9-2022

Cost-Benefit Analysis of the Saudi Land Bridge Project

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THESIS

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AFIT-ENS-MS-22-S-054

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Wright-Patterson Air Force Base, Ohio

AFIT-ENS-MS-22-S-054

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Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics and Supply Chain Management

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September 2022

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Abstract

Projects are the backbone of economic thrive of nations, especially infrastructure projects. It's counted as the base layer of allowing economic trade between beneficiaries. Railway projects have always been a huge element in increasing trade operations between Saudi Arabia and the rest of the world, by providing an efficient and environmentally friendly way that is capable of hauling large loads of exports all the way to the seaports and from there to the rest of the world. The Saudi land bridge project will cost about $11 billion and will provide a new link between the existent railway in the eastern region to the west of the kingdom all the way to Jeddah Islamic seaport right on the red sea. The goal of this research is to perform a cost-benefit analysis of the new Saudi land bridge project, by studying all the data available to determine if the government of Saudi Arabia should proceed with this project or not. The cost-benefit analysis will compare the project's expenses with the advantages that will be realized once it is completed. It indicates that the project should be carried out since the project's benefits will outweigh the expenses associated with its completion.

To

my country.

my parents.

my wife.

and my daughter.

Acknowledgments

My warmest gratitude is being extended to my academic advisor, Dr. William Cunningham, for his assistance and support in both the classes attended with him and during the writing of this thesis. The knowledge and experience I gained from you were definitely what made these results achievable.

Faris J. AlOtaibi.

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COST-BENEFIT ANALYSIS OF THE SAUDI LAND BRIDGE PROJECT

I. Introduction

1.1 Background

One of the many infrastructure projects that Saudi Arabia is interested in is the Saudi land bridge project that will link the two existing railway networks both in the eastern and western region. This huge project is anticipated to cost roughly around $11 billion that will be funded by the government (CNBC Arabia, 2020). The land bridge will provide a connection between the existing railway network in the eastern region that links the Dammam seaport on the Arabian gulf to Riyadh the capital of Saudi Arabia and all the way to the northern borders and the other network in the western region that serves the three major cities there, Jeddah, Makkah, and Madinah (Alarabia, 2021). It will start from the current railway station in Riyadh all the way to Jeddah. The Saudi ministry of transport and logistic services revealed that the project will be performed by a major corporation in the Chinese government sector over a period of 5 to 7 years from signing the contract (Alekhbariya, 2020). This massive infrastructure project will provide a connection between the two major seaports located on both sides of the kingdom, which will generate a lot of job opportunities in both the government and the private sectors. Additionally, it will establish a new method of transport across the kingdom and serve millions of pilgrims during Hajj season every year.

In a recent study done by King Abdullah Petroleum Studies and Research Center about the transfer policy design for sustainable freight movement in Saudi Arabia, it shows that when it comes to moving freight Saudi deeply relies on its road network that stretches for more than 42,500 miles compared to the existing 2,600 miles of railroads that are dedicated to moving goods.

In the meantime, there are only two railroads that are important for shipping goods and moving freight. The first one connects the main dry port in Riyadh to the King Abdulaziz commercial seaport in the eastern region. And the second one connects Riyadh to the mineral deposits area in the Northeast side of the Kingdom (MTLS, 2022). Diesel is used in all logistical services for moving shipments through roads and rail roads in the Kingdom of Saudi Arabia. Also, sea shipping is one of the main ways of shipping in the Kingdom with its existing 9 public seaports. Seven of them are commercial and two are industrial and one private seaport (Mawani, 2019).

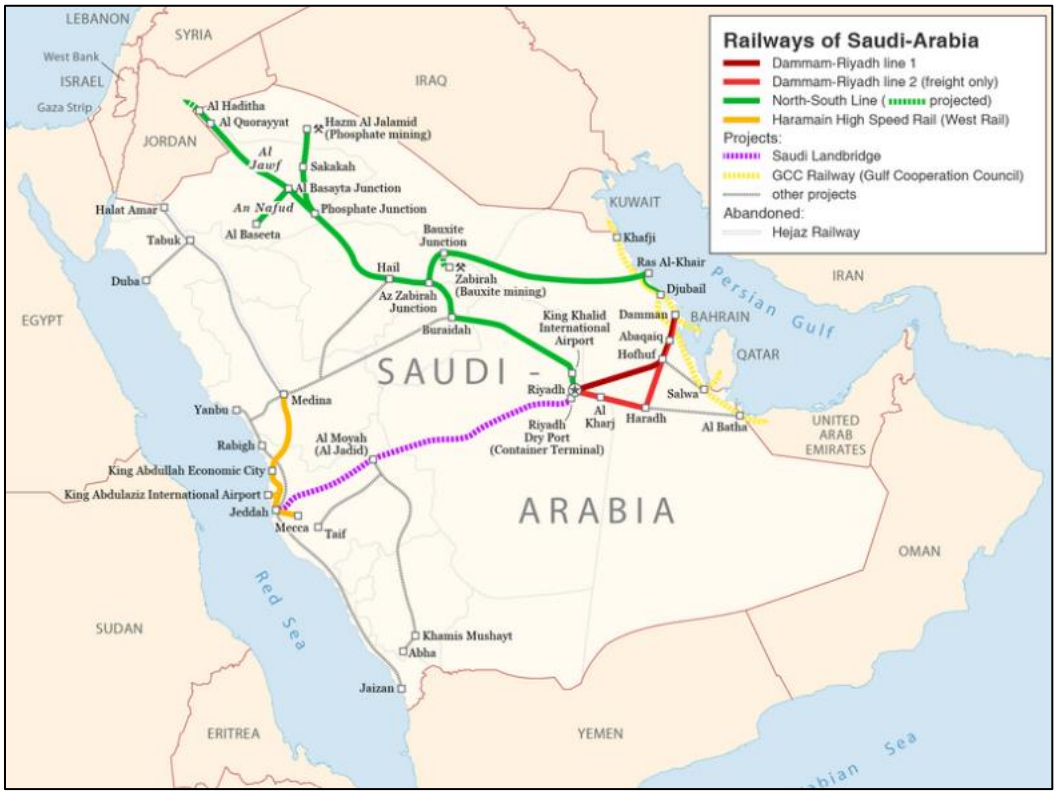

Figure 1. Railways network in Saudi Arabia (SAR, 2019)

1.2 Problem Statement

An estimated $11 billion will be spent on the building of the Saudi Land Bridge. Another cost involved with the project, in addition to the direct financial expenditures associated with the building of the railway network, is the cost of maintaining and operating the infrastructure. The project will provide a variety of advantages, which will serve as a driving element for the Saudi Arabian government to proceed with its construction. It will provide a fast, spacious, and fuel-efficient path of transportation of goods, lowering the use of trucks which will lead into noticeable decrease in both fuel consumption, emissions, and highways maintenance expenses, in addition to the positive impact on highways safety levels when accidents numbers are dropped.

