



**COST-BENEFIT ANALYSIS OF KING SALMAN CAUSEWAY
BETWEEN SAUDI ARABIA AND EGYPT**

THESIS

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AFIT-ENS-MS-20-S-032

**DEPARTMENT OF THE AIR FORCE
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Captain, Royal Saudi Air Force (RSAF)

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Abstract

Infrastructure projects are important in the economic development of countries as they boost economic growth by allowing mutual trade between nations. One infrastructure project that is aimed to increase trade operations between Saudi Arabia and Egypt is King Salman Causeway. The project is going to cost about \$4 billion and will establish closer links between the two countries, creating job opportunities for both Saudi and Egyptian citizens. The purpose of this research is to carry out a cost-benefit analysis of the causeway infrastructure project, by providing information to decide whether the project should be undertaken or not. The cost-benefit analysis will compare the costs involved in the project with the benefits that will be resulted after the project completion. It concludes that the project should be executed because the benefits that will come from the project exceed the costs that will be incurred in its construction.

To my country

To my parents

To my wife

To my kids

Acknowledgments

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Abdulrahman D. Alamri

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COST-BENEFIT ANALYSIS OF KING SALMAN CAUSEWAY BETWEEN SAUDI ARABIA AND EGYPT

I. Introduction

1.1 Background

Saudi Arabia is considering building a causeway that will link it to Egypt. The President of Egypt has suggested that the bridge be named King Salman bin Abdulaziz Bridge. The infrastructure project is estimated to cost about \$4 billion and will be primarily financed by the Kingdom of Saudi Arabia (Arab News, 2016). The causeway is going to provide a link between Tabuk and Sharm el-Sheikh, which is located on the Sinai Peninsula (Alarabia, 2020). It will go through the entrance of the Gulf of Aqaba in Tiran Island as shown in Figure 1. The Saudi Binladin Group announced that they are willing to work on the project with Arab Contractors, a firm that is run by the government of Egypt (Ahram Online, 2013). This proposed infrastructure project aims to establish closer links between Saudi Arabia and Egypt. This has the potential of creating many jobs for both Saudis and Egyptians. Moreover, King Salman Causeway will provide an alternative route for Hajj, and will serve millions of pilgrims and passengers every year.



Figure 1. King Salman Causeway Project (Neszmelyi, 2018)

In a 2016 visit to Egypt by King Salman, he announced together with President El-Sisi of Egypt an agreement to construct a causeway linking the two countries (BBC News, 2016). This announcement came after the two countries signed an agreement regarding the demarcation of maritime borders and the marking of the Sanafir and Tiran Islands within the regional waters of Saudi Arabia (Ahram Online, 2016). The length of the Saudi-Egypt Causeway is estimated to lead to trade revenues averaging \$200 billion every year (Middle East Monitor, 2018). One of the consultants of the project is the former Egyptian minister of transportation Ibrahim Eldmiri who said that the bridge will have a width of 36 meters and will have, on both directions, three road traffic lanes plus a two-track railway that has a width of 11.3 meters (Almasryalyoum, 2016). The route will be used for high-speed trains to ease transport between the two countries (Anderson, 2016).

King Salman of Saudi Arabia said the bridge is a historic step that would connect the continents of Asia and Africa and is a qualitative transformation that will lead to

increased trade between the two continents to levels that have not been witnessed before. El-Sisi, the President of Egypt, said that the depth of the ties between Egypt and Saudi Arabia would allow the countries to face mutual challenges (Aljazeera.com, 2016). He expressed optimism that the cooperation would help in resolving regional crises such as in Libya, Yemen, Syria, and Palestine. Linking the two countries will be an important step since Saudi Arabia is a top foreign investor in Egypt and has pledged to help it in meeting its needs for energy (Aljazeera.com, 2016).

1.2 Problem Statement

The construction of the King Salman Causeway is estimated to cost \$4 billion. Apart from the direct financial costs associated with the project, there is another cost associated with maintenance and operation. Besides the costs, the project will be associated with various benefits, which are the motivating factor for the government of Saudi Arabia in constructing it. It is going to ease transport between, not only Egypt and Saudi Arabia, but also the whole of Asia and Africa. It is also estimated to lead to a trade revenue of about \$200 billion every year. To know whether the project is viable, it is important to carry out a cost-benefit analysis to see whether the benefits that accrue from the project are greater than the costs that will be incurred in the construction of the bridge. This will be useful in making decisions on whether to continue with the project or not.

1.3 Research Objectives and Questions

The main objective of this research is to examine the benefits and the costs that are associated with the King Salman Causeway construction project to determine the viability of the project. In so doing, the costs that are associated with the project will be determined,

as well as the benefits that are likely to be realized from the project once it is completed. From that, the payback period and the net present value can be calculated. If the benefits outweigh the costs, the project is warranted. On the other hand, if the costs are more than the benefits, the project is not warranted.

