RMIT

Group Number: 20

Assignment 3 Title: Project Appraisal Report

Due Date: October 19th, 2020

Word Count: 3937

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<u>Table of Contents</u>

List of Tables and Figures

1 Introduction

Risk is defined as an uncertainty of outcome, whether positive opportunity or negative threat, of actions and events. (Keegan, 2004). The risks happening at any event is evaluated according to the likelihood of it happening along with the effect of the risk on to the event. (Keegan, 2004).

The most important causes for failures of project are improper planning. Without proper planning and control, the project being executed would have several unexpected outcomes. Poor or improper planning also leads to unrealistic time and resource estimate creating unwanted expenditure and investments on the project. Also, improper planning leads to unclear or unmeasurable project objectives. These are the reason why a project should have a thorough planning which lays out the complete steps in executing the project, the risks involved in these projects, the ways to control them, the cost incurred in executing projects etc.

By performing the risk analysis for an event or project allows the management organisation to:

- Enhance their confidence in executing the project or the event.
- Effectively constrain threats to acceptable levels or even nullify a few threats.
- Take appropriate, effective, and informed decisions about exploiting opportunities and execute them at the right time to enhance the benefits from the project.
- Good risk management also allows stakeholders to have increased confidence in the organisation corporate governance and capability. (Keegan, 2004).

This report will elaborately discuss the risk analysis of Morley – Ellenbrook Line METRONET project, which has Australian Government's contributions of $500 million (AUD). The Morley-Ellenbrook project is a 21km long heavy rail corridor between Morley and Ellenbrook in the north-east region of Perth. The project would connect Ellenbrook to Perth CBD via Bays water station on the Midland line. It is proposed that the construction phase of the project would start from 2020-2021 and is expected to be completed in between 2023-2024. The main proposed objectives from this project is to develop an integrated station that would support Perth on meeting demands of the fast-growing city, demands of capacity, fast journey time, and provide business/jobs opportunities (METRONET, 2019).

2 Problem Diagnosis

Number of population and employment are tremendously growing in Western Australia. As the result, it requires North-East of Perth to assist Western Australia for minimizing the excessive growth by accommodating any possible economic activities in the future. However, it creates challenges for the existing corridors that link Morley and Ellenbrook. Followed by the fact that the region has high road congestion, poor connectivity and urban form, and risk of continuous urban sprawl. Thus, it is project that within 2016 and 2031, those areas will experience population growth rate of 3.3% per annum which is greater than the growth rate across metropolitan area in Perth (1.8% per annum). Additionally, 80% within the corridors lived in separated houses, while there are on 77% of population in Greater Perth lived in separated houses. Hence, the corridor has poor urban form.

Despite COVID-19 situation, which is expected to be heavily impacted Western Australia's economic status, the project is believed to be one of the key solutions to recover economic loss suffered by Western Australia (Government of Western Australia, 2020).

Finally, below are lists for the key internal and external stakeholders that may affect the project and to ensure successful completion of the project:

Internal Stakeholders:
- Employees (e.g. constructors, engineers, etc.)
- Directors
- Project partners
- Hygiene & Maintenance (crucial for COVID-19)

External Stakeholders:
- Environmentalist
- Western Australia Government
- Commuters
- Job Seekers
- Pedestrians
- Business owners within the line's stations
- Media
- Possible construction projects nearby
- Taxpayer
- Nearby residents

3 Project option description
Table 1: Morley-Ellenbrook Project options

Strategy Number	Strategy Description	Project Option Description
0	Zero investment	**Option 0:** Zero Project Investment
1	Heavy rail	**Option 1A:** New heavy rail line that link Perth – Morley – Ellenbrook. Additionally, the tunnelling from CBD to Malaga
		Option 1B: New heavy rail line from Bayswater – Ellenbrook via Tonkin highway
2	Bus rapid transit	**Option 2:** Bus rapid transit with the alignment of **Option 1B**
3	Hybrid bus rapid transit	**Option 3:** Hybrid heavy rail-bus transit with the alignment of **Option 1A.**

Option 0:

The existing connection within the corridors will be maintained. Since, rapid population growth, and poor connectivity are major problems that have been diagnosed, therefore this option will not be investigate any further. Since it will develop risks that lead to another risks.