A cost-benefit analysis of the proposed project is necessary to assess whether the benefits arising from the project exceed the costs involved with its implementation or not. This will give a deciding tool whether to continue with the project or not.

1.3 Research Objectives and Questions

The primary goal of this research is to assess the advantages and expenses involved with the building of the Saudi Land Bridge in order to establish the project's feasibility. In doing so, the expenses connected with the project will be established, as will the advantages that are anticipated to be obtained once the project is done. The payback time and net present value may then be computed. The undertaking is justified if the benefits outweigh the expenses. On the other side, if the expenses exceed the benefits, the project is not reasonable.

The findings of the study will demonstrate how cost-benefit analysis may be used to determine if the benefits of megaprojects outweigh the costs. The project's effectiveness is determined by comparing the project's expenses to the benefits that are anticipated.

The research questions are:

1. The project's break-even stage must be reached within what amount of time?
2. The Saudi Land Bridge is predicted to provide a number of indirect advantages. What are these?
3. What are the potential indirect costs and obstacles in this project?

1.4 Methodology

The first stage in this study is to look into the direct advantages and disadvantages. This step helps evaluating the costs as well as the benefits that will accrue over the course of the project's existence. The second step will include putting a dollar value on the project's expenses and benefits. The third step is to weigh the costs and advantages. The findings of this study will be used to determine the appropriate course of action to take. This is performed by calculating the total predicted costs as well as the projected benefits, and then determining if the benefits outweigh the expenditures. This stage entails calculating the payback time, which is used to determine how long it will take to reach the break-even point.

1.5 Assumptions and Limitations

Most of the calculations in this study are based on the data available through official websites, government press releases and trusted news channels reports, and since these are the only data will be used in the cost benefit analysis of the building of the Saudi Land bridge, it is better to say that the final calculations that this study will be building decisions based on what are going to be roughly estimated values. One of the many obstacles to this way of evaluating megaprojects or any other projects is not being able to quantify intangibles, also the issue of the imperfect market, we need to understand that it's impossible to operate in a market without the existence of monopolies, therefore we could try to resolve this issue by setting fixed prices before putting the cost benefit analysis in action.

1.6 Preview

In this chapter we discussed the Saudi Land Bridge in general. Chapter II will focus more on similar projects of this kind and what studies have been made in this field. Chapter III will go through the methodology employed in this study. Chapter IV will provide the results and analysis. In the end, Chapter V summarizes the findings, draws conclusions, and makes recommendations for future studies.

II. Literature Review

2.1 Chapter Overview

The most cost-effective means of transporting commodities on land is via railways. Trains play a critical role in the transportation of heavy, bulky goods across long distances. Examples of items transported by rail include coal, grain, fertilizer, chemicals, and forest products, as well as cars and metals. Compared to truck, railroads are less expensive, but they also provide a poorer quality of service in most cases. Shipments by train are generally priced at a 10 percent to 15 percent discount as compared to shipments by truck in the railroad revenue segment that is most competitive with trucking in the industry. For items that are less competitive with trucking, the gap in pricing can be significant, and the trucking business may be unable to compete for the freight at a profitable level (Freight waves, 2019).

2.2 Cost-Benefit Analysis

A cost-benefit analysis is a logical approach that corporations use to determine which actions to make and which actions to avoid based on the financial implications. An analyst who performs a cost-benefit analysis adds up all of the potential rewards that may result from a situation or action and then subtracts all of the overall expenses connected with that scenario or activity. Additionally, some consultants or analysts develop models to give cash values to intangible elements, such as time. And because of the discount rate that is used in the cost-benefit analysis, a good trade-off is presented between the project's net present and projected benefits. Both direct and indirect cost resulting in this project must be considered and compared to the benefits of this project. Summing up all the calculated positives of the Saudi Land bridge and identifying the costs that are possible to quantify to subtract it from the benefits. After finalizing this step, the ending result from subtracting the costs from the benefits will give a clear

idea whether the Saudi Land Bridge has a positive or a negative net profit. This would be the main drive of deciding that this mega project should be implemented or not.

2.3 Cost-Benefit Analysis in Infrastructure Projects

The business case of any project, especially the infrastructure ones, is the tool that decision makers rely on when trying to anticipate future outcomes of that project, taken in consideration the cost benefit analysis with its potential economic, environmental, social benefits and costs, and the timeline that involves the potential risks. The cost benefit analysis main purpose is evaluating the economic benefits and costs of the project with a wider look over its lifetime (Grimes, 2010). If the calculations of benefit-cost ratio (BCR) turned out to be more than one, then analysts with a bit of confidence would be able to say that this project have a positive net profit. Cost-benefit analysis of infrastructure projects considers the net benefit of it to the community, it can help decrease doubt in making decisions as it simplifies the benefits and costs of a project. It can also set ground for the consideration of other replacements to the project.

One of the essential ideas to be aware of when practicing cost-benefit analysis is that it is not a fixed procedure. The process relay deeply on how the individual analysts would handle setting weights for different benefits and costs and recruiting their professional judgment and decisions when it comes to the development alternatives that should be considered. Not forgetting to use all the useful data and technology that are already available (Boardman et al., 2017). There are many other tools used in the decision making for investment based mega projects beside the cost-benefit analysis. But what makes it more comprehensive is its involvement of implementing a wide arranged evaluation of the possible impacts of the project from the economic side and its effect on communities. It has a wider look beyond the financial gains of a group of investment. It highlights the positive and negative side of a project (Jones et al., 2014). The intent of the cost-benefit analysis approach is simplified by the idea that all effects are

transformed into the present dollar value of the project. Even for big infrastructure projects where the translation to money value of all benefits is challenging, cost-benefit analysis is still a useful tool in decision making.

2.4 The Transcontinental Trail (The Pacific Railroad).

The Pacific railroad, the first transcontinental railroad that was built in the United States back in 1869. It connected the West side of America with the east. it was constructed by both central Pacific railroad and the Union Pacific Railroad, it would meet the existing network on the eastern coast of America Connecting it to the Pacific Coast of the United States. And for that reason, this line got its nickname the Overland Route (UPRR names, 2010).

This infrastructure project was operated by the government, and to afford the costs of the construction the government issued 30-year bonds, as well as providing government owned lands to contractors. It was considered a great achievement for the two companies involved in the construction, Union Pacific constructing from Iowa to the West, and central Pacific taking over from California to the east.