The focus of this research is the use of cost-benefit analysis in evaluating the viability of a project. To do this, King Salman Causeway will be used as a case study. The paper will demonstrate the way cost-benefit analysis can be used for mega projects to determine whether their benefits exceed their costs. To determine the effectiveness of the project, the project's costs are contrasted with the expected benefits. The project will be compared to the King Fahd Causeway, which connects the Kingdom of Saudi Arabia and Bahrain.

The research questions are:

1. What is the time period that the project needs to reach the break-even point?
2. What are the indirect benefits that might be expected from building King Salman causeway?
3. What are the indirect costs and challenges that might be expected from building King Salman causeway?

1.4 Methodology

This research starts with brainstorming the direct benefits and costs. This step involves identifying the costs that will be incurred and the benefits that will come about in a project's lifetime. The second step will be to assign a monetary value to the costs and the benefits of the project. The last step involves comparing the costs and benefits. This

analysis will be used to determine the right course of action to take. This is done by calculating the total estimated costs and the estimated benefits and determining whether the benefits are more than the costs. At this stage, the payback time is determined to find out the length of time it will take for the break-even point to be reached.

1.5 Assumptions and Limitations

Due to the limited data, the main assumption in the cost-benefit analysis of King Salman Causeway is that the costs and benefits which will be calculated are only the direct ones, and they are going to come out as estimated. There are various limitations to this method of evaluating projects. The main limitation is imperfections in the market. This method would work best under conditions of markets that are perfectly competitive where there is a large number of buyers and sellers of whom none can dominate the market. However, it is hard to meet such a condition in the real markets. Monopolies exist, and there are governments whose interventions further cause distortions in the market. There is, therefore, a need to adjust prices before being used for CBA. Another limitation is that it is difficult to quantify intangibles.

1.6 Summary

This chapter provided an overview of the King Salman Causeway Project. Chapter II will review relevant researches in this area. Chapter III explains the methodologies used in this research. In Chapter IV, results and analysis will be conducted. Finally, Chapter V provides a summary of the research, conclusion and recommendations for future effort.

II. Literature Review

2.1 Chapter Overview

The building of bridges in the modern world is more than just the physical and economic inputs into it. Other things must be taken into consideration, such as its socio-economic impact, influence on the people, traffic, migration, the safety of construction, the usage of primary materials, environmental impacts, risk scenarios, energy, health, and carbon dioxide emissions and climate. All these are things that should be considered in decision-making at the conceptual level, the selection of the sites of bridges, the types of bridges, methods of construction, and the selection of products and materials (Ostenfeld & Andersen, 2011).

2.2 Cost-Benefit Analysis

The Cost-benefit Analysis (CBA) is a useful tool for comparing the benefits and costs of a project. It clarifies the size, nature, and timing of the benefits and costs of a project. It also covers both intangible and tangible items in addition to the wider benefits to the economy such as an agglomeration of externalities. The cost-benefit analysis also presents a good trade-off between the project's net present and future benefits through the discount rate that it chooses. The cost-benefit analysis process involves considering the total costs, both explicit and implicit, against the benefits that are likely to be realized from a project. This analysis explores, quantifies, and sums up all the positives of the project, that is, its benefits. It then identifies, quantifies, and subtracts the costs of the project. When this has been done, the difference that is found between the costs and the benefits indicates

whether the action planned has a net benefit or loss. This is the basis of making decisions on whether the project should be implemented or left.

2.3 Cost-Benefit Analysis in Infrastructure Projects

In infrastructure projects, makers of policy depend on appraisals of business case incorporating cost-benefit analysis. The business case states the project's business need with the assessment of the strategic fit of the project and its environmental, economic and social benefits costs, affordability and feasibility, and a delivery plan that considers potential risks. The cost-benefit analysis estimates the economic benefits and costs of the proposal during its lifetime (Grimes, 2010). If the Benefit-Cost Ratio (BCR) are greater than one, then the project is taken to have a net benefit to society. There is a difference between a financial evaluation and the cost-benefit analysis in that the cost-benefit analysis considers the net benefit of a project to the community. CBA can help reduce uncertainty in the process of making decisions as it clarifies the quantifiable benefits and costs of a project. It can form a basis for the consideration of the benefits of qualitative alternatives to the project.

