to the UAE economy. The primary source of data used to evaluate the impact of the ER project is the Economic Return Analysis, obtained from the Etihad Rail Company.

2. Literature Review

2.1. Viability of Investing in HSR

Many studies have discussed the cost-benefit analysis of investing in HSR (Nash, 2015). Nash et al. examined generic literature of the costs and benefits of HSR from different countries, such as the United Kingdom (UK), Europe, and Japan. The literature illustrated five main factors that determine if HSR projects are worth investing in; the factors are:

- Construction costs: Vast amount of savings can occur if the HSR construction line avoided tunneling. Thus, an alternative lower-cost solution proposed by the study is the placement of underground suburban services.
- Value of time savings per passenger: This factor depends on the level of income and the quality of available alternatives. A higher savings of time achieved per passenger by HSR than conventional rail and cars.
- Traffic volume: The existence of high demand in densely populated cities is critical to invest in HSR projects. People will prefer HSR over cars in a denser city. In addition, HSR can compete with the air industry if the traveling time is up to 3 hours.
- Degree of congestion of existing transport networks: Providing broader capacity in HSR projects will lead the passengers to prefer HSR over road and air.

The literature emphasized the importance of further investigation on the extent of broader economic impacts an HSR project can have on countries. In addition, De Rus (2011) supported Nash's (2015) findings by addressing four main factors for policymakers in deciding to invest in HSR: high traffic volumes, high

rate of willingness to pay by passengers, and considerable savings in time and broader capacities. De Rus (2011) discussed that the passenger's willingness to pay factor is crucial in compensating the high construction, maintenance, and operation costs of HSR projects, thus, ensuring high rates of social revenues generation is essential for HSR to maintain a stable operation. Based on international experiences (Albalate & Bel, 2012), HSR investments are viable when they aim to reduce congestion, manage and solve capacity constraints and improve freight movement facilitation. HSR can be an economic failure if it seeks to boost equity and enhance development on a regional level.

2.2. Economic and Social Impacts of HSR

HSR services are of higher quality in comparison to other modes of transport. HSR's significant merits are high safety measures, reduced labor costs, and fast timing in point-to-point movement, loading, and unloading (Levinson, 2012). However, HSR's prime negatives are its high, fixed costs. In addition, to the vast energy costs and noise discomforts, this study will provide a generic literature review on the economic and social impacts of HSR projects from different countries across the world. A study in the United States (US) investigated the Chicago-Hub H.S.R.'s long-term user and community effect (Peters et al., 2014). The study found that a total of $400 million annual savings is achievable by 2050 in safety, vehicle operating cost, and annual travel time compared to $200 million annual savings in 2012. Another study discussed the accessibility impacts of HSR in the US, showed that the local accessibility effects of HSR are improbable. The study referred to the lack of features, merits, and advantages for people and business owners to locate their properties next to HSR due to its irregular usage compared to public transportation. However, on a broader level, such as metropolitan areas, HSR can have a more considerable practical impact. The first HSR was built in Japan in 1964 under the name of Shinkansen. A study conducted by Cho et al. (2016) discussed the regional productivity benefits of the Japanese HSR. The study showed that HSR networks and stations significantly affect regional productivity. In addition, the accessibility provided by HSR has a positive impact on regional productivity. In a published report by the Community of European Railway and Infrastructure Companies (CER) in 2014-2015 illustrated that high-speed rails energy consumption in Europe (per seat mile) is 2.4 times lower in comparison to aviation.

The United Kingdom has two HSR networks: High Speed 1 (HS1) and High Speed 2 (HS2). HS1 was established in 2003 and has contributed towards a fast passenger commuting movement on the network. HS2 construction processes started in 2012. Although, UK has been slow in investing in HSR projects and observing the development of HSR in other countries (Bolden & Harman, 2013). He illustrated that the UK must construct HSR projects due to its more comprehensive benefits in capacity and connectivity, journey benefits, economic development and regeneration, spatial development, environmental sustainability,

and international links.