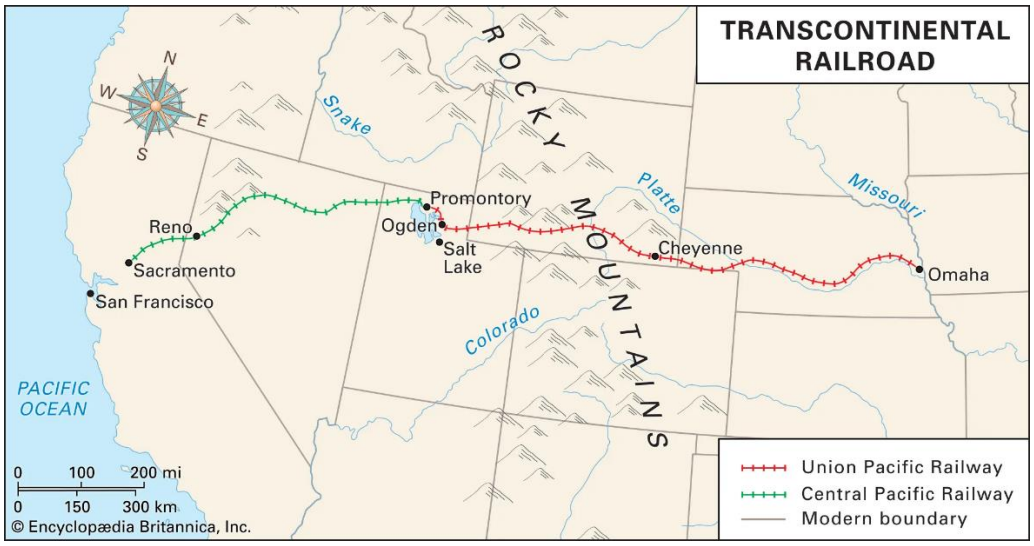

Figure 2. The transcontinental railroad (UPRR, 2020)

The transcontinental railroad made huge impact in changing the population and the economic trade of the American West. The idea was that the West was the land of dreams and where achievements could be made, especially with the gold rush back in 1849 (Daggett Stuart, 1908).

The Pacific railroad is one of America's greatest accomplishments of the 19th century, along with building the Erie Canal. It was an important connection to the West of America for goods exchange and travel, it gave a fast and safe path for Americans to set their campus West over land. The more traveling was easy the more it brought with it lumber end harvests from the east. providing a healthier environment for building homes, creating business opportunities, therefore establishing towns and cities.

The building of the railroad also helped improve the communication methods back then, the manufacturing companies started sitting telegraph lies on the way they were building the railroad, giving these lines the advantage of being easily repaired and protected.

The amount of money and sweat put in this project was huge considering the area that was covered, The Union Pacific managed to lay down around 1087 miles off track. The central Pacific covered less than 690 miles, and they were connected at Promontory Summit in Utah (Cooper, 2005).

Another interesting fact is that the Union Pacific part of the transcontinental railroad did not connect to the existing rail network in the east of the United States. At first to be able to get a train from the East Coast of the states to the West Coast a ferry had to be used for the train across the Missouri River. that was the only way until the Missouri River bridge was opened in 1873.

2.5 Adelaide-Darwin Railway

A study published by the South Australian Center of Economic Studies talks in depth about another big infrastructure project that took place in Australia (Andrew Symon, 2004). Darwin city, or what Australians like to call the getaway to Asia, is located on the northern side of the Australian continent making its seaport the closest to executing trades with the Asian markets in the north. This trading idea was a dream up until 2004 when the 1430 km railway connecting Darwin to the existing rail network at Alice Springs in the center of Australia.

This $1.3 billion project provided a huge improvement for the freight transport from all over the Australian major cities located in the south and east side of the country to Darwin in the Northern Territory. It is now within reach for passengers to travel from Perth in the West and Brisbane and Sydney in the east across the country all the way to the north passing through Melbourne and Adelaide. The railway was constructed by both the private sector and the Commonwealth governments.

Now with that land bridge in place It would enable a fast and more cost-effective shipment transport than the other methods for containerized imports and exports to the South region of Australia and to both western and eastern costs. In the present time there are two shipping providers connecting

Darwin to Singapore operated by the Swire group, along with Northern Territory company and Perkins Shipping which provides its services to Jakarta in Indonesia and port Klang in Malaysia.

Tourism also had its share from this project with the high demand for services of the Darwin Adelaide railroad, Railway operators anticipated that an additional 30,000 local and international visitors to the northern side of the country choose to visit there by train.

A report prepared by the Northern Territory Government on the Northern Territory economy and tourism estimates that the services provided by the company operating the north south train Great Southern Railway (GSR) introduces an additional economic activity that could reach around $1 billion, 300 million of which are related to the tourism sector and creating between 700 and 1000 jobs (Great Southern Railway, 2006).

Figure 3. Adelaide-Darwin Railway (All about Australia, 2020)

The suppliers in the South would also take advantage from this railroad since it provides a more safe and easy access to the demand growing up in the northern coast, it should also motivate the suppliers in the eastern cities to move their distribution points to the South, especially when the transit time using the railroad for moving goods would take around 43 hours compared to moving it using trucks which would take 54 to 66 hours. This movement would benefit the southern region economically by providing a wide range of business opportunities and tourism expansion as mentioned earlier. (Andrew Symon, 2004).

2.6 The Saudi North Railroad

In May 2011 Saudi Arabia Railways (SAR) finished the constructions of one of the biggest railroad projects, the north railroad connecting the capital of Saudi Arabia to the northern border with a cost of $6.6 billion that covered the construction of 6 train stations, 3 train carts maintenance shops, 36 railroad maintenance stations and purchasing 6 passengers trains along with 2000 transportation tanks and carts (Maaal, 2016). This project consists of two railroad lines, the minerals line going from Aljalamid mine far up north to Alba'aitha mine and continues to the end point where the factories and facilities for processing and exporting are located at Ras-Azzawr industrial city on the coast of the Arabian gulf covering more than 1000 mile.