Cost-benefit analysis is, however, not procedural and standardized. The process used to carry it out and its outcome can be determined through the individual analysts' professional judgment and decisions regarding the development options that should be considered. These should focus on making effective use of the data and technology that are already in place (Boardman et al., 2017). The Cost-benefit analysis is not the only tool that is required for the making of decisions on infrastructure investment projects. Instead, it is just one of the inputs that are needed. The use of Cost-benefit analysis in the assessment of

infrastructure projects is an important tool. It involves carrying out a systematic evaluation of the impacts of the project for all the aspects of the economy and the community. It is not concerned only with the financial and direct effects on one group. It emphasizes a valuation of the losses and gains from a project. It is an objective framework that allows for the determination of the various impacts of the project (Jones et al., 2014). The objective of the cost-benefit analysis method is supported by the fact that all impacts are converted into the present value dollar terms of the project. Even for projects like the King Salman Causeway where the quantification of all benefits is difficult, cost-benefit analysis is still a useful tool in the making of decisions.

2.4 King Fahd Causeway

The King Fahd Causeway is a set of bridges located in the Gulf nations. The 25km long Bridge links the Bahrain Kingdom with the Eastern Part of Saudi Arabia as shown in Figure 2. The causeway starts in Saudi Arabia in a place known as Al-Aziziyya and ends at Al-Jasra, located in Bahrain. The Bridge is made up of two sections, where one is long, and the other one is short. The longer section starts from Khobar to Nasan Island in Bahrain, and the shorter section starts from Nasan Island to the main island of Bahrain (Road Traffic Technology, n.d.). Official figures indicate that more than 390 million individuals have used the causeway from its opening date (Bahrain News Agency, 2019).



Figure 2. King Fah Causeway (World View, 2011)

The design of the causeway is a four-lane road. Each lane of the road has two roadways. The roadways are approximately 11.6m wide. The roadways have two paths that run in counter directions. The causeway also has a curb that facilitates emergency parking. In the Saudi Arabia part, there are three bridges measuring 934m, 2,034m, and 5,194m. On the Bahrain side, two bridges measure 934m and 3,334m (Bahrain News Agency, 2019).

The cost used in developing the project was \$800 million. Ballast Nedam (a Dutch-based construction and engineering company) was the major company involved in the project. The plan to build the bridge and its facilities included signing four contracts;

- The first contract: includes construction of the bridge, at a cost of \$ 569 million
- The second contract: It was concerned with buildings construction, at a cost of \$ 96 million.

- The third contract: Concerning the construction of approaching roads and intersections to connect the bridge to the main road networks in Saudi Arabia, at a cost of 53 million.
- The fourth contract: Concerning the construction of approaching roads and intersections to connect the bridge to the main road networks in Bahrain, at a cost of 53 million.

In addition, the cost of technical and administrative supervision was 23 million (Alsaud, 1996).

King Fahd Causeway has benefits to both nations (Saudi Arabia and Bahrain). Utmost, the causeway has boosted the business within the two kingdoms. According to some business individuals, the causeway's construction has played an important role in boosting trade and commercial exchange between the two countries and other regions. The value of trade exchange between the two kingdoms during 2018 was 2.7 billion US dollars. The Saudi-Bahraini Business Council said that Saudi export to Bahrain represent 83% of trade between the two countries (Arab Economy News, 2019). Besides, the causeway has also facilitated economic integration of the area. For example, the small Bahrain market benefits significantly from the great Saudi Arabia market. On the other hand, the main challenge that curbed the King Fahd Causeway is the presence of high traffic. However, with the expansion plan which aims to increase the number of lanes in the causeway, this problem will be solved effectively.

2.5 The Channel Tunnel

Thomas & O'Donoghue (2013) discuss the transport patterns and regional impacts of the Chunnel Tunnel project. The Channel Tunnel Bridge connects England and France. The Channel Tunnel was opened in 1994, and has become an important transport infrastructure element. Although many people and goods are transported across the channel on a yearly basis, these numbers have not reached the levels forecasted and the project's benefits are less than what had been anticipated. Language differences have created a psychological barrier, and the frontier zone has not developed as an integrated labor market (Thomas & O'Donoghue, 2013). In addition, the effects of the channel on the economy of the region have been limited. The project has benefitted regions that are far away from the tunnel than the areas crossing it.

The Channel Tunnel project has a length of more than 50 km, and 37.9 km of these are in the Tunnel's submarine section. By December 2012, more than 280 million people had crossed the tunnel. As shown in Figure 3, the tunnel provided a connection between London, Brussels, and Paris. There are intermediate stops at such stations as Lille, Ashford, and Calais (Thomas & O'Donoghue, 2013). When the final section of the tunnel's rail link was completed in 2007, there was now a direct railway connection from London to Brussels for 2 hours, and one between London and Paris for 2 hours and 25 minutes. Although the time taken by vehicles is only 35 minutes, the time taken during the journey are significantly longer as a result of stringent checks and passport controls that can lead to major delays.