Option 1A:

A new heavy rail line project options with path line that connects Perth – Morley – Ellenbrook. Furthermore, the heavy rail line will also include tunnelling from CBD to Malaga. Despite the ability to provide large economic benefits, it leads to higher capital cost that fails the option to return net benefit to the community. Hence, the project is not feasible and will not be investigated any further.

Option 1B:

The option offering a new heavy rail line with Bayswater – Ellenbrook alignment via Tokin Highway. This option is the result of refined and developed scopes, where those changes affecting cost and benefits of the option. Furthermore, the path chosen for the line provide faster travel time and provide better cost and benefits to be returned to the community. Hence, the option will be investigated further.

Option 2:

Finally, the last option offering a bus rapid transit with Bayswater – Ellenbrook alignment. The system will be investigated further due to its potential to provide higher benefits by providing higher capacity.

Option 3:

This option proposes a hybrid heavy rail-bus rapid transit with Perth – Morley – Ellenbrook alignment. However, the options will not be investigated any further and feasible due to the same reason as **Option 1A** above. The project cost higher capital cost and not able to return net benefit to the community.

4   Technical Description

Out of all the different project options discussed, only two options were considered for the analysis as per the feasibility criteria, the technical description for these project options are discussed below-

Option 1B (New Heavy Rail):

- The New Heavy Rail option outlays a 21km long heavy rail corridor between Morley-Ellenbrook along the Tonkin Highway in the north-eastern region of Perth.
- This option will have two elevated stations.
- This option is designed to have a provision for Future station at Bennett springs East.
- This Heavy rail project would run at grade rail line from Malaga to Ellenbrook.

- The main benefit of the New Heavy Rail option would be the travelling time from Ellenbrook to Perth CBD would be 30 mins or lesser.
- The planned Frequency of one train running along this rail would be one in every 10 minutes in the peak time and one in every 15 minutes off peak time by 2031.

Option 2B (Bus Rapid Transit):

- The Bus Rapid Transit option is a 12.5 km transit journey.
- This Rapid transit would consist of approximately 40 stops.
- The minimum travelling time taken would be 46 mins, but this could vary based on traffic.
- The frequency of buses from Morley Ellenbrook to Perth CBD is 40 minutes.

5 Financial analysis

5.1 Introduction

Financial analysis is an important aspect of every project because it justifies the economic viability of the project. The main objective of performing financial analysis is to determine the profitability and cost-effectiveness of the proposed project. The results of financial analysis help in choosing the best option out of all available projects based on their financial performance. (Tuovila, 2020)

5.2 Cost-Benefit Analysis

Cost benefit analysis (CBA) is the comparison of cost and benefits of a new project which forms the basis of comparing different project options and decide which has the greater benefits. A good CBA analysis includes following parameters. (Kenton, Cost-Benefit Analysis, 2020)

5.2.1 Benefit Cost Ratio (BCR):

BCR is an indicator representing the relationship between total relative cost and benefits of a new proposed project expressed in monetary terms. A BCR value of greater than 1 indicates a positive NPV to the organization and its investors whereas a BCR value of less than 1 indicates that a project is non profitable financially and should not be considered. (Hayes, 2020)

Benefit cost ratio of any project is calculated as shown below:

$$BCR = \frac{Present\ Value\ Benefit\ Expected\ From\ the\ Project}{Present\ Value\ of\ Cost\ of\ the\ Project}$$

Present value is calculated using following formula:

$$PV = FV*(1/(1+r)^n$$

Where, FV= Future Value.

r = Rate of return.

n = number of periods.

5.2.2 Net Present Value (NPV):

Present value and future value are closely related to each other and NPV help in finding the relationship between the two, NPV is the difference between present values of cash inflows and present value of cash outflows over a period, it is calculated as shown below- (Kenton, Net Present Value (NPV), 2020)

Figure 1: Net present value formula (Getcalc.com, 2020)

5.2.3 Payback Period:

Payback period is defined as the time period within which the total initial investment will be recovered or the time period within which an investment reaches break-even point, it is estimated as shown below- (Kagan, 2020)

Figure 2: Payback Period Formula (EDUCBA, 2020)

5.2.4 Internal Rate of Return (IRR):

The Internal rate of return is the discount rate at which the net present value of all the cash flows from an investment or a project becomes zero, it is useful in estimating an expected annual rate of growth from an investment.

$$0 = CF_0 + \frac{CF_1}{(1 + IRR)} + \frac{CF_2}{(1 + IRR)^2} + \frac{CF_3}{(1 + IRR)^3} + ... + \frac{CF_n}{(1 + IRR)^n}$$