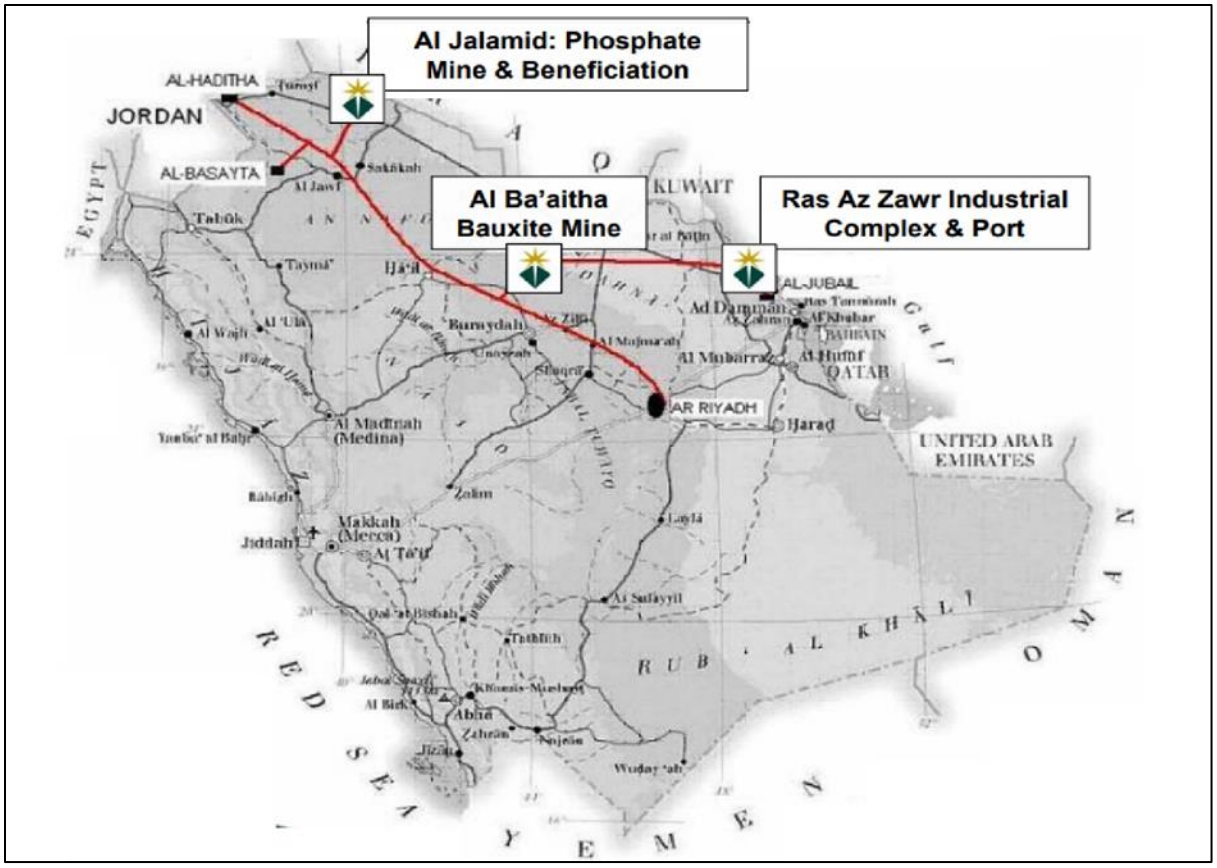

Figure 4. North Railroad (Ma'aden, 2012)

The first trip from Aljalamid's phosphate mines to Ras-Azzawr had a carrying capacity of 16,000 tons which is equivalent to 650 truckloads, and the Bauxite train that runs from Alba'aitha mine to Ras-Azzawr had another 11,000 tons. These railroads had a huge impact in decreasing the use of trucks on the highways between the raw materials mines and refinery factories on the East Coast. The total materials moved using the north train since the beginning of its use until October 2016 was about 17 million tons which in term of truckloads equal to 680,000 trucks which would result in the saving of more than 1.2 million barrels of diesel (Maaal,2016). SAR now is planning to extend its fleet to carry more than 10,000 tons of molten sulfur and phosphoric acid on a daily basis using the north railroad, which would remove about 1000 trucks off the roads each day.

The second passenger railroad goes from Riyadh heading north to Al Qrayat city Just before the Jordanian border, passing through four major cities, Al Majma'ah, Al Qassim, Hail and Al Jouf, covering around 800 miles.

Some of the goals of the north train according to the Saudi transport minister statement is its contribution in improving the safety level and lowering the accidents rates on highways along with providing transport solutions between the center of the Kingdom and its northern side with the current existing highways and flight routes. Increasing the quality of life in the cities that train passes through is one other advantage and would act as an economic incentive for investors to practice their trade activities outside of the capital city (Aljazeera, 2017).

2.7 Preview

At the end of this chapter the importance of the cost benefit analysis was discussed to show the big effect of this analysis on decision makers specially when dealing with mega infrastructure projects. Also, the social and economic impact of the construction of railroads whether it's for passenger transportation or the movement of goods. Railroads provide a safe, environment friendly and cost-efficient method of transport that would result in creating more job and business opportunities.

III. Methodology

3.1 Chapter Overview

In this chapter a wider look is taken over the methodology of this research. To be able to make an accurate judgment on the profitability of the Saudi land bridge project, the research should answer a set of questions through a qualitative method using the available data, with this approach the study will highlight the problems it would come across, provide possible solutions, and pave the way for additional research paths related to the main subject. The final result of this study will increase the certainty for the decision makers to either continue with the Saudi land bridge project or not.

3.2 Methodology

There are many factors this research needs to be focusing on when applying the cost benefit analysis for the Saudi land bridge. First by defining the primary costs and benefits related to this project, this step would be used in defining the benefits and costs into a monetary value which important for later calculations to determine the net benefit of the Saudi land bridge project. Having a clear understanding of the benefits and costs in terms of a dollar value, the total costs will be eliminated from the total benefits in order to have the net profit of the project. assuming that a perfect market condition is applied in this study, meaning that any non-market costs and benefits will not be considered in this research. Another factor needs to be considered after the previous sequence of steps would be applying the appropriate discount rate, this would show the effect of the time spent on this project from the start point until the project is finished and ready to be used to the money value invested in the land bridge at the beginning. Once all the calculations in place then it would be feasible to determine the cost benefit ratio along with the payback time.

3.3 Data Collection

The more the data collected for any research are rich and reliable the more the data driven decisions resulting from the research are accurate and dependable. The data used in this study were collected from previous related studies, official publications, news articles, official's statements through trustworthy media channels and conducting an interview with one of the Saudi Railway Company representatives.

3.4 Interview

When dealing with a huge infrastructure project like the Saudi land bridge it's important to get a clear idea about the operational costs of it. There comes the need to arrange for a conference call in order to interview Mr. Ashraf Aljabry, Maintenance Manager at the Saudi Railway Company (SAR) and get the answers for the following questions:

1- When talking about a big railway project like the Saudi land bridge it would be beneficial to have an understanding about the current existing railway network. Therefore, what's was the latest maintenance contract SAR has signed recently to support its fleet?

2- The land bridge is going to be covering a wide area passing through many stations along its way, so what are the expected maintenance jobs to be performed?

The answers to the previous questions will be provided in the next chapter along with the results of this study.

3.5 Preview

In this chapter, a simplified explanation of the research methodology was presented along with the data used and its sources to achieve the study results, which would be the main focus of this paper in the next chapter.

IV. Analysis and Results

4.1 Chapter Overview

The final results of this qualitative research about the cost benefit analysis of the Saudi land bridge will be presented in this chapter. The findings and results will be used to answer the study questions presented at the beginning of this paper.

4.2 The Process of Cost-Benefit Analysis

This research started with a wide understanding of the problems generated when looking to this project from an investor point of view and the background of it in order to be able to focus the effort on the key factors of the cost benefit analysis of the Saudi land bridge, leading to an outcome for the cost benefit ratio to be more than 1 when dividing the benefits after being discounted by the discounted total costs. Having a positive net benefit indicates that the benefits generated from the Saudi land bridge are more than the costs invested in the creation of this infrastructure project.