From the Gulf Cooperation Countries, there is a scarcity of published studies available on HSR projects. One of the reasons is the lack of previous investment in the rail industry in general. There are ongoing HSR developments in Saudi Arabia, Kuwait, Oman, Bahrain, and Qatar (Mahendran & Pillai, 2016). For example, the Kingdom of Saudi Arabia (SA) is the largest Arabian country and ranks among the top 25 globally (Aldagheiri, 2010). However, it has a limited rail industry. To achieve one of the strategic goals, SA diversified the national economy, and the rail industry is in the path of expansion. For that reason, the Supreme Economic Council in SA approved the development of 3 high-speed rail projects, which are the Saudi Land Bridge, The Western Railway, and The North-South Railway. The most significant agreement using Build Operate Transfer (BOT) was awarded to the private sector through the Saudi Government to build the Saudi Land Bridge railway. It is the largest BOT contract in the Middle East region. The rail supports the Kingdom's vision by providing convenient and safe passenger lines across the country. In addition, it will transfer large quantities of cargo.

The Western Rail will connect the cities of Makkah, Jeddah, and Madinah. The rail will contribute towards reducing the traffic jam in SA and serve commuters demand. The North-South Railway will enhance the predicted industrial development and strengthen industrial development. It will connect Az Zubairah and Al Jalamid phosphate and bauxite mines with the Ras Azur processing facilities at the Arabian Gulf. The indirect benefits of the rail industry in SA are developing the Kingdom's tradable sectors such as agriculture, industry, and commerce. The direct benefits are the economic outcomes of the mining field, which is considered a futuristic plan for country development.

3. Etihad High-Speed Rail Project

3.1. Etihad Rail Overview

The Etihad High-Speed Railway project (ER) is the only HSR in the country. ER is a flagship program of the UAE government that aims to significantly boost the economic growth in the country (Almardood & Mahelal, 2020). The establishment of ER began in 2009, under Federal law No. 2, with a mandate to manage the development, construction, and operation of the UAE's national freight and passenger rail network. The total cost of ER is AED 40 billion (Todorov & Akbar, 2018). The rail network plan is designed in three stages.

- Stage one links Shah and Habshan to the port of Ruwais.
- Stage two connects the rail to Mussafah to the Gulf ports of Khalifa and Jabal Ali, and the Saudi and Omani borders.
- Stage 3 will extend the network from Dubai to the northern regions of Fujairah, Ras Al Khaimah, and Sharjah.

The length of each stage is 264 km, 628 km, and 279 km, respectively. Several studies such as Geotechnical study, Topographical survey, Environmental Im-

pact Assessment, Preliminary Engineering, and Traffic Study conducted to ensure that HSR meets the targets. The studies supported achieving the principles of ER Company which are safety, connectivity, economic growth, efficiency, and sustainability. In 2011, ER signed a partnership with Abu Dhabi National Oil Company (ADNOC) (Al Suwaidi, 2017). The partnership enabled the transport of sulfur from its origins in Shah and Habshan to the port of Ruwais, with a quantity of more than 7 million tons of granulated sulfur transported annually. The partnership included Operation and Maintenance (O&M) and Construction Management agreements. ER and ADNOC collaborated on the maintenance and transportation of granulated sulfur.

3.2. Etihad Rail Project Finance and Stakeholders' Structure

The financing of the first stage of the ER project was based on project finance with a club deal basis concept (De Rus, 2012; Al Saadi & Abdou, 2013). The timeline was as follows:

- In early 2012, the UAE Federal Cabinet and Abu Dhabi Executive council approved and authorization for stage one financing plan.
- In 2013, ER and ADNOC companies secured a 5-year loan for stage one; the loan facilitator and security agent was one of the central banks in the emirates.
- Assigned contracts and funding sources.
  - The funding came from the Bank of Tokyo—Mitsubishi UFJ (BTMU), Abu Dhabi Commercial Bank (ADCB), and HSBC Bank Middle East Limited (HSBC). The loan value was AED 4.7 billion (USD 1.28 billion).
  - ATKINS Company contracted preliminary Engineering services (for all the stages).
  - The project management consultant (P.M.C.) was an international consortium joint venture between Parsons and AECOM companies.
  - In October 2012, a design and build contract was awarded to Saipem, Maire Tecnimon, and Dodsal companies to carry out the construction. In addition,
  - Al Hai & Al Mukaddam for Geotechnical Works LLC contracted the geotechnical investigation for stages one and two.
  - Topographical surveys such as aerial surveying, ground surveying, and aerial photography were contracted to Fugro Maps Holding Ltd., in 2014.
  - ER signed an Operation and Maintenance (O&M) joint venture agreement with DB Schenker Rail, a German-based Deutsche Bahn (DB) subsidiary. 49% is the total shares subscription of DB of the issued share capital by ER. The Etihad Rail DB joint venture was signed exclusively for stage one of the projects. However, this will also allow DB to act as a consultant for the future operations of future stages of ER.
  - Good Harbour Company carried the safety consultant services.
  - Lloyd's Register awarded the independent safety assessor contract.
  - The rolling stock supply contracted to Electromotive Diesel (EMD) and Chi-