Where:

CF_0 = Initial Investment / Outlay

$CF_1, CF_2, CF_{3,...} CF_n$ = Cash flows

n = Each Period

N = Holding Period

NVP = Net Present Value

IRR = Net Present Value

or

$$0 = NVP = \sum_{n=0}^{N} \frac{CF_n}{(1 + IRR)^n}$$

Figure 3: IRR Formula (McCamish, 2002)

5.2.1 Costs for the project

The total cost of the project comprises of initial investment/capital cost and annual maintenance/ operational cost, the cost estimated for the Morley- Ellenbrook project for both the options i.e. heavy rail and rapid bus transport are discussed below.

Table 2: Capital cost of project for Heavy rail and Rapid Bus transport

S.no.	Parameters	Cost (AU$ Million) (Heavy Rail)	Cost (AU$ Million) (Rapid bus transport)
1	Land Acquisition	150.0	180.0
2	Construction Materials	50.0	40.0
3	Construction Equipment's	100.0	60.0
4	Energy Resources	200.0	140.0
5	Geological Survey / Soil Investigation	50.0	50.0
6	Construction Labor Cost	100.0	80.0

7	Project Employees salary and wages	200.0	150.0
8	Electrical and Signaling Works	50.0	60.0
9	Stakeholders Engagement	50.0	40.0
10	Civil Works	200.0	100.0
11	Miscellaneous	100.0	50.0
	Total Cost	**1250.0**	**950.0**

Table 3: Annual Cost (financial) for heavy rail and rapid bus

S.NO.	Parameters	Cost (AU$ Million) (Heavy Rail)	Cost (AU$ Million) (Rapid Bus transport)
1	Maintenance	25.0	15.0
2	Employee and Labor salary and wages	10.0	5.0
3	Energy Resources	15.0	5.0
	Total Cost	50	25.0

5.2.2 Benefits for project

Benefits for financial analysis only considers direct monetary benefits which includes annual benefits of the project after its construction is completed and is ready to operate. The total annual benefits for both the options i.e. heavy rail and rapid bus transport are discussed below-

Table 4: Annual benefit (financial) for heavy rail (Option 1B)

S.NO.	Parameters	Cost (AU$ Million) (Heavy Rail)
1.	Fares	100.0
2.	Rent	20.0
3.	Increased Patronage	30.0

Table 5: Annual benefit for rapid bus transport (Option 2)

S.NO.	Parameters	Cost (AU$ Million) (Rapid Bus Transport)
1.	Fares	80.0
2.	Advertisement	20.0
3.	Increased Patronage	10.0
	Total Benefit	110.0

5.2.3 Cash Flow Calculation

The cash flow of any Project is calculated using net annual cost and net annual benefit, cash flow chart for the heavy rail option is shown below-

economic
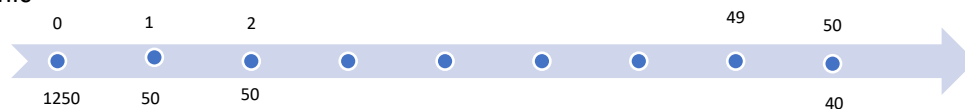
Cost of the project (AUD

Benefit of the Project

Annual Cash Flow of The Project

Figure 4: Cash Flow (financial) for heavy rail

5.2.4 Cost-Benefit Analysis (Financial) for the Morley-Ellenbrook Project

Table 6: Cost benefit analysis (financial) for new heavy rail (Option 1B)

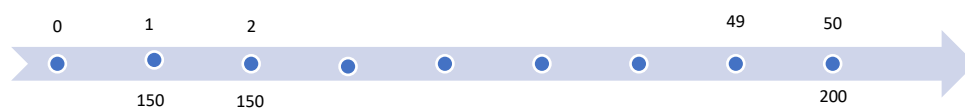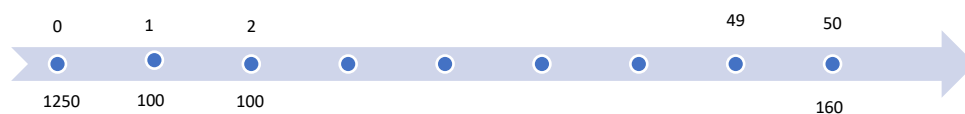| Inflation Rate	4%	7%	12%
Present Value Factor (PVF)	21.5	13.8	8.3
Net Present Value (NPV)	915.8	134.3	-417.5
Internal Rate Return (IRR)	8.2	8.2	8.2
Payback Period (PB) years	12.5	12.5	12.5
Benefit Cost Ratio (BCR)	1.73	1.1	0.66

