International Journal of Computational and Experimental Science and ENgineering
(IJCESEN)
Vol. 11-No.2 (2025) pp. 2436-2444
http://www.ijcesen.com
ISSN: 2149-9144

Research Article

Economic Analysis of proposed Ramadi Karbala Railway Project in Iraq

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Article Info:

DOI: 10.22399/ijcesen.1294
Received : 25 February 2025
Accepted : 09 April 2025

Keywords :

Cost-benefit Analysis,
Railway engineering,
Economic evaluation,
Operating cost,
Transportation.

Abstract:

In the majority of nations, the railway network is regarded as one of the main pillars of the economy. Here, the user benefit of installing a new railway track connecting the western Iraqi cities of Ramadi and Karbala was examined. The new railway line's operational expenses are contrasted with those of the current forms of transportation, which rely solely on multilane highways to connect the two cities. The associated parameters used in the cost-benefit methods were used in the analysis. The findings demonstrate that there is no user benefit and the economic assessment is negative when building and other initial costs are included. In contrast, the implementation of such transportation projects in the actual world has an impact on the advancement of society. Apart from the upfront expenses, like in the case of the construction of the road, this article determined that the proposed project has a great deal to offer users when accidents, time-saving expenses, and environmental effects are considered operating. Using a cost-benefit analysis, this study compares the effects of the existing modes of transportation (roadway travel) and tries to understand the impact of introducing a new one (railway travel).

1. Introduction

The Ramadi Karbala Railway project, which is still unfinished, has a significant impact on local passenger and freight transit in western Iraq. The locations of the two cities of railways line which located in western Iraq are depicted in Figure 1. The majority of Iraq's transportation projects are government-sponsored, which implies that all fares are often lower than those of private sector road transit services. This work's goal is to analyse the cost-benefit ratios of the proposed Ramadi Karbala Railway line by conducting an economic assessment of the track and taking into account all relevant factors that affect the project's financial decision. Because of their close linkages and frequent social and economic exchanges, Ramadi and Karbala are likely to see a lot of traffic, which might use the line to enhance the number of journeys and the transit of commodities. Numerous opportunities will arise in a distant city like Ramadi when the direct railway line is extended there [2].

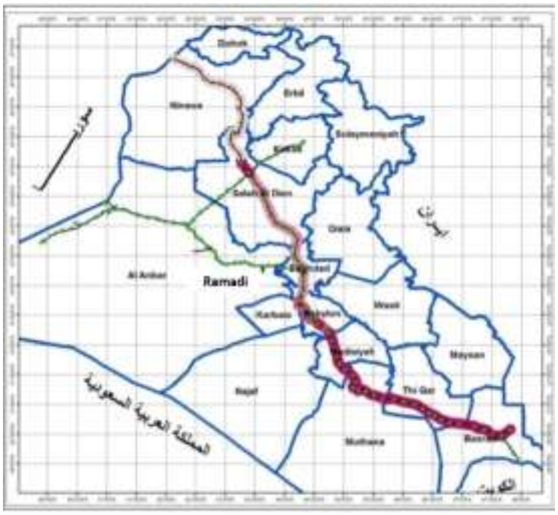

***Figure 1**. The locations of the western Iraqi cities of Ramadi and Karbala [1].*

The expansion of markets and trade in the entire region necessitates the proposed line's addition of a massive multiservice and multifunctional new traffic line in order to improve the two cities' investment and economic environments. Following the track's completion, the addition of this transportation facility can have a major positive impact on regional and national development. Additionally, introducing this new mode will help reduce the demand for private vehicles, taxis, as well as other land vehicles such as buses and large machinery, which will lessen their negative environmental effects [3]. Since railway lines can carry people and commodities for an extended period of time at a lower cost than alternative modes of transportation, they are the most practical, necessary, and sustainable means of transporting people and goods in Iraq [2].