The first stage consists of highlighting the goals of the project. The Saudi land bridge project is expected to act as a huge booster to the transportation capability of the Kingdom. Allowing a safe and fast transport of imported cargos whether from East Asian countries vie King Abdulaziz seaport in Dammam or from Europe and North America via Jeddah Islamic port. Also lowering the dependence on the current method used of transporting goods by trucks which would lead to a significant decrease in fuel consumption and not having to maintain highways as frequent as it used to be, removing this huge number of trucks from highways would make it safer for other travelers when truck related accidents are eliminated, saving more lives and putting hospital beds to a better use. A project of this size will positively impact the job market creating many opportunities not only in one city but in many regions of the country.

The second stage is exploring the obstacles and constraints that this project might face. Starting with the financial limitations that the projects budget could encounter, managerial constraints which could extend from navigating for the proper expertise to execute this project to securing sufficient manpower to do the job specially when talking about aggressive weather conditions. The railroad path also will overcome many terrain difficulties specially when approaching the west side of the country where the highest mountains in the Kingdom are located.

The third stage would be providing other alternatives beside building the Saudi land bridge. Providing choices with detailed explanation to the decision makers to choose the best alternative and go with it. And in this study choosing not to build the Saudi land bridge or the "Do nothing" would be the other alternative.

The fourth stage is calculating the primary direct benefits and costs of the Saudi land bridge, the direct benefits in this case would be the additional fuel savings in the current costs of shipping goods in the Kingdom of Saudi Arabia, and the tickets sales of this new method of transportation. And the direct costs would be the initial amount invested in this project along with the continuous maintenance and operational costs.

The fifth stage will include using a computer spreadsheet to simplify the calculations needed to determine the break-even point in years and other significant results using the acquired information about the direct costs and benefits.

4.3 Data Preparation

4.3.1 The Direct Benefits of the Project

There are two direct benefits considered in this study, The savings in the costs of freight transportation when using the land bridge and the passenger's tickets sales.

- **Cost savings when shipping goods using the proposed railroad.**

In 2017 the total weight of shipments moved on land between Riyadh city the capital of Saudi Arabia in the central region and the seaports on the coast of the Red Sea in the western region was (11.16) million metric tons, using only trucks which consumes primarily diesel. On the other side the current existing railroad between Riyadh and Dammam city on the coast of the Arabian gulf in the east is used to move 80% of the packed shipments between the eastern region and the capital city.

Applying this percentage to the amount of moved shipments between the central and the western region Using the Saudi land bridge shows that (8.93) million metric tons would benefit from this new transport method allowing a 13% reduction in the total fuel consumption used in the existing shipping methods, shifting it from 87,445,176 BOE (barrels of oil equivalent) to 76,441,076 BOE (KAPSARC, 2020). saving about $733 million each year when using the average oil price from the last ten years which is $66.57 per barrel. (MACROTRENDS, 2022).

- **Tickets fare**

In 2021 Crown Prince Mohammed bin Salman announced the new national strategy for transport and logistics services aiming to position the Kingdom as a logistic center that connects the three continents by improving the current means of transport across the country. One of many projects mentioned in this strategy was the Saudi land bridge where the Crown Prince highlighted that this project would have the capacity to serve 3 million travelers per year. (Alnaql, 2021).

To have a better understanding of how much the sales profit of this project would be a comparison needs to be made between the Saudi land bridge and the current existing railway between Riyadh and Dammam City. A report published by the Saudi press agency stated that in 2019 the Saudi general corporation of railways provided transport on its trains between Riyadh and Dammam to 1.8 million passengers. (SPA, 2020). knowing that each train capacity of that fleet is 288 passengers divided into 94 passengers in first class and 194 passengers in economy class charging $77.3 for first class and $45.3 for economy, knowing that all of Saudi Arabia Railways (SAR) fleet of passenger's trains have the same configurations, almost 30 percent of passengers are in first class and 60 percent are in economy. By multiplying the(0.3) and (0.6) factors to each class fare and combining the results will show that the amount paid in total if divided by each passenger would be $50.37 for the whole trip covering 449 kilometers, which means that each kilometer would cost each passenger about $0.112.

from the previous calculations an estimation could be made for the ticket fare on the trains using the Saudi land bridge by multiplying $0.112 by the distance traveled from Riyadh to Jeddah which is 950 kilometers.

Estimated Fare = 0.112 Dollar per Km X 950 Km = $106.4

Considering the importance of Mecca city, especially in the pilgrimage season where around 2.5 million pilgrims arrive to the holy city only in this season, and Jeddah city being the second largest city in the Kingdom after the capital, it would be fair to consider that the passenger trains would operate at its maximum announced capacity of three million passengers per year.

The direct benefits from tickets fare = $106.4 X 3,000,000 = $319,200,000

Table 1. Direct Benefits

Benefit	Value
Oil cost savings when moving shipments using the land bridge.	$732,542,937
Tickets fare	$319,200,000

4.3.2 The Direct Costs of the Project

There are two direct costs considered in this study, The initial construction amount invested in this project and the operational and maintenance costs.

- **Initial Investment**

Based on the average cost of constructing railroads in the Kingdom of Saudi Arabia estimated by around $11 million per one kilometer of railroad (KAPSARC, 2020) The Saudi land bridge initial cost would be $11 billion, the Saudi land bridge is going to be an EPC (Engineering, Procurement, and Construction) project based on specific details stated in the contract where the contractor will provide labor, materials, equipment and all other expenses through one agreement to deliver the project over a period of 6 years in exchange for a fixed price.

- **Operational and maintenance costs**

The Chief Executive Officer at Saudi Arabia Railways (SAR) Dr. Bashar bin Khalid Almalik during an interview in 2021 on the Saudi news channel explained that the railroad industry all over the world in general and between cities to be specific is a difficult sector that consumes a lot of its financial resources, and if we are looking into the direct profit returns from the railroad investment around the globe we can see that it doesn't make any profit and it's being supported by governments, and the Kingdom of Saudi Arabia isn't an exception in this matter. But when we look to this sector as

an enabling tool to many other different industry sectors it is noticeable that the indirect benefits from it is very high. Dr. Almalik stated that each one US dollar invested in the Saudi railroad industry has a $3.4 in return as both direct and indirect profit, like providing job opportunities, help establishing simple industry opportunities along the way of the railroad, minimizing the costs of maintaining highways when removing high percentage of trucks that are being used nowadays in moving shipments which will lead to an increase in the safety levels on the roads raising the available operational capacity in hospitals by clearing more beds for a better use, and many other indirect benefits. Dr. Almalik mentioned that the proposed Saudi land bridge project could cost when talking about its annual operational and maintenance costs about $400 million.

Table 2. Direct Costs

Cost	Value
Initial Investment	$11,000,000,000
Maintenance & Operation	$400,000,000

4.3.3 Discount Rate for Saudi Arabia

The discount rate refers to the interest rate used in discounted cash flow (DCF) analysis to determine the present value of future cash flows. In Saudi Arabia the average interest rate between 1992 and 2022 is 3.5 percent, reaching its maximum of 7 percent in 2000 and its minimum of 1 percent in 2020 (Trading Economics, 2022).