na South Locomotive and Rolling Stock Corporation Limited (CSR) to provide seven EMD SD70 locomotives and 240 covered hoppers, respectively.

- SAP awarded the contract for information systems and implementation.

3.3. Etihad Rail Social Impacts

The social impact of Etihad Rail acts as an indirect benefit. With the expected increase in population, the passenger volume will reach 27 million by 2035 in the UAE. The rail will connect the community across the Emirates by overpassing the main cities, suburbs, and rural areas. Access to facilities such as schools, hospitals, and shopping malls with a shorter travel time and reasonable fees was also an objective of HSR. The rail would also help bring positive social impact to residents and tourists with more convenient travel to their destination across the Emirates (Juaidi, Montoya, Gázquez, & Manzano-Agugliaro, 2016). The efficiency of social impact is affected by many quality aspects, as shown in **Figure 1**, but the main affecting aspects are the travel duration and fee-saving (Lingaitis & Sinkevičius, 2014; Wilhelms, 2014; **Figure 2**). The time-saving in rail is due to the average higher speed, and rail passengers avoid delays from road congestion.

Rail is known to have a better safety record than other transportation modes; thus, minimizing accidents and related costs. Railway crash is rare but if it happens the consequences are fatalities and injuries. While on the other hand, other transportation modes accident can cause the mentioned in addition to property

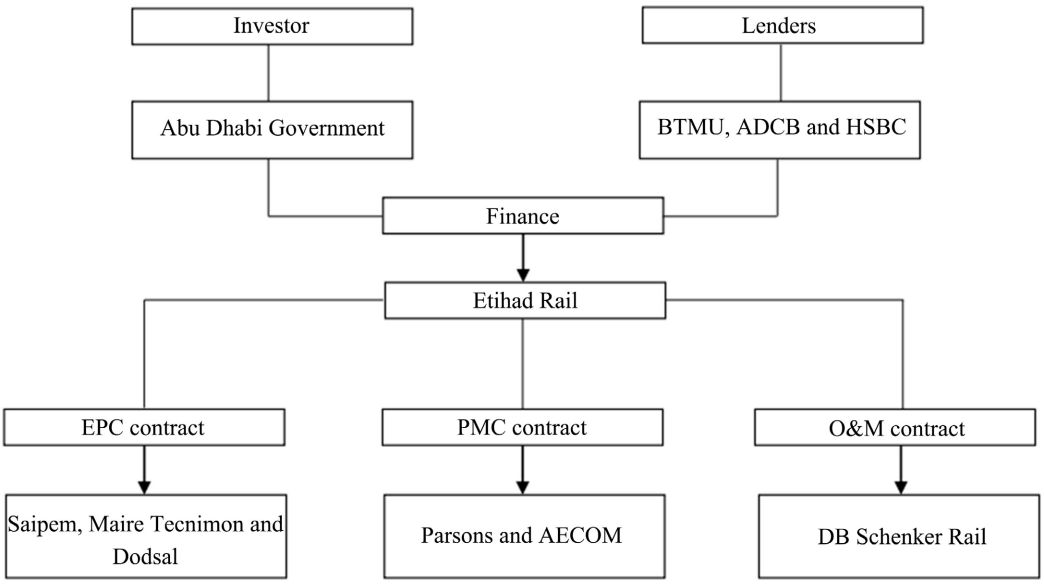

Figure 1. ER corporate structure.