2. Iraqi Republic Railways Company (IRR)

With more than 1,900 kilometers of standard gauge rail, the Iraqi Republic Railway Company (IRR) connects Basra via Baghdad, Bayji, and Mosul from the south to Rabiya in the north. Figure 2 shows the railway network in Iraq [4]. In addition, there is a branch line that travels west from Baghdad via Ramadi and Haqlaniya to Al Qaim and Husayba, and from the ports of Khor Az Zubair and Umm Qasr to Shouaiba Junction, which is close to Basra. Lastly, there are branch lines that go from Haqlaniya via Bayji to Kirkuk and from Al Qaim to Akashat.

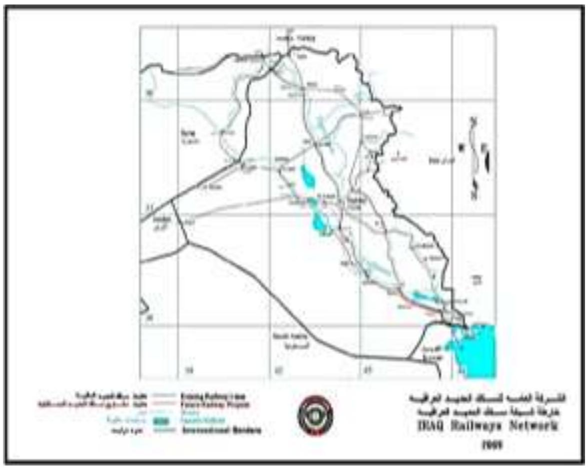

***Figure 2**. Iraqi Railway Network. [4]*

About 123 kilometers of the Baghdad Railway opened in 1914, marking the beginning of the railway in the Ottoman Empire's former province of Mesopotamia. From Baghdad, work had started to move northward to connect with a segment of railroad that was being constructed across Syria and Turkey. However, in order to bolster their action against the Turks. They were successful and were given a League of Nations authority to govern the region. The rails were then turned over to the British government as Mesopotamian rails in 1920. In addition, Hudswell Clarke 2-8-4T locomotives were introduced in 1951. In 1950, a road and rail bridge was opened, finally connecting the east and west sides of the Tigris River. During this period, new steam locomotives were also introduced, such as 2-8-2 locomotives from the Vulcan Foundry and Maschinen fabrik Esslingen and 2-8-0 locomotives from Krupp. After the Hashemite monarchy was overthrown in 1958 and Iraq was proclaimed a republic, the next significant event took place. At this stage, the railroad underwent yet another name change. During this period, it also began to replace its steam locomotives with a fleet of diesels, however the 1961–1983 replacement program took far longer than anticipated. The railways have sustained significant damage in recent years due to both looting and conflict, and the reconstruction effort is probably going to take several years. The poor degree of efficacy of the Iraqi railways in the country's transportation network is maintained by these damages, which cause logistical and budgetary issues. Iraqi railroads have a decent chance of traveling through the Arabian Gulf. The construction of the Iraqi large marine port in the Gulf will expand this potential and lead to a significant advancement in the transit of people and goods between Asia and Europe.

3. The Suggested Lane

The lane is a mixed lane that transports both freight wagons and passenger locomotives. The current transportation system connecting the two cities, which consists of a two-way, four-lane road that carries both people and goods., is inefficient in meeting the needs of transportation.The Italian consulting firm Sotecni created the project drawings in 1982. It is a double line that is 193 kilometers long. The locomotives travel 250 km/h for passengers and 149 km/h for cargo. Three million passengers travel there each year, and 36 million tons of commodities per year are transported there. Residential complexes for

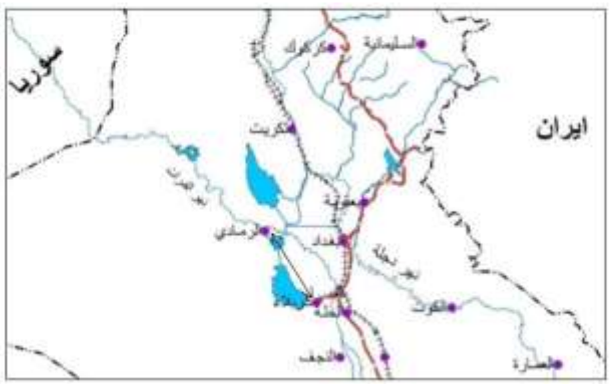

***Figure 3**. The Suggested Railroad Track [4].*

railway workers will be built as part of the project, which is expected to cost $3043 million and take ten years to complete. [5]. Figure 3 shows the proposed railway line.