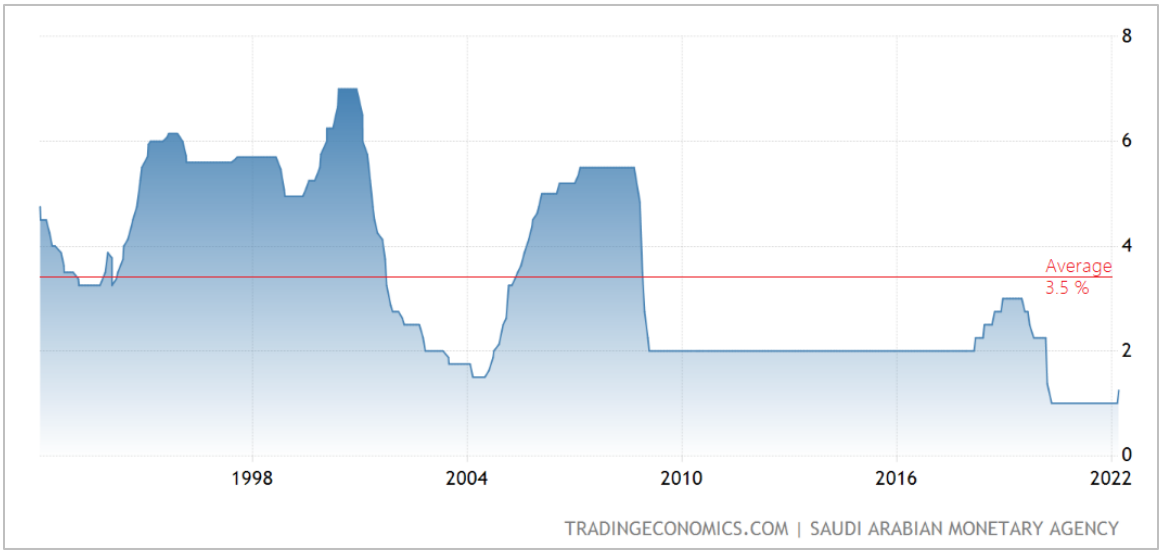

Figure 5. Saudi Arabia Interest Rate from 1992 until 2020 (Trading Economics, 2020)

4.4 Results

Running the calculation for 50 years in the future while taking in consideration the initial investment cost, the annual cost, and both two sources of direct benefit mentioned earlier and applying the interest rate of 3.5% to reveal that the Net Present Value of Benefits will be $19,065,012,425 and the Net Present Value of Costs will be $18,250,825,940 resulting in a DBCR (Discounted Benefit-Cost Ratio) of 1.04461 and a Payback Period of 44 Years.

Table 3. Analysis Results

Based on calculations for 50 years from signing the contract	
Net Present Value of Benefits	$19,065,012,425
Net Present Value of Costs	$18,250,825,940
Discounted Benefit-Cost Ratio	1.04461
Payback Period	44 Years

4.5 Preview

In this chapter, both direct benefits and costs were calculated and presented. Additionally, the net present values, the DBCR and the period of time the project will take to be profitable were calculated. Chapter V will add some closing thoughts, answers to the research questions from the first chapter, and suggested topics for future studies.

V. Conclusions and Recommendations

5.1 Chapter Overview

A summary of the study that has been conducted is presented in this chapter. Addressing the highlighted questions from previous chapters and concluding this research with the recommended study topics for future research.

5.2 Conclusion of Research

The Saudi Land bridge will be a qualitative leap for the logistics sector in the Kingdom, leading it towards globalization, with regard to the transport of goods between the world's continents, especially in the current supply chain crisis.

The distinguished geographical location of Saudi Arabia and the huge infrastructure that it possesses, including seaports and airports, qualifies it to be a leader in the logistics sector regionally and globally.

This study's goal is to investigate the primary benefits and costs of building the Saudi Land Bridge in order to assess the project's viability. The DBCR is computed by dividing the project's total net present value of benefits by its entire net present value of expenses.

The Saudi Land Bridge DBCR was found to be 1.045. making it a long-term investment with around 44 years of operation to be profitable. But on the other hand, looking at the bigger picture, railways are not meant to be profitable but rather, to serve for the greater good by enabling business, industry, environment and, in general, a better lifestyle for the country. Taking all these considerations together, the nation becomes a wealthier place. Therefore, the undertaking of the project is recommended since it will benefit society more than it will cost by enhancing the economic and social conditions of the Kingdom and helping many other fields of industry to conduct its business more efficiently.

5.3 Investigative Questions Answered

1. ***The project's break-even stage must be reached within what amount of time?***

When all costs and benefits mentioned earlier are equal, based solely on direct benefits and costs, the project will take 44 years to reach the break-even point.

2. ***The Saudi Land Bridge is predicted to provide a number of indirect advantages. What are these?***

Many indirect benefits will result from the Saudi Land Bridge, specially to the capital city Riyadh by making it one of the biggest logistical centers in the middle east when linked to the commercial capital city Jeddah in the west and the oil exporting ports in the east, lowering the time spent in shipping from 5 days to 72 hours and eliminate dealing with the Iranian threats of blocking strait of Hurmuz the only way out to the international waters for ships leaving from the Arabian gulf.

The Saudi Land Bridge will provide a more efficient method of transporting goods across the country that will have a direct positive affect on industry operations by allowing the existence of new factories along the path of the railroad, leading to additional economic growth, and creating many job opportunities.

Another indirect benefit would be improving the safety levels on highways by reducing the need of trucks, causing in a lower maintenance cost for the roads and minimizing accidents rates and maintaining a higher hospitals capacity to serve the public. Also having a positive environmental impact by reducing the carbon dioxide emissions.

3. ***What are the potential indirect costs and obstacles in this project?***

The noise and vibrations generated from railways plus the air pollution and soil destruction all cause disturbance to the wildlife. noise can irritate wild animals while contaminants in soil may have an impact on desert plants. Moreover, the presence of railways causes wild animals to stay away from the area create imbalance in the diversity and quantity of some animal species.

The presence on a new travel mean could affect the demand on the current transportation flight routes between the three biggest cities in the kingdom, possibly lowering the flights count and impacting the operating airways business.

5.4 Recommendations for Future Research

Suggestions of related study topics for future research:

1. Measuring the effect of imposing more fuel fees in the transformation to this new method of transport.
2. Analysis of the impact of launching the Saudi Land bridge on highways accidents rate.
3. Identifying the economic value of the Saudi railway network if expanded to southern region of the country.
4. Quantifying the environmental impact of lower emissions when using the Saudi land bridge.