Figure 3. Channel Tunnel (Euro Star, 2010)

It is quite difficult to make reliable forecasts regarding the traffic for new transportation infrastructure. For the Channel Tunnel project, one of the factors that had not been taken into account in the forecasts was the continuation of duty-free sales on ferries coming from other countries and aircraft in the European Union until 1999. This gave the competitors of the Channel Tunnel a subsidy. Another important change in the travel market was caused by the expansion of low-cost airlines. In the year 1994, air travel accounted for only 69.7 of UK foreign travel. 30.3% was by sea. However, by 2005, air travel accounted for 80.7%, sea 12.2%, and the Channel Tunnel only 7.1%. The competitive position of the Tunnel was further weakened by the delay in the completion of the rail link of the Channel Tunnel.

All these reasons made it quite difficult for the Channel Tunnel to achieve its forecasts in terms of traffic. Besides, the costs of construction went above the estimated costs by about 80%. This caused the project's commercial viability to be questioned.

Above all, the Channel Tunnel provides an important link with a high-speed rail network that connects Paris, London, and Brussels. The connectivity between the three areas has been greatly improved.

2.6 The Ambassador Bridge

The Ambassador Bridge is one of the busiest international bridges located in North America. It is one of the major entrance points in the US. The bridge is very important because it spans from Detroit, Michigan to Windsor, Ontario as shown in Figure 4. Moreover, the Bridge is important in North America because it helps in handling about a quarter of all trade that is conducted between the US and Canada, which is about 700 billion US dollars (Luiza, 2015). Due to this, Canada and the US are said to have one of the largest trade relationships in the world. Across the Detroit River, a lot of people have been crossing there since the 19th century using railroads on the edge of the river and boats across it. As such, to help cut down the cost of crossing the Detroit River, the bridge had to be constructed.



Figure 4. Ambassador Bridge (Open Street Maps, 2015)

The construction of the bridge begun in 1927 and was completed in 1929. The company that undertook this task was McClintic-Marshall Company. The bridge's total length is 2.2 Km and has a roadway that goes as high as 46 meters (Detroit Historical Society, n.d.). The construction of the bridge is said to have cost about \$23.5 million (Detroit Historical Society, n.d.). The amount of money that was invested in this project can be said to be worth it because it has largely helped the two countries over the years.

After its completion, it led to a lot of benefits between the two countries. For instance, it allowed shipping companies to easily transport their products across the two borders. It has impacted the economies of the two countries positively because the transportation of goods across the border is much faster. Due to this, a lot of jobs have been created helping the countries increase the growth of their GDPs. Additionally, it has allowed for tourism to take place because people can easily travel across either side of the border to visit the places that they wish to see.

While constructing the bridge, it is difficult to accurately point out what was done wrong while constructing this bridge. It has been standing for over 90 years, serving a lot of people. The bridge helps a lot in transportation with an approximate of 10,000 vehicles crossing on a typical weekday (Detroit Historical Society, n.d.).

Even though the bridge is beneficial to the two countries, it has brought along a few challenges. For instance, health care workers have been easily recruited from Canada to Michigan, bringing about a shortage in Canada. The capacity, congestion, and delays at the borders have been a serious challenge for many years because there is no direct connection to the freeway system (Luiza, 2015). Even though the bridge has brought about

these challenges, they cannot be said to outweigh its benefits because they can be easily solved.

2.7 Summary

Concluding this chapter, the reader should have an understanding of cost-benefit analysis and its role in infrastructure projects. Moreover, bridges play a crucial role in promoting the economic growth of multiple countries. Additionally, bridges enable companies and organizations to enhance their productivity.

III. Methodology

3.1 Chapter Overview

Chapter III explains the research methodology and the importance of this research. In order to evaluate the performance of King Salman Causeway project, it is first important to define the problem. Through a quantitative study, this research will suggest the general problem, frame it with questions to identify the problems, recommend actions, and suggest additional research. The expected outcome will support the decision-makers in Saudi Arabia in concluding whether to undertake the project or not.

3.2 Methodology

The cost-benefit analysis for King Salman Causeway will be conducted through a series of steps. The first step will be determining the costs and the benefits associated with the project. In this step, all the benefits and costs that are likely to be incurred in the project are going to be identified and quantified. The identification and quantification of these benefits and costs is an important step in the cost-benefit analysis as it is what is used to determine the project's net benefit. Once the benefits and costs have been identified and quantified, the total costs will be subtracted from the total benefits to get the net benefit of the project. All other non-market costs and benefits are not going to be taken into consideration. This will be followed by social discounting in which the benefits and costs of the project will be discounted relative to the rate of social discount. The next step will be the calculation of the performance indicators of the project. These will include the benefit-cost ratio, the net present value and the payback period.

3.3 Data Collection

Data Collection is an essential part of any type of research study. Inaccurate data collection can impact the results of a study. The collection of data in this research will be through official documents, interviewing officials of the Ministry of Transport, research articles, official media statements and using relevant previous studies.