Table 7; Cost benefit analysis (financial) for rapid bus transport (Option 2)

Inflation Rate	4%	7%	12%
Present Value Factor (PVF)	21.5	13.8	8.3
Net Present Value (NPV)	889.35	226.3	-242.04
Internal Rate Return (IRR)	9.4	9.4	9.4
Payback Period (PB) years	11	11	11
Benefit Cost Ratio (BCR)	1.94	1.24	0.74

5.2.5 Sensitivity Analysis (Financial)

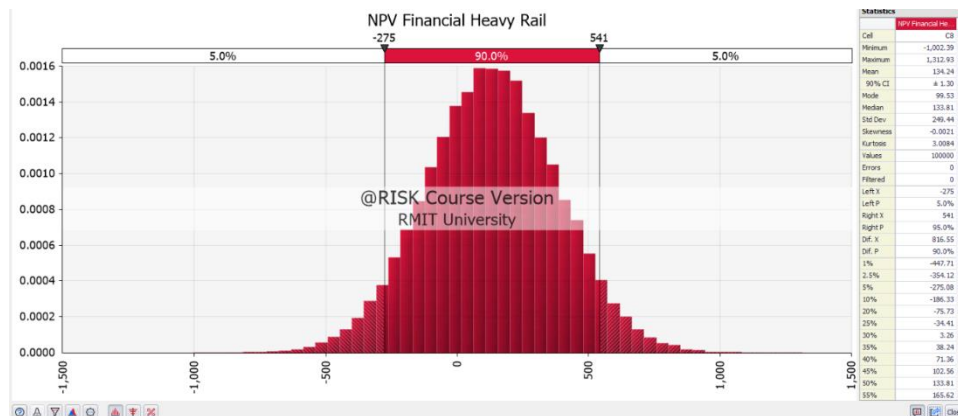*Figure 5: New heavy rail (Option 1B) probability density*