Appendix A. Data Results

Cost Analysis of The Saudi Landbridge

Initial Investment	$11,000,000,000
Annual M&O Costs	$400,000,000
Discount Rate	3.50%

Present Value of Total Costs	$18,250,825,940.34

Year	Initial Investment	M&O	Total Cost	Annual P.V of Costs	Accumulated Annual Costs
0	$11,000,000,000	$0	$11,000,000,000	$11,000,000,000.00	$11,000,000,000.00
1	$0	$0	$0	$0.00	$11,000,000,000.00
2	$0	$0	$0	$0.00	$11,000,000,000.00
3	$0	$0	$0	$0.00	$11,000,000,000.00
4	$0	$0	$0	$0.00	$11,000,000,000.00
5	$0	$0	$0	$0.00	$11,000,000,000.00
6	$0	$0	$0	$0.00	$11,000,000,000.00
7	$0	$400,000,000	$400,000,000	$314,396,384.27	$11,314,396,384.27
8	$0	$400,000,000	$400,000,000	$303,764,622.49	$11,618,161,006.76
9	$0	$400,000,000	$400,000,000	$293,492,388.88	$11,911,653,395.64
10	$0	$400,000,000	$400,000,000	$283,567,525.48	$12,195,220,921.12
11	$0	$400,000,000	$400,000,000	$273,978,285.49	$12,469,199,206.61
12	$0	$400,000,000	$400,000,000	$264,713,319.32	$12,733,912,525.93
13	$0	$400,000,000	$400,000,000	$255,761,661.17	$12,989,674,187.10
14	$0	$400,000,000	$400,000,000	$247,112,716.11	$13,236,786,903.21
15	$0	$400,000,000	$400,000,000	$238,756,247.45	$13,475,543,150.66
16	$0	$400,000,000	$400,000,000	$230,682,364.69	$13,706,225,515.35
17	$0	$400,000,000	$400,000,000	$222,881,511.77	$13,929,107,027.12
18	$0	$400,000,000	$400,000,000	$215,344,455.82	$14,144,451,482.94
19	$0	$400,000,000	$400,000,000	$208,062,276.15	$14,352,513,759.10
20	$0	$400,000,000	$400,000,000	$201,026,353.77	$14,553,540,112.87
21	$0	$400,000,000	$400,000,000	$194,228,361.13	$14,747,768,474.00
22	$0	$400,000,000	$400,000,000	$187,660,252.30	$14,935,428,726.31
23	$0	$400,000,000	$400,000,000	$181,314,253.43	$15,116,742,979.74
24	$0	$400,000,000	$400,000,000	$175,182,853.56	$15,291,925,833.30
25	$0	$400,000,000	$400,000,000	$169,258,795.71	$15,461,184,629.00
26	$0	$400,000,000	$400,000,000	$163,535,068.32	$15,624,719,697.32
27	$0	$400,000,000	$400,000,000	$158,004,896.92	$15,782,724,594.24
28	$0	$400,000,000	$400,000,000	$152,661,736.16	$15,935,386,330.40
29	$0	$400,000,000	$400,000,000	$147,499,261.99	$16,082,885,592.39
30	$0	$400,000,000	$400,000,000	$142,511,364.24	$16,225,396,956.63
31	$0	$400,000,000	$400,000,000	$137,692,139.36	$16,363,089,096.00
32	$0	$400,000,000	$400,000,000	$133,035,883.44	$16,496,124,979.44
33	$0	$400,000,000	$400,000,000	$128,537,085.45	$16,624,662,064.89
34	$0	$400,000,000	$400,000,000	$124,190,420.73	$16,748,852,485.62
35	$0	$400,000,000	$400,000,000	$119,990,744.66	$16,868,843,230.28
36	$0	$400,000,000	$400,000,000	$115,933,086.63	$16,984,776,316.91
37	$0	$400,000,000	$400,000,000	$112,012,644.09	$17,096,788,961.00
38	$0	$400,000,000	$400,000,000	$108,224,776.90	$17,205,013,737.90
39	$0	$400,000,000	$400,000,000	$104,565,001.83	$17,309,578,739.73
40	$0	$400,000,000	$400,000,000	$101,028,987.28	$17,410,607,727.01
41	$0	$400,000,000	$400,000,000	$97,612,548.09	$17,508,220,275.10
42	$0	$400,000,000	$400,000,000	$94,311,640.67	$17,602,531,915.77
43	$0	$400,000,000	$400,000,000	$91,122,358.14	$17,693,654,273.91
44	$0	$400,000,000	$400,000,000	$88,040,925.74	$17,781,695,199.65
45	$0	$400,000,000	$400,000,000	$85,063,696.36	$17,866,758,896.01
46	$0	$400,000,000	$400,000,000	$82,187,146.24	$17,948,946,042.25
47	$0	$400,000,000	$400,000,000	$79,407,870.77	$18,028,353,913.02
48	$0	$400,000,000	$400,000,000	$76,722,580.45	$18,105,076,493.47
49	$0	$400,000,000	$400,000,000	$74,128,097.05	$18,179,204,590.53
50	$0	$400,000,000	$400,000,000	$71,621,349.81	$18,250,825,940.34

Benefits Analysis of The Saudi Landbridge

Shipping Costs Savings	$732,542,937
Tickits Fare	$319,200,000
Discount Rate	3.50%

Present Value of Total Benefits	$19,065,012,425.41
Present Value of Total Costs	$18,250,825,940.34