4. Economic Assessment of the Suggested Lane

The social, economic, environmental, and other relevant factors should all be included in the multilevel, multi objective economic evaluation. Economic evaluation is a crucial component shared by all track construction-related operations. Both users and non-users of the transport network are impacted economically by the addition of a new mode of transportation. The following are its goals [6]

- to make railway travel more competitive with other forms of transportation in order to win over the users of the transportation network.
- to give the local government and other decision-makers a realistic assessment of the consequences of constructing the railway line.

The accountant's perspective of the railway system should not be the exclusive basis for economic appraisal. It should consider its qualitative features as well as future developments, such as the long-term advantages of railway refunds. "A modern transportation system must be sustainable from both an economic, social, and environmental point of view," as stated in the European transportation strategy, essentially encapsulates the worries of the transportation agencies collectively, and of its economic evaluation unit specifically. Usually, easily accessible data sources or model results (such building and upkeep expenses), as well as estimations of travel demand before and after, broken down by trips, and corresponding journey times) can be used as inputs for benefit-cost evaluations. Based on recent empirical investigations, international proposed values can typically be used to accommodate the assessment of variations in external, relatively intangible travel expenses (such air pollution and crash injuries). [6]

4.1 Cost-benefit analysis (CBA) principal types

One method for ranking projects or selecting the best course of action is cost-benefit analysis, or CBA. The anticipated economic expenses and advantages serve as the basis for the ranking or choice. According to the criterion, If the projected lifetime benefits outweigh the projected costs, the project should be initiated [7]. The analysis procedure requires expertise in measuring these impacts, accounting for market failure, time, income distribution, incomplete information, and potentially irreversible outcomes. Although there are other ways to perform a CBA, the most popular one can be summed up as follows: [8]

4.1.1 Net present value (NPV)

At zero time, the difference between the outflow and inflow is calculated using the NPV approach, which first determines the future cash inflow's present value, followed by the investment-related cash outflow's present value. If NPV is greater than zero, the project is profitable; if NPV is less than zero, the investment is not worth it.

$$NPV = B\left(\frac{(1+i)^n-1}{i(1+i)^n}\right) - C_1 - C_2\left(\frac{(1+i)^n-1}{i(1+i)^n}\right) \quad (1)$$

where (i) is the least appealing rate of return, n is the project study term, B is the annual benefit, C1 is the construction and other initial expenditures, and C2 is the operation and other periodic costs each year. The general equation can be expressed as follows if the costs and benefits fluctuate over the project: [8]

$$NPV = \sum_{K=0}^{n} B_K\left(\frac{1}{(1+i)^K}\right) - \sum_{K=0}^{n} C_K\left(\frac{1}{(1+i)^K}\right) \quad (2)$$

Because it is founded on the idea that the total amount of money now is worth more than an equivalent amount one year from now, the NPV technique provides the following advantages: It accounts for the time value of money. It is possible to add the net present value (NPV) of different projects as they are now valued in rupees. This characteristic guarantees that a project with an NPV less than zero will not be approved simply because it is paired with another project with an NPV greater than zero. Additionally, the NPV approach has the following drawbacks:

• It necessitates discount rate data.

• The procedure is not simple to comprehend, and calculating NPV is similarly challenging.