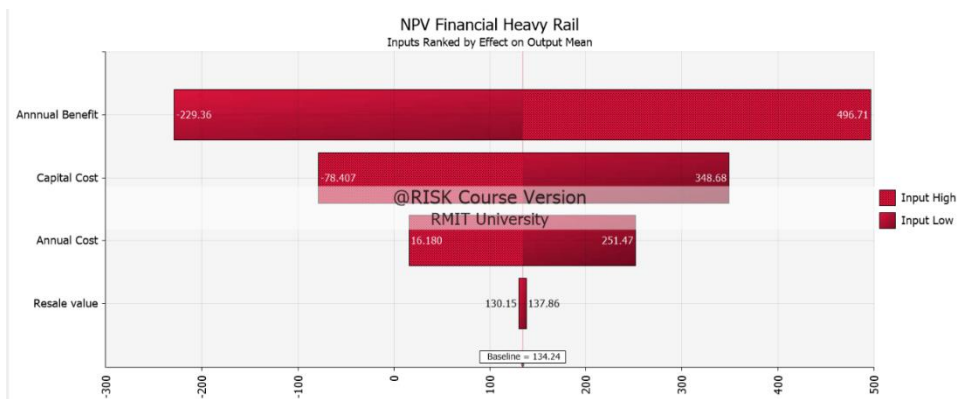
Figure 6: New heavy rail (Option 1B) tornado output statistics
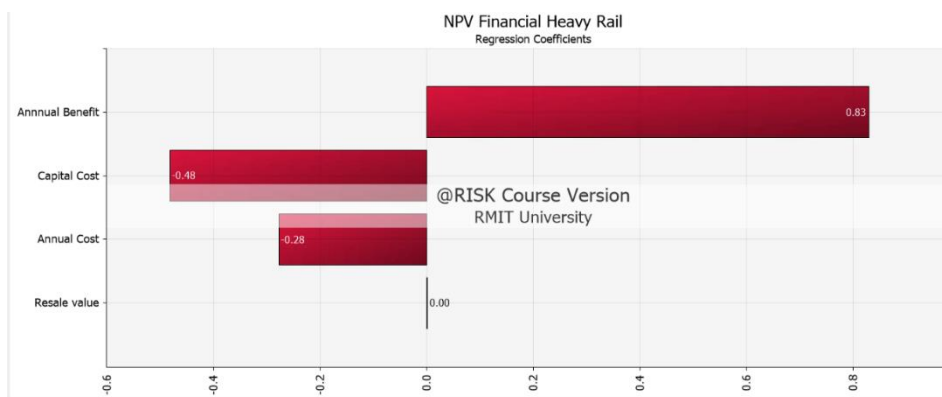
Figure 7: New heavy rail (Option 1B) tornado regression coefficient
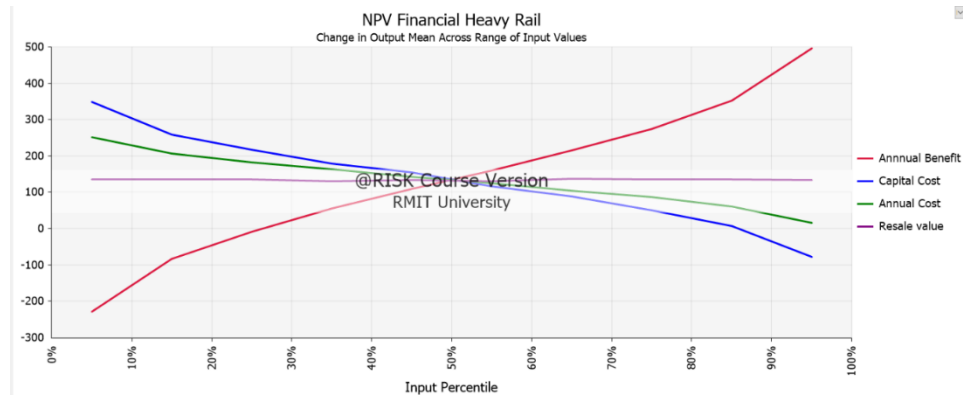
Figure 8: New heavy rail (Option 1B) spider output statistics
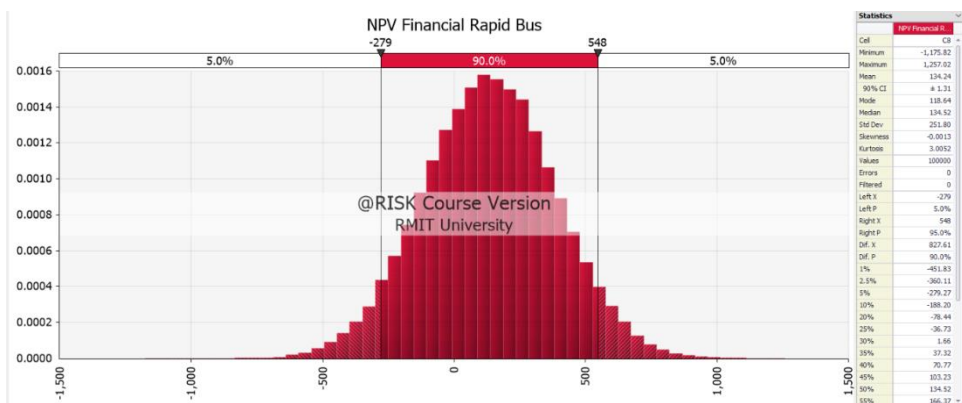