3.4 Interview

It is important to acquire information regarding the maintenance and operation of the King Salman Causeway Project. Mr. Abdulkhaleq Alqahtani, Director of the General Directorate of Maintenance of the Saudi Ministry of Transport (MOT), will provide the needed input for this research. These questions were provided during a phone call. The answers will be shown in Chapter IV.

The questions were:

- 1- What would be the expected maintenance and operation tasks for a project such as the King Salman Causeway?
- 2- What is the expected cost for maintaining and operating the King Salman Causeway project?

3.5 Summary

In summary, this chapter outlined the required data that will be collected to give a clear idea of the topic that will meet the research objectives and questions in Chapter I. The results and analysis will be shown in Chapter IV.

IV. Analysis and Results

4.1 Chapter Overview

This chapter discusses the results of the cost-benefit analysis. A variety of data collected and findings gathered from the multiple resources. As a result, the analysis will be largely quantitative to answer research questions in Chapter I.

4.2 The Process of Cost-Benefit Analysis

This cost-benefit analysis started with an investigation of the problem, its background, and its context. This provided an opportunity for placing the project in the broad context before narrowing the focus. In calculating the cost-benefit ratio, the total discounted benefits were divided with the total costs discounted. The project was found to have a cost-benefit ratio that was greater than 1, meaning that the benefits that would come from the project were greater than the costs that would be incurred in its construction. Therefore, the King Salman Causeway project's net benefit is positive.

The first step involved identifying the objectives of the project. It was determined that the objectives of King Salman Causeway Project were to ease movement between Saudi Arabia and Egypt, increase trade between the two countries, provide more employment opportunities, and boost the growth of the economy in the two countries.

The second step is the identification of the constraints that are likely to be encountered as one works towards meeting the objectives. This is to make sure that all the alternatives that were examined in the analysis are possible. Financial constraints could include budget limits and price floors and ceilings. Distributional constraints could include requirements that relate to the distribution of the benefits of a project to groups. Managerial

constraints could include limits on the quality and quantity of the human resources available for the project to be implemented. Environmental constraints could include standards of environmental protection.

The third step entails considering other alternatives. The importance of considering alternatives is that the decision-maker gets a good scope to allow for the best choice to be made. Alternatives need to be clearly distinguished from one another. There should be the identification of a "do nothing" alternative. Benefits and costs are considered incremental to what would be done if the project had not been implemented. Therefore, doing nothing is the base case.

The fourth step is determining the direct benefits and costs of the project. The benefits that are expected to come out of the project are the cost-saving on shipping oil and petrochemical products to Africa and South Europe, and the toll fee of the bridge. On the other hand, direct costs include the initial investment and the cost associated with maintenance and operation.

Step 5 is the preparation of a spreadsheet. Using a computer-based spreadsheet simplifies the work of the analyst in that data can be stored, and calculations are done at a rapid rate. On the spreadsheet, it is important to present the key benefits and costs alongside key results.

4.3 Data Preparation

4.3.1 The Direct Benefits of the Project

This project is associated with a number of direct benefits. These benefits will be summed up in Table 2.

- **Saving on Shipping Oil and Petrochemical Products**

To understand Saudi Arabia's role in global oil markets, we can look at its contribution to the world's spare production capacity. The daily world oil market provides about two million and 400 thousand barrels of spare production capacity, which can enter the markets when needed, and the contribution of Saudi Arabia alone from this reserve capacity constitutes about 70 percent. Saudi Arabia has approximately 298 billion barrels of proven oil reserves in the world, equivalent to 17 percent of global oil reserves, and alone makes up about 12 percent of global oil exports in 2018. (Sky News Arabia, 2019).

Moreover, According to its vision 2030, the Kingdom of Saudi Arabia aims to be the first in the production and export of petrochemicals in the world, at least for the next seven years. Experts believe that the Kingdom's target will be logical and realistic as it expands the petrochemical industry, especially as it is the largest oil exporter in the world. According to Ibrahim Eldmiri, one of the advisers to the King Salman Causeway project and the former Egyptian Minister of Transport, transporting oil and petrochemical products through the causeway will save Saudi Arabia about 1.5 million US dollars a day (547500000 US dollars a year) (Almasryalyoum, 2016).

- **Bridge Toll**

A toll bridge or toll way is a public or a private roadway for which a monetary charge or fee is collected to pass over. It is implemented to help investors recoup their investment. In the case of King Salman Causeway, it will be compared to King Fahd Causeway, which connects the Eastern region of Saudi Arabia to Bahrain. The average bridge toll for all vehicles is 8 US dollars.