B/C, or benefit-to-cost ratio

All costs and benefits must be represented as discounted present values at zero time points utilizing this approach, which is a refined form of the NPV method. Projects with a (B/C) > 1 (positive net benefits) will have more benefits than expenses. In cases where the B/C ratio is higher, benefits exceed expenses. [9]

$$\frac{B}{C} = \frac{\sum_{K=0}^{n} B_K \left(\frac{1}{(1+i)^K}\right)}{\sum_{K=0}^{n} C_K \left(\frac{1}{(1+i)^K}\right)} \quad (3)$$

The following are the benefits of the (B/C) method:

• The BCR criterion may accurately rank projects in decreasing order of efficient use of capital when the starting funds available to spend in the present time are restricted. • In the absence of restrictions, the BCR will use the NPV criterion to determine whether to approve or reject a project. Additionally, the (B/C) technique has the following drawbacks:

• It is not possible to combine smaller projects into a package that can be compared to a larger project.

• The BCR criterion is not appropriate for project selection when cash outflow takes place after the present period.

4.1.3 Internal Rate of Return (IRR)

The internal rate of return is the "annualized effective compounded return rate" or "rate of return" that makes the net present value (NPV) of all cash flows, both positive and negative, from a particular project equal zero. The rate at which an investment's net present value (negative cash flows) is discounted and benefits (positive cash flows) are equal is known as the investment's internal rate of return, or IRR.

$$NPV = 0 = \sum_{K=0}^{n} B_K \left(\frac{1}{(1+i)^K}\right) - \sum_{K=0}^{n} C_K \left(\frac{1}{(1+i)^K}\right) \quad (4)$$

where k is the project's period step (from 0 to n) and r is the internal rate of return.The following is an advantage of the IRR method:

• The projects are ranked based on their NPV/IRR. Out of multiple projects, one with a greater IRR is chosen.

• It takes into account its entity's cash flow stream.

Additionally, the IRR approach has the following drawbacks:

• Since the IRR number is unable to differentiate between loan and borrowing, a high IRR may not always represent a favourable criterion for project selection.

• It might not have a strict definition. [10]

5. User Benefit Evaluation Task

The following methods can be used to complete the evaluation tasks: establishing a simple methodology: reporting formats, statistical techniques, and economic evaluation tools. Tasks for evaluation: by calculating the project's expenses and advantages. The initial design drafting and this process begin at the same time. Setting up comprehensible economic models to forecast long-term consequences and conduct ex-post evaluation are examples of descriptive tasks. In certain ways, A non-profit organization is behind the proposed railway transit project. In contrast to other projects that are often profitable, it possesses the following attributes [11].
1) Expensive and protracted investment
2) Under government direction
3) Noncompetitive
4) Incorporeal advantage
Because of these features, the economic assessment of the advantages of this type of project primarily focuses on the national economy. Investors are the objective of both costs and benefits for typical lucrative initiatives. The government bears the costs of these transportation improvements, while everyone benefits [12]. Costs associated with building stations, tracks, complicated signals, and signal equipment systems and land purchase and conflict structure removal charges comprise the proposed railway line's costs. Control units and equipment costs. Costs of operations social costs Nonprofit initiatives only benefit the national economy, but railway transit projects have both financial and national economic benefits, such as [12]. Lower operating expenses for automobiles; save time for passengers and freight; lower the frequency of traffic accidents; lower noise pollution; and lower air pollution. The input parameters for creating a user benefit analysis are displayed in Figure 4.

6. Gathering Information for Economic Assessment

The following guidelines must be followed while gathering data on the railway economy in order to create understandable and practical economic

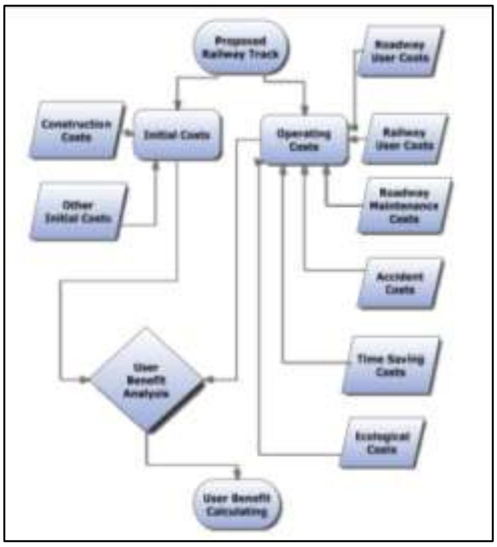

Figure 4. *The User Benefit Analysis Input Parameters.*

evaluation models and to provide the prerequisites for conducting practical assessments for both the future and the present. [12]