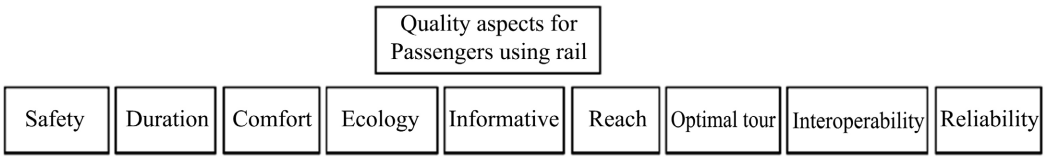

Figure 2. Main quality aspects considered for rail users (adapted from Lingaitis & Sinkevičius, 2014).

damage which adds up to accident costs massively. Another valued benefit is creating a new paradigm of an extensive infrastructure that will open new job opportunities across the Emirates. These careers will develop highly specialized skills for employees and involved organizations with Etihad Rail. Figure 3 shows the various social impact of rail transportation. The Social impact evaluation improves the environment, i.e., reduction of greenhouse gases per capita. Diesel engines in the rail are more fuel-efficient than normal transportation modes. Rail transportation is masked by heavy growth in corridor traffic. Rail transit is both safe and environmentally friendly. Rail systems expand mobility and reduce household investment in transportation. Through the increased accessibility, the new business formation will flourish. Examples of these planned business layouts are Mussafah and Kizad industrial areas in the capital of UAE.

3.4. Etihad Rail Economic Impacts

The economic impact study conducted was to identify and promote the kind of infrastructure investment needed for the region (Aleknaite & Grubliauskas, 2018). Based on the data that every AED invested in Etihad rail will create 2.7 AED in return, with a present total value of benefit 186 Billion AED and the present value of CAPEX and OPEX to be 70 Billion AED, the total benefit comes from freight (48.9%), passenger (27.4%), Land value and other benefits (11.3%), and tourism (12.4%). With several scenarios in consideration, the implementation of this project would be profitable.

A sensitivity analysis study was conducted based on different scenarios. The following scenarios were studied and shown in Figure 4.

- The original plan: A benefit of 186 Billion AED with a CAPEX and OPEX value of 70 Billion AED; which means that for every 1AED spend Etihad rail would create 2.7AED.
- Scenario A: if the expected number of passengers decreased by 30%, CAPEX and OPEX value remains the same. A benefit of 147 Billion AED is reached. This means that for every 1 AED spend, Etihad rail would create 2.5 AED.
- Scenario B: Assuming the benefit to remain the same and if the CAPEX and OPEX cost increased by 17%, OPEX and CAPEX values would increase by 82 Billion AED. So for every 1 AED spend, Etihad rail would create 2.3 AED.

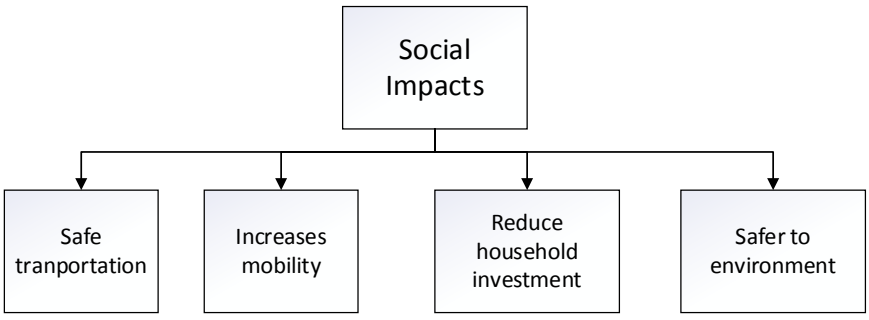

Figure 3. Main social aspects.