Due to the limited data on the project, analogous estimate will be used to forecast the number of vehicles that would pass over King Salman Bridge annually. An analogous estimate is a process in which costs are developed by comparing previous projects with a current one. As illustrated in Table 1, the population of the Eastern region in Saudi Arabia and the number of vehicles passing over King Fahd Bridge will be compared to the population of the Region of Tabuk to forecast the number of vehicles would pass over the causeway every year.

Table 1. Population Vs. Vehicles Passing over the Causeway

Population of Eastern Region (2019)	Population of Tabuk Region (2019)	Number of Vehicles passing over King Fahd Causeway annually (2019)
5028000	910000	12539940

The number of vehicles that would pass King Salman Causeway =

$\frac{\text{Population of Tabuk Region}}{\text{Population of Eastern Region}} \times \text{Number of Vehicles passing over King Fahd Causeway}$

$= 910000 * 12539940 / 5028000 = 2269559 \text{ Vehicles}$

Yearly Bridge Toll= Number of Vehicles passing over King Salman Causeway $\times$ \$8

$= 2269559 * 8 = 18153640 \text{ US dollars.}$

Table 2. Value of Direct Benefits

Benefit	Value
Saving on Shipping Oil and Petrochemical Products	\$547,500,000
Bridge Toll	\$18,153,640

4.3.2 The Direct Costs of the Project

This project is also associated with a number of direct costs. These costs will be summed up in Table 3.

- **Initial Investment**

The initial investment or startup capital is the amount of cash that investors need to start a business or a project. The type of contract that would be signed by the Saudi government to cover the project's work is a fixed-price contract with a scheduled time of delivery. A fixed-price contract is a type of contract where the price or payment is not subject to any adjustment. The cost of initial investment on King Salman Causeway is set to be 4 Billion US dollars.

- **Maintenance & Operation**

Maintenance and operation management is a set of procedures and a series of continuous operations that must be performed to have a fully prepared work environment and to keep necessary equipment or systems in good working condition. Maintenance and operation goals include achieving successful operating conditions that provide a pleasant work environment and establish safety conditions and climates for worksites. According to Abdulkhaleq Alqahtani, Director of the General Directorate of Maintenance of the

Saudi Ministry of Transport (MOT), the cost of maintaining and operating a project such as the King Salman Causeway can reach up to 20 million US dollars.

Table 3. Value of Direct Costs

Cost	Value
Initial Investment	\$4,000,000,000
Maintenance & Operation	\$20,000,000

4.3.3 Discount Rate for Saudi Arabia

A discount rate is the rate of return used to determine the net present value of future cash flows. As illustrated in Figure 5, interest Rate in Saudi Arabia averaged 3.62 percent from 1992 until 2020, reaching an all-time high of 7 percent in May of 2000 and a record low of 1 percent in March of 2020 (Trading Economics, 2020).

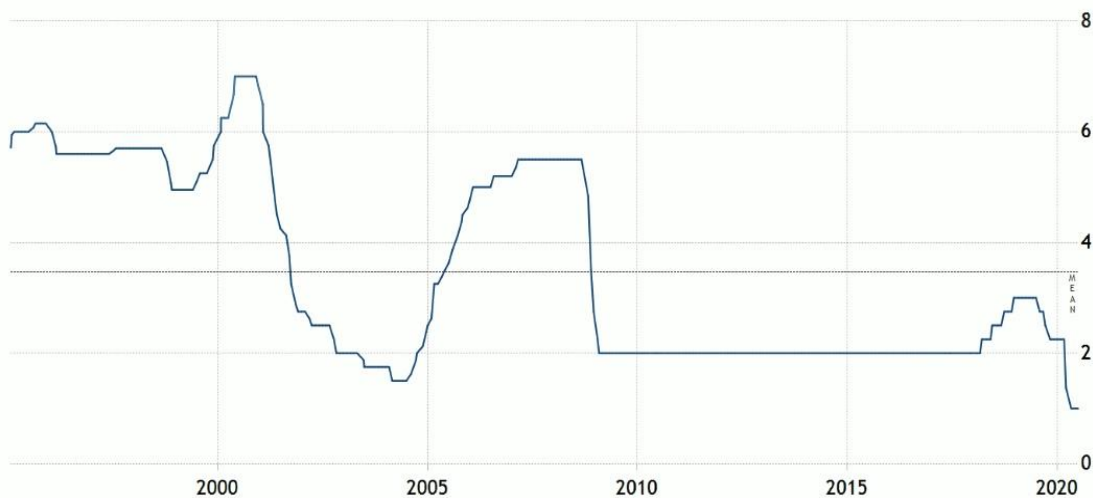


Figure 5. Saudi Arabia Interest Rate from 1992 until 2020 (Trading Economics, 2020)

4.4 Calculations and Results

In the calculation of the benefit-cost ratio, the formula used is $\Sigma(B_i/(1+d)^i)/\Sigma(C_i/(1+d)^i)$, summed over $i = 0$ to n . In this formula, $n+1$ is the length of time in years over which the costs and benefits of the project were analyzed.