DBCR	1.04461

Year	Shipping Costs Savings	Tickits Fare	Total Benefits	D. P.V. of Benefits	Accumulated Annual Benefits
0	$0	$0	$0	$0.00	$0.00
1	$0	$0	$0	$0.00	$0.00
2	$0	$0	$0	$0.00	$0.00
3	$0	$0	$0	$0.00	$0.00
4	$0	$0	$0	$0.00	$0.00
5	$0	$0	$0	$0.00	$0.00
6	$0	$0	$0	$0.00	$0.00
7	$732,542,937	$319,200,000	$1,051,742,937	$826,660,441.45	$826,660,441.45
8	$732,542,937	$319,200,000	$1,051,742,937	$798,705,740.53	$1,625,366,181.97
9	$732,542,937	$319,200,000	$1,051,742,937	$771,696,367.66	$2,397,062,549.63
10	$732,542,937	$319,200,000	$1,051,742,937	$745,600,355.23	$3,142,662,904.86
11	$732,542,937	$319,200,000	$1,051,742,937	$720,386,816.64	$3,863,049,721.50
12	$732,542,937	$319,200,000	$1,051,742,937	$696,025,909.80	$4,559,075,631.30
13	$732,542,937	$319,200,000	$1,051,742,937	$672,488,801.74	$5,231,564,433.04
14	$732,542,937	$319,200,000	$1,051,742,937	$649,747,634.53	$5,881,312,067.57
15	$732,542,937	$319,200,000	$1,051,742,937	$627,775,492.30	$6,509,087,559.87
16	$732,542,937	$319,200,000	$1,051,742,937	$606,546,369.37	$7,115,633,929.24
17	$732,542,937	$319,200,000	$1,051,742,937	$586,035,139.49	$7,701,669,068.73
18	$732,542,937	$319,200,000	$1,051,742,937	$566,217,526.08	$8,267,886,594.81
19	$732,542,937	$319,200,000	$1,051,742,937	$547,070,073.50	$8,814,956,668.31
20	$732,542,937	$319,200,000	$1,051,742,937	$528,570,119.33	$9,343,526,787.64
21	$732,542,937	$319,200,000	$1,051,742,937	$510,695,767.47	$9,854,222,555.11
22	$732,542,937	$319,200,000	$1,051,742,937	$493,425,862.29	$10,347,648,417.40
23	$732,542,937	$319,200,000	$1,051,742,937	$476,739,963.56	$10,824,388,380.96
24	$732,542,937	$319,200,000	$1,051,742,937	$460,618,322.28	$11,285,006,703.24
25	$732,542,937	$319,200,000	$1,051,742,937	$445,041,857.28	$11,730,048,560.52
26	$732,542,937	$319,200,000	$1,051,742,937	$429,992,132.64	$12,160,040,693.15
27	$732,542,937	$319,200,000	$1,051,742,937	$415,451,335.88	$12,575,492,029.03
28	$732,542,937	$319,200,000	$1,051,742,937	$401,402,256.89	$12,976,894,285.92
29	$732,542,937	$319,200,000	$1,051,742,937	$387,828,267.53	$13,364,722,553.45
30	$732,542,937	$319,200,000	$1,051,742,937	$374,713,301.96	$13,739,435,855.40
31	$732,542,937	$319,200,000	$1,051,742,937	$362,041,837.64	$14,101,477,693.04
32	$732,542,937	$319,200,000	$1,051,742,937	$349,798,876.95	$14,451,276,569.99
33	$732,542,937	$319,200,000	$1,051,742,937	$337,969,929.42	$14,789,246,499.40
34	$732,542,937	$319,200,000	$1,051,742,937	$326,540,994.61	$15,115,787,494.01
35	$732,542,937	$319,200,000	$1,051,742,937	$315,498,545.51	$15,431,286,039.52
36	$732,542,937	$319,200,000	$1,051,742,937	$304,829,512.57	$15,736,115,552.09
37	$732,542,937	$319,200,000	$1,051,742,937	$294,521,268.19	$16,030,636,820.28
38	$732,542,937	$319,200,000	$1,051,742,937	$284,561,611.77	$16,315,198,432.05
39	$732,542,937	$319,200,000	$1,051,742,937	$274,938,755.34	$16,590,137,187.39
40	$732,542,937	$319,200,000	$1,051,742,937	$265,641,309.50	$16,855,778,496.89
41	$732,542,937	$319,200,000	$1,051,742,937	$256,658,270.05	$17,112,436,766.95
42	$732,542,937	$319,200,000	$1,051,742,937	$247,979,004.88	$17,360,415,771.83
43	$732,542,937	$319,200,000	$1,051,742,937	$239,593,241.43	$17,600,009,013.26
44	$732,542,937	$319,200,000	$1,051,742,937	$231,491,054.52	$17,831,500,067.78
45	$732,542,937	$319,200,000	$1,051,742,937	$223,662,854.61	$18,055,162,922.40
46	$732,542,937	$319,200,000	$1,051,742,937	$216,099,376.44	$18,271,262,298.83
47	$732,542,937	$319,200,000	$1,051,742,937	$208,791,668.05	$18,480,053,966.89
48	$732,542,937	$319,200,000	$1,051,742,937	$201,731,080.25	$18,681,785,047.13
49	$732,542,937	$319,200,000	$1,051,742,937	$194,909,256.28	$18,876,694,303.41
50	$732,542,937	$319,200,000	$1,051,742,937	$188,318,122.01	$19,065,012,425.41

Calculations

Y : the year over which the costs and benefits of the project were analyzed and starts from 0 to 50.

BY : the benefits of the project in the year Y.

CY : the costs of the project in the year Y.

RD : the rate of discount.

First, applying the discount rate to benefits and costs in each year in the future.

discounted benefits calculated as: $\frac{(B_Y)}{(1+R_D)^Y}$

discounted costs calculated as: $\frac{(C_Y)}{(1+R_D)^Y}$

The formula used to calculate the discounted cost-benefit ratio is:

$$\text{DCBR} = \sum \frac{(B_Y)}{(1+R_D)^Y} \div \sum \frac{(C_Y)}{(1+R_D)^Y}$$

Then, the payback period can be calculated by subtracting the cash flow of benefits from the cash flow of costs until achieving balance, that's when the payback period would be reached.

Appendix B. Interview

The following interview made with Mr. Ashraf Aljabry, Maintenance Manager at the Saudi Railway Company (SAR):

1- When talking about a big railway project like the Saudi land bridge it would be beneficial to have an understanding about the current existing railway network. Therefore, what's was the latest Maintenance contract SAR has signed recently to support its fleet?

Back in 2018 SAR has awarded a two-year contract with an amount of $350 million to its partner (THALES) to support the freight and passenger's north train. the contracts involves both corrective and preventative maintenance operations allowing SAR to maintain an intact infrastructure to conduct its business safely and properly in addition to enhance the performing of the current engines used and providing support to the 6 train stations along the route.

2- The land bridge is going to be covering a wide area passing through many stations along its way, so what are the expected maintenance jobs to be performed?

The expected maintenance jobs could be daily tasks before each trip like checking the four engines in each train monitoring heat levels and inspecting for unusual vibrations or leakage in the hydraulic brake systems, also inspecting the wheels thickness making sure it is within the allowable limits and of course washing the whole train before each trip.

There are also deep maintenance procedures like scheduled corrosion and cracks inspections in addition to the periodic checks for the electronic signaling systems. the rail tracks unless there is something reported by the train driver during a trip could take up to three years between inspection except the process of removing sands from the track which could be repeated up to 6 times a year per track depending on the

severity of the Sand encroachment, keeping in mind that each new track before allowing passengers train to travel on it goes under four months of daily testing.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
15-09-2022	Master's Thesis	January 2021 - September 2022

4. TITLE AND SUBTITLE
COST-BENEFIT ANALYSIS OF THE SAUDI LAND BRIDGE PROJECT

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Faris Alotaibi, Capt, RSAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way
Wright-Patterson AFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT-ENS-MS-22-S-054

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Intentionally Left Blank

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A.
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES
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14. ABSTRACT
The Saudi land bridge project will cost about $11 billion and will provide a new link between the existent railway in the eastern region to the west of the kingdom all the way to Jeddah Islamic seaport right on the red sea. The goal of this research is to perform a cost-benefit analysis of the new Saudi land bridge project, by studying all the data available to determine if the government of Saudi Arabia should proceed with this project or not.

15. SUBJECT TERMS
CBA, Saudi Land Bridge, Discounted Rates, Cost, Benefit, Railways, Shipping.

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Dr.William Cunningham, AFIT/ENS
					19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	UU	48	9372553636(4283)William.Cunningham@afit.edu