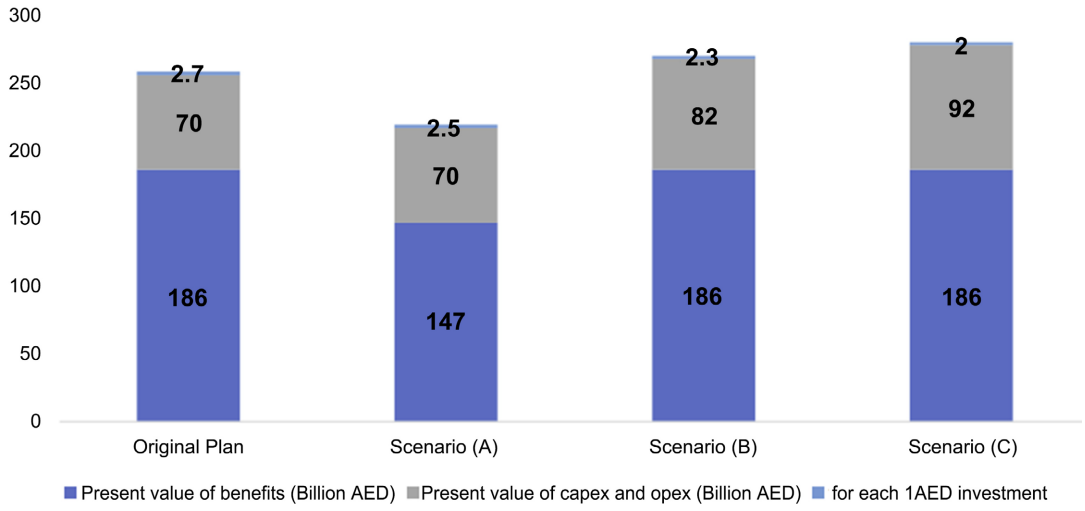

Figure 4. Sensitivity analysis.

- Scenario C: Assuming the benefit to remain the same and if the CAPEX and OPEX cost increased by 31.5%, OPEX and CAPEX values would increase by 92 Billion AED, for every 1 AED spend Etihad rail would create 2.0 AED.

3.4.1. Freight Benefits

Road transport is the most popular mode of freight because of its flexibility to reach the destination and also if the load capacity is low. Freight transport is usually more attractive using an adequate railway system because it reduces congestion significantly on the highway (Pazour, Meller, & Pohl, 2010). Freight volume compacted in the trains; thus, reducing carbon dioxide emission due to less fuel consumption. This improves reliability and reduces transportation costs (Vierth, 2011). Using HSR also reduces the dependence on the road, which means lower utilization of road, which in turn reflects on lowering maintenance costs. Presently, the freight benefits are estimated at 91 Billion AED, where 64% of the saving is from transportation cost savings. Fatal accidents of freight vehicles will reduce by 33% in five years after the shift from road to rail freight transport; the cost per freight fatal accident in UAE is 2.7 million AED. The freight transport costs saving by Etihad rail estimates to be 58 billion AED (64% of total freight benefits). Freight benefits count as a primary factor for implementing an efficient rail system in the UAE. **Figure 5** displays the estimated freight benefits. The split-up of all the freight benefits is shown in **Figure 5**.

Shippers can convert the long haul freight from road to rail. Rail also has lower fuel costs than road transport, especially the amount of load transported, and the cost involved with drivers and other taxes involved. The significant net saving is environmental saving, 19% cost saving in the environmental benefits. Train burns less fuel per tom mile than trucks. According to the Association of American Railroads (AAR), freight railroads transport one ton to an average of 479 miles on a single gallon, which also helps to reduce greenhouse gases by 75%. Trains handle a high volume of freights; a double-stacked train can hold

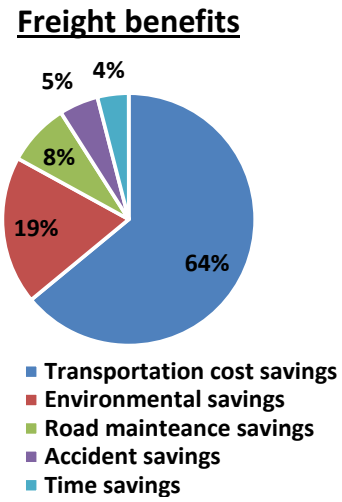

Figure 5. Estimated freight benefits.

approximately the same amount as 280 trucks. Having more trucks on the roads means more frequent road maintenance and is estimated to have an 8% savings. Rails have standardized transit schedules, and they don't share their tracks with the public as trucks do with the road and an estimated cost saving of 4%. Trains are also not hindered by traffic and weather.