- B_i refers to the project's benefits in the year prior to its start.
- C_i refers to the project's costs in the year prior to its start.
- d is the rate of discount.

The first step was to discount the benefits and costs in future years. In year i , the project's discounted benefits are $B_i/(1+d)^i$. On the other hand, the project's discounted costs equal $C_i/(1+d)^i$. Besides, the payback period can be calculated by subtracting the cash flow of benefits from the cash flow of costs until the break-even point is reached.

As shown in Figure 6 and Figure 7, over 20 years from the day construction starts:

- Net Present Value of Benefits = 6371571332 US Dollars
- Net Present Value of Costs = 4225281723 US Dollars
- Discounted Benefit-Cost Ratio = 1.507963669
- Payback Period = 12.93588714 Years

King Salman Causeway Benefits_Cost Analysis					
		Interest Rate	3.62%		
Costs					
	Year	Initial Investment	M & O	Total Cost	Present Value
	0	4000000000	0	4000000000	4000000000
	1	0	0	0	0
	2	0	0	0	0
	3	0	0	0	0
	4	0	20000000	20000000	17348248.88
	5	0	20000000	20000000	16742181.89
	6		20000000	20000000	16157288.06
	7		20000000	20000000	15592827.7
	8		20000000	20000000	15048086.95
	9		20000000	20000000	14522376.91
	10		20000000	20000000	14015032.72
	11		20000000	20000000	13525412.78
	12		20000000	20000000	13052897.88
	13		20000000	20000000	12596890.44
	14		20000000	20000000	12156813.79
	15		20000000	20000000	11732111.35
	16		20000000	20000000	11322246.05
	17		20000000	20000000	10926699.52
	18		20000000	20000000	10544971.55
	19		20000000	20000000	10176579.38
	20		20000000	20000000	9821057.113
				TOTAL PV OF COSTS	4225281723

Figure 6. Calculations and Results 1

<i>Benefits</i>						
	Year	Saving on Oil Products shipping	Bridge Toll	Total Benefits	Present Value	Balance (payback)
	0	0	0	0	0	400000000
	1	0	0	0	0	400000000
	2	0	0	0	0	400000000
	3	0	0	0	0	400000000
	4	547500000	18153640	565653640	490655006.2	3529344994
	5	547500000	18153640	565653640	473513806.4	3075831187
	6	547500000	18153640	565653640	456971440.3	2638859747
	7	547500000	18153640	565653640	441006987.3	2217852760
	8	547500000	18153640	565653640	425600258	1812252502
	9	547500000	18153640	565653640	410731768	1421520734
	10	547500000	18153640	565653640	396382713.8	1045138020
	11	547500000	18153640	565653640	382534948.6	682603071.3
	12	547500000	18153640	565653640	369170959.9	333432111.5
	13	547500000	18153640	565653640	356273846.6	-2841735.162
	14	547500000	18153640	565653640	343827298.4	-326669033.6
	15	547500000	18153640	565653640	331815574.6	-638484608.2
	16	547500000	18153640	565653640	320223484.5	-938708092.7
	17	547500000	18153640	565653640	309036368	-1227744461
	18	547500000	18153640	565653640	298240077.2	-1505984538
	19	547500000	18153640	565653640	287820958.5	-1773805496
	20	547500000	18153640	565653640	277765835.2	-2031571332
				TOTAL PV OF BENEFITS	6371571332	
		Benefit Cost Ratio (BCR) for 20 years		Payback Period (YEARS)		
		1.507963669		12.93588714		

Figure 7. Calculations and Results 2

4.5 Summary

In this chapter, direct benefits and costs were identified and quantified. Moreover, the net present values, the benefit/cost ratio and the payback period were calculated. Chapter V will provide concluding remarks, answers to the investigative questions from Chapter I, and recommendations for future research.

V. Conclusions and Recommendations

5.1 Chapter Overview

This chapter presents a summary of the study that has been worked on. Investigative questions from previous chapters are answered, and the conclusion of this research and the recommendations for future work are described.

5.2 Conclusion of Research

King Salman Causeway is a project that is of great importance for both countries in terms of the supply chain. Both countries, individuals and businesses, are expected to benefit from the project, and the project needs to be initiated to facilitate the benefits expected.

The purpose of this research is to examine the benefits and the costs that are associated with the King Salman Causeway construction project to determine the viability of the project. The discounted benefit/cost ratio is calculated by dividing the total net present value of the benefits by the total net present value of the costs of the project.