Figure 9: Rapid bus transport (Option 2) probability density
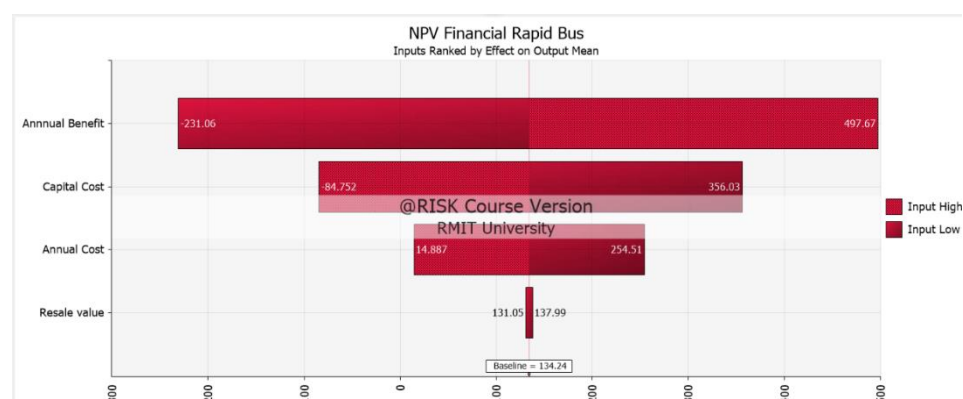
Figure 10: Rapid bus transport (Option 2) tornado output statistics
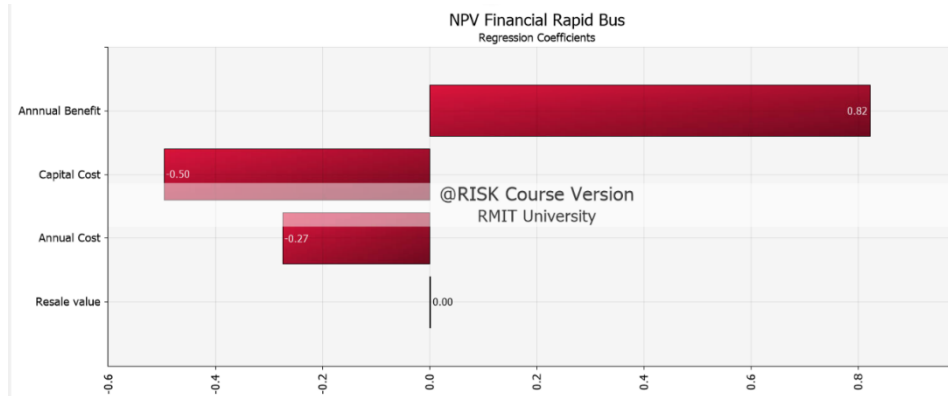
Figure 11: Rapid bus transport (Option 2) tornado regression coefficient
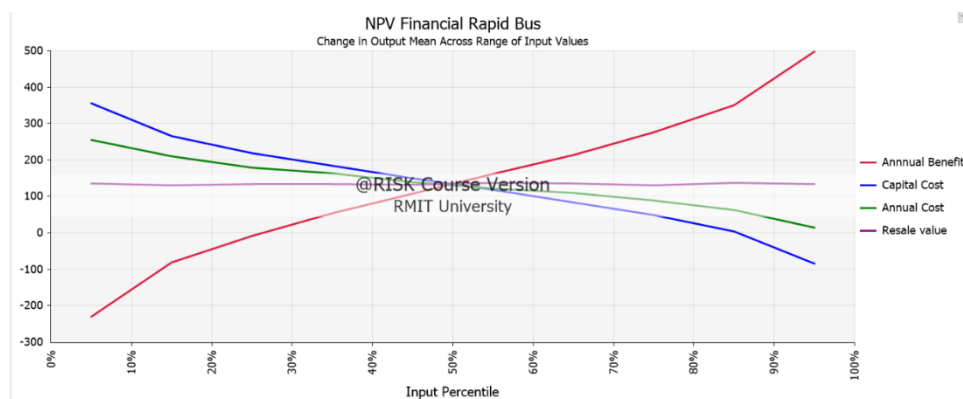
Figure 12: Rapid bus transport (Option 2) spider output statistics