3.4.2. Tourism

An efficient rail system will enhance the country's tourism experience, allowing easier access to touristic landmarks with a safer, faster, and cheaper mode of transport (Pagliara, La Pietra, Gomez, & Vassallo, 2015). The existence of high-speed rail is not a key factor for all tourists; this implies for tourists who travel a very long distance to reach hence their only means of transportation is the airplane. However, it acts as a significant attractive mode of transport where tourists seem to be less sensitive to ticket fees than finding a way to reduce time and provide comfort (Albalate & Fageda, 2016). A recent study emphasized studying the destination characteristics, thus understanding the expected groups of tourists. It showed that in one area, most tourists using high-speed rail are older, stay longer, and come in larger groups than in other destinations (Gutiérrez & Ortuño, 2017). Destination creates the basis for tourist characteristics. Another study showed that having a high-speed rail might increase the annual tourism frequency and the length of stay, which will help the Government's economic growth and involved entities. Still, it will have a direct adverse effect on tourism's carbon emission footprint (Sun & Lin, 2018).

Tourism in UAE expects to increase at a rate of 2.7% for the next ten years. A tourism-benefit analysis found that HSR would increase tourist length of stay by an average of 3.8 days. It will also increase their expenditure due to visiting more areas and the spending within UAE instead of international tour operators.

3.4.3. Land Value

The expectation of enhanced accessibility to the places makes it a more excellent

rental value. The accessibility support to change the land value enhances the economic benefit of the area. Kanasugi et al. studied land value and high-speed rail infrastructure in fifteen significant cities. The result of the study was that 53.3% of the cities showed positive land value uplift due to rail infrastructure, 20% showed the opposite results where the land value dropped and 26.7% of the cities had no significant change (Kanasugi & Ushijima, 2018), which means that the construction of rail effect on land value might be heterogeneous (Hensher, Li, & Mulley, 2012). The development of high-speed rail would positively impact economic growth, but it will be more affected in the surrounding area. An example of that is Google bought a one-hectare land next to King's Cross station (immediately after its completion); the value of the land at that time was 650 million pounds (3.2 Billion AED). As the surrounded area of King's Cross developed with shops, new streets, restaurants, leisure facilities, and residential houses, the value of Google land increased up to 1 billion pounds (4.9 Billion AED) (Lin, Zhou, Kuang, & Luo, 2017). A recent study in Japan confirmed the positive impact on residential land price as the new railway station was published; the expected completion of the rail is in 2027. Still, the land investors took action as the information is disclosed. The introduction of Etihad Rail expects an increase in land value of its surrounding areas based on the estimation conducted using lease rates across the proportion of residential, commercial, and industrial developments. It assumed that the land value would increase by 15% and 27.5% in 2025 and 2030, respectively the enhanced land value is expected to add up to 0.6 billion AED.

4. Discussion and Conclusion

Constructing a rail infrastructure is the most expensive mode of land transportation; however, backed up with several advantages: 1) the transportation market is constantly growing; 2) it is safer and more reliable than other land transportation; 3) it reduces the carbon footprint per capita; 4) and it reduces travel time. Etihad rail's social impact lies in opening a new job sector in the region. Also, with the new sustainability-driven generation, people would tend to find better modes of transportation to reduce their carbon emission, i.e., using the rail instead of private cars. Etihad rail will serve as a great asset to propel and serve the economic growth in the UAE. Freight benefits are significantly used with many positive economic impacts, such as savings on transport, environment, road maintenance, accidents, and travel time, with an estimated benefit of approximately 90 billion AED. Although tourism in literature does not correlate directly to high-speed rail literature, Etihad rail implementation expects an increase in the duration of tourists' stay. The main drawback would be affecting the environment in terms of tourism's carbon footprint. On the other hand, the land value depends heavily on the surrounding areas; the more attractions around the rail station, the more added values to the land. Major conclusions drawn from the application of the rail system in UAE are: 1) Safer, more reliable, and faster

way of transport for passengers and freight who are using congested roads; 2) Shifting cargo loads from roads to rail contributes to the Government's road maintenance savings; 3) There are significant direct, indirect, and broader economic impacts in which ER project supports achieving the UAE vision 2030. There are also some limitations or further research that need to be done, especially with road transportations. A high-speed rail would require high passenger loading (load factor) or a very high freight loading. This means that a small country like UAE should also consider the feasibility of a GCC connectivity system rather than the small geographical area. In terms of CO_2 emitted, the proportion of electricity supplied from noncarbon sources is essential. The UAE is rich in Oil and Gas and the study was based on using diesel engines to run the rail freight. Aerodynamic design to reduce drag is vital, as is light-weighting to give a nimble footfall and hence reduce infrastructure maintenance costs.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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