The benefit/cost ratio of the project was found to be 1.5. This shows that the benefits of the project are 1.5 times more than the costs that are going to be incurred as a result of it. Besides, there are many indirect benefits that will result from building this causeway, and it will recover its cost in a short period of time compared to other bridges. Therefore, the project should be undertaken because it is going to be beneficial more than it is going to be costly for society.

5.3 Investigative Questions Answered

1. *What is the time period that the project needs to reach the break-even point?*

The project will need 12.93 years to reach the break-even point, and that is when the total costs equal total revenue, depending only on direct benefits.

2. *What are the indirect benefits that might be expected from building King Salman Causeway?*

There are many indirect benefits that are expected from King Salman Causeway to both countries. Considering that the proposed construction aims to create a closer connection between the two countries, there are a lot of benefits expected from the project, job creation being one of them.

The construction will lead to an improvement in the supply chain management between the two countries, possibly creating many job opportunities. This will, in turn, improve the economies of the two countries. There are different factors that lead to countries' economic growth, supply chain being among the major ones. An appropriate means of transportation for individuals from both countries will have a direct positive impact on business operations, leading to further economic growth.

Moreover, tourism is another factor that affects the economic growth of a country. Through an appropriate means of transportation, both countries are expected to improve the tourism aspect since it will be easy for tourists to travel between the countries. Many private organizations are expected to improve their business operations through the transportation of their goods and services between both countries using the Causeway. A cheaper means of transportation will lead to operational cost reduction for the

organizations. The communication between suppliers and customers will also improve because of the bridge, as there will be an accessible and cost-effective means of transport.

3. What are the indirect costs and challenges that might be expected from building King Salman Causeway?

Considering that the bridge will be passing over the sea, some environmental costs and challenges are likely to be faced. One of the identified problems is the potential damage to coral reefs. It will have effects on the flow of water in the sea. This will lead to a degradation in the habitat of the sea creatures.

The project will also have a significant impact on the quality of water. For example, motor vehicles may deposit rubber particles, oil, and other pollutants on the way. This will be swept into the sea, where they may cause the death of sea organisms. Another cost is the impact on airlines and ferry operators that are connecting the two countries. Many flights and sea trips will be canceled as some travelers between the two countries will choose to travel via King Salman Causeway.

5.4 Recommendations for Future Research

Recommendations will be provided to give a deep insight into the research; such as:

1. Quantifying indirect benefits and costs through proper assumptions and hypothesis.
2. Doing a sensitivity analysis to appreciate the effects of uncertainty to which the project is exposed
3. Identifying the impact and social equity of the project to the beneficiary.

Appendix A. Interview

The interview with Mr. Abdulkhaleq Alqahtani, from the Saudi Ministry of Transport (MOT), Director of the General Directorate of Maintenance.

Q1. What would be the expected maintenance and operation tasks for a project such as the King Salman Causeway?

For a project such as the King Salman Causeway, the expected maintenance and operation tasks would be the following:

- 1- Regular maintenance includes all the simple work carried out by the maintenance units, which aims to ensure the provision of high-level service that guarantees safety and security for the causeway's users to limit any damage that might happen. It includes the following:
 - Filling cracks and repairing minor damages on the road surface and concrete structures.
 - Fixing shoulders and sideways inclinations.
 - Inspecting, maintaining, and repairing safety devices, such as barriers, road signs and fences.
- 2- Preventive maintenance that extends the life of the road and carries out the following work:
 - Continuous periodic inspection of the causeway and the associated shoulders, traffic lights, etc.
 - Covering the road surface with new layers.
 - Replacing the asphalt layers, whether by repaving them or removing them completely and recreating them according to the paving condition.

3- Operating all digital and communication devices, and all security and alarm systems.

Q2. What is the expected cost for maintaining and operating the King Salman Causeway project?

In 2014, the General Organization of King Fahd Causeway signed a contract with Kuwaiti Almudeer Company (a company specializing in managing and operating major projects) for maintaining and operating the King Fahd causeway, with a total cost of 45 million US dollars for a period of 5 years. Therefore, the cost of maintaining and operating a project such as the King Salman Causeway could reach 20 million US dollars per year.

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14. ABSTRACT Infrastructure projects are important in the economic development of countries as they boost economic growth by allowing mutual trade between nations. One infrastructure project that is aimed to increase trade operations between Saudi Arabia and Egypt is King Salman Causeway. The project is going to cost about \$4 billion and will establish closer links between the two countries, creating job opportunities for both Saudi and Egyptian citizens. The purpose of this research is to carry out a cost-benefit analysis of the causeway infrastructure project, by providing information to decide whether the project should be undertaken or not. The cost-benefit analysis will compare the costs involved in the project with the benefits that will be resulted after the project completion. It concludes that the project should be executed because the benefits that will come from the project exceed the costs that will be incurred in its construction.					
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