6 Economic Assessment

6.1 Introduction

Economic impact assessment is an important aspect of every project because it justifies the economic viability of the project by considering both financial and social factors cost. The main purpose of economic assessment is to optimise the use of taxpayer money and ensure maximum benefit is achieved for the society from the project.

6.2 Annual Cost of Social Factors

Table 8: Annual cost of social factors of the project

S.NO.	Parameters	Cost AUD (Million) (Heavy Rail)	Cost AUD (Million) (Rapid Bus transport)
1.	Cost Due to Deforestation	10.0	15.0
2.	Environment Pollution cost	20.0	40.0
3.	Revenue from small business affected due to project.	30.0	15.0
4.	Cost due to congestion on road network	40.0	20
	Total Cost	100.0	90.0

6.3 Annual Benefit of Social Factors

Table 9: Annual benefits of social factors of the project

S.NO.	Parameters	Cost (AU$ Million) (Heavy Rail)	Cost (AU$ Million) (Rapid Bus transport)
1.	Benefit due to reduced congestion on the road network	60.0	40.0
2.	Travel Time Saving Cost	70.0	60.0
3.	Reduced accidents on Road	10.0	10.0
4.	Vehicles Operating Cost saving	10.0	10.0
	Total Benefit	150.0	120.0

- **For Heavy Rail option**

Total Economic Cost = Financial cost +Social factor cost =*150 Million (A$)*

Total Economic benefit = Financial Benefit + Social Benefits= *300 Million (A$)*

- **For Rapid Bus Transport**

Total Economic Cost = Financial cost +Social factor cost =*115 Million (A$)*

Total Economic benefit = Financial Benefit + Social Benefits= *230 Million (A$)*

6.4 Cost- Benefit Analysis (Economic) for Morley- Ellenbrook Project

Table 10: Cost benefit analysis (economic) for new heavy rail (Option 1B)

Inflation Rate	4%	7%	12%
Present Value Factor (PVF)	21.5	13.8	8.3
Net Present Value (NPV)	1989.9	824.35	-2.25
Internal Rate Return (IRR)	11.9	11.9	11.9
Payback Period (PB) years	8.3	8.3	8.3
Benefit Cost Ratio (BCR)	2.59	1.65	0.99

Table 11: Cost benefit analysis (economic) for rapid bus transport (Option 2)

Inflation Rate	4%	7%	12%
Present Value Factor (PVF)	21.5	13.8	8.3
Net Present Value (NPV)	1533.8	640.3	7.09
Internal Rate Return (IRR)	12	12	12
Payback Period (PB) years	8.26	8.26	8.26
Benefit Cost Ratio (BCR)	2.614	1.67	1.005

6.4.1 Sensitivity Analysis (Economic)
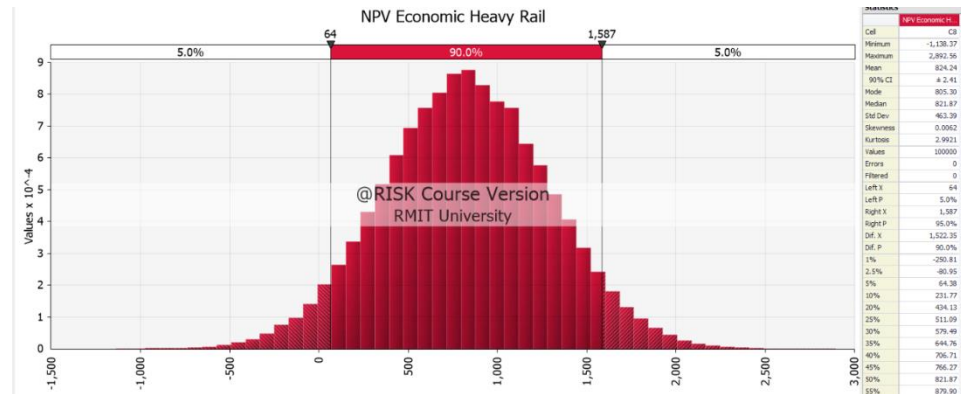
Figure 13: New heavy rail (Option 1B) probability density (economic analysis)
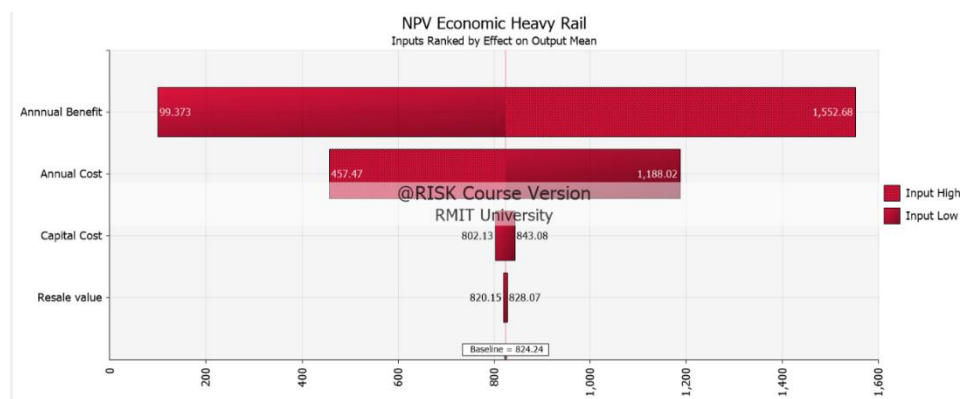
Figure 14: New heavy rail (Option 1B) tornado output statistics (economic analysis)

Figure 15: New heavy rail (Option 1B) tornado regression coefficient (economic analysis)