6.1 The principle of macroscopic

The division principle should adhere to the following principles from a macroscopic perspective:

(1) Trains carrying passengers and freight should have separate finances.
(2) Promote economic growth and increase the railway industry's level of competition.
(3) All division schedules should create the harmonious railway in order to promote socially harmonious development. Pay attention to the effects on the environment.
(4) In Favor of using the entire capacity of each line in the railroad corridor.
(5) In order to create favourable driving and organizing conditions for train operation, cooperation with the tie line, disconnect line, terminal, etc., is required.

6.2 The principle of the microcosm

The division principle should adhere to the following points from a microcosmic perspective:
(1) Make it easier for travellers, enhance the quality of the services, and cut down on the frequency of passenger transfers.
(2) Effectively increase the train's speed within the railway corridor.
(3) Give careful thought to how each circuit's speed target and the train's grade of speed in the corridor work together.
(4) Be able to run and adapt the train on a daily basis and establish favourable conditions for organization and operation.
(5) As long as practicable, high-grade passenger trains and longer passenger trains within transport corridors should run on passenger special lines, or travel as far as possible on passenger special lines.

7. An analysis of the Ramadi Karbala Railway Project's costs and benefits

7.1 Lower operating cost models for automobiles

Many travellers will switch from using cars and buses to trains once the railway line project is finished. It is also possible to switch to freight wagons for the freight movement. As a result, the costs associated with using trains rather than automobiles, buses, or large vehicles will change. [13]

7.2 The Total Cost of Transporting a Vehicle

Direct user costs for private vehicle ownership and operation are included in vehicle costs. These expenses could be separated into two categories: fixed expenses (car purchase or lease, insurance, registration, and vehicle taxes) and variable costs (maintenance and repair, fuel, fuel taxes, and oil). Buses typically depreciate over 20 years, while private cars do so over 10 years.

Table 1 displays the traffic data that was computed from the study areas. Before the new railway line (B_{1V}) was added, the cost of operating vehicles might be calculated as follows:

$$B_{\mathrm{IV}} = C_V * T * V_V * 365 \quad (5)$$

where: B_{IV} is the operating cost of running cars prior to the new railway line being added, C_V = Hourly vehicle operating costs (passenger, bus, and heavy trucks). T = The hourly travel time of individual vehicles (heavy vehicles, buses, and passengers), V_V = The daily number of vehicles (passengers, buses, and heavy vehicles) in traffic [14]. Table 2 displays the outcomes of Equation (5).

7.3 Train Transportation Costs

Table 3 displays the train's running costs, which are derived from related projects. Typically, trains lose value over a period of 30 to 40 years [17].The following formulas must be applied in order to determine the cost of train operation:

$$B_{\mathrm{IT}} = C_T * T * V_V * 365 \quad (6)$$

***Table 1**. Test model Specifications and test conditions.*

The traffic volume during peak hours.	1240 vehicles/ hr
percent of buses	15%
The proportion of large cars	20%
Passenger automobile operating costs [15]	15$ / hr
Bus operating costs [15]	20 $/ hr
Heavy truck operating costs [15]	40 /hr
The travel line's length	193 km
A medium speed for passenger cars.	90 km/h
Passenger Car travel time	1.8 hr
A moderate Buses travel	60 km/h
Buses travel time	2.10 hs
Heavy vehicles moving at a medium speed	55 km/h
Heavy Vehicle Travel Time	2.35 hr
K value (the hourly peak flow divided by the daily flow) [16]	0.17
The number of passenger cars on the road each hour	75% *1240 =930 vehicle /hr
The daily amount of passenger car traffic	930/0.17= 5470 vehicle /day
The number of busses in traffic each hour	10% *1240 =124 vehicle/hr
The number of busses travel per day	124/0.17= 729 vehicle / day
The amount of heavy vehicle traffics each hour	15% *1240 =186 vehicle/ hr
The amount of heavy vehicle traffics each day	186/0.17= 1094 vehicle/ day

***Table 2.** The results of Equation (5).*

Vehicle type	C_V	T	V_V	365	Operating cost
Passenger	15	1.8	5470	365	53906850
Busses	20	2.10	729	365	11175570
Heavy	40	2.35	1094	365	37535140
Total operating cost * 10^6 $ per year (B_{IV})				365	102.617560

***Table 3**. operational expenses for train lines.*

Train Operations	Unit	Average Cost $
Administration and sales	Passengers	5.0
Control of Tracks	Trains	90.0
Train servicing	Train- hour	95.0
Driving	Train- hour	50.0
Operations/Safety on lines	Train- Km	1.0
Energy on lines	Train- Km	2.5
Maintenance	Train- Km	5.0

where T is the operating period (hours per day), VV is the number of trips per day, B1T is the train operation cost per year, and CT is the train operation cost per hour. It is likely that the train will run at full capacity when the track opens. The track can carry 3.0 million passengers annually (an average of about 8,000 passengers per day, requiring an average of 6199 vehicles between buses and cars each day, with an average of eight people in each vehicle and 36 million tons annually (98,000 tons per day or around 1094 heavy vehicles). Using Equation (6), B_{1T} = 4.13 million dollars annually. The project typically lasts at least 25 years before needing to be replaced, and the installation of the proposed line would cost $3043 million. The cost of conveying the aforementioned passengers and cargo is 4.13 million dollars.

7.4 Costs of Road Maintenance

The current road between Ramadi and Karbala may be regarded as a rural road, meaning that traffic volumes are typically lower than on urban roads inside cities. Additionally, vehicle speeds may be uniform, and there are fewer stops along the route, resulting in fewer vehicle-damaging effects than inside cities. Table 4. [18]

***Table 4.** the annual maintenance costs for the road between Ramadi and Karbala. (The information was gathered from comparable road upkeep initiatives in Iraq.)*

	Value in millions of dollars
Annual Maintenance Costs per Kilo-meter	0.005
Total Maintenance Costs of the roadway / year	0.59

7.5 The Cost of Accidents

Removing the expenses associated with accidents (death, injury, and property loss). Table 5 displays the data collected on the accidents.

***Table 5.** The accident data gathered in the research area (the numbers are taken from Iraqi accident damage claims)*

Accident Type	Number	Cost of the accident $	Total cost
Fatal	10	10000	100000
Non-Fatal	120	5000	600000
Property damage	125	1000	125000
Total Cost in million $	0.825		

7.6 Passenger Time Saving

Trains are designed to travel at 250 km/h, whilst passenger cars go at 90 km/h and buses travel at 60 km/h. The time savings when using the planned railway route is displayed in Table 6. The majority of workshops offer an additional $4 for each hour beyond working hours, with the assumption that 50% of the time savings will be put to work. [6]. Additionally, according to a field traffic survey, 67% of all passengers use small vehicles (passenger cars plus taxis), with buses accounting for the remaining 33%.

Table (6): *Time savings with the proposed railway line.*

travel Mode	Journey time (hr)	Passengers Number	Total time (passenger.hr)
Train	0.98	3000000	2940000
Passenger Car	1.8	1996550	3593790
Busses	2.10	266085	558779
Total saving in time (passenger.hr)	(3593790 + 558779) – 2940000 = 1212569		
The proportion of the saved hours that will be used toward labor	50%		
The annual benefit of saving time	0.5*4* 1212569 = 2425138		

7.7 Advantages for the Environment

It has long been known that the actual financial cost of the environmental harm caused by road users is not borne by them. According to recent statistics, the expenses of accidents, congestion, and environmental damage per passenger kilo-meter travelled by car are three to ten times more than those incurred by rail. 19]

8. Analysis of Cost-Benefit (CBA)

Table 7 displays the proposed railway track's cost-benefit analysis. The majority of governments view transportation projects as strategic when creating plans, and government agencies cover the project's initial expenditures. As seen in Table 6, the NPV is equal to 1055.376 million dollars when the initial costs are disregarded. Utilizing the new train line will directly benefit the user, but there are also numerous social and economic effects on the two cities, the majority of which contribute to societal advancements. As seen in Figure 5, a range of interest rates was used to calculate the NPV. For the benefit cost calculation, the Ministry of Planning's Transportation department

Table 7. *The suggested track's CBA.*

Cost or Benefit Type	Millions of dollars
Construction cost	3043
Train operating cost	4.13
Benefit of a diverted vehicle per year	62.5
Saving in accident benefit/year	0.825
Savings on annual accident benefits	1.23
Time and year savings	25
B in Equation (1)	102.61+0.59 +0.825+1.23= 105.255
C1and C2 in Equation (1)	3043, 6.4
NPV (using Equation (1)) at i = 8%* when the beginning costs are valued in millions	-1987.624
NPV (using Equation (1)) for i = 8%* when the starting costs are disregarded in millions	1055.376
Internal Rate of Return (IRR) after deducting the original expenses	12.5E-15

* For the benefit cost calculation, the Ministry of Planning's Transportation department recommends an interest rate of 0.08.

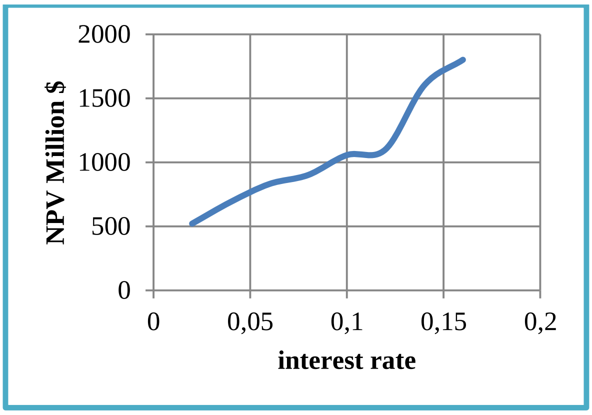

Figure 5*. The net present value (NPV) based on interest rate values without taking starting costs into account*

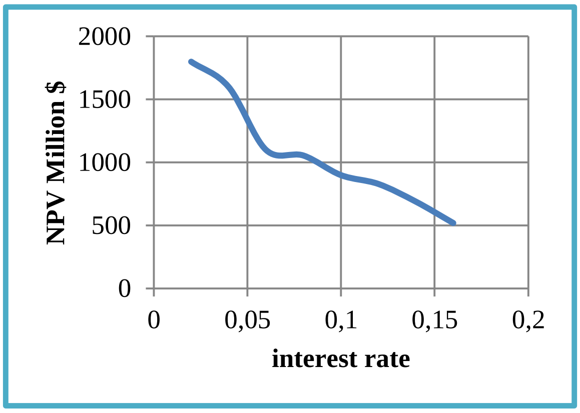

Figure 6. *The net present value (NPV) as a function of interest rate values when starting costs are taken into account.*

recommends an interest rate of 0.08. Using the methods outlined in 4.1.3, the internal rate return (IRR) is computed. After adding the initial expenses, Table 7 shows that the IRR = 12.5E-15, which is extremely low and cannot be accepted for the economic evaluation if the initial costs are taken into account. The computation of the IRR in relation to NPV when starting costs are taken into account is displayed in Figure 6.

9. Conclusions

It has been examined how the installation of a new railway track between Ramadi and Karbala cities might benefit users. In the actual world, the installation of such transportation projects has an impact on the growth of society, However, when building and other initial costs are taken into account, the economic evaluation is negative and produces no user benefit. When operational costs, accidents, time-saving expenses, and ecological effects are taken into account, the proposed project offers significant user benefits. If building and other early expenditures are excluded, the new railway will have a significant advantage over the existing roads when comparing the cost of travel for passengers on the new railway line. The government typically pays for these expenses as part of a strategic plan to boost the local economy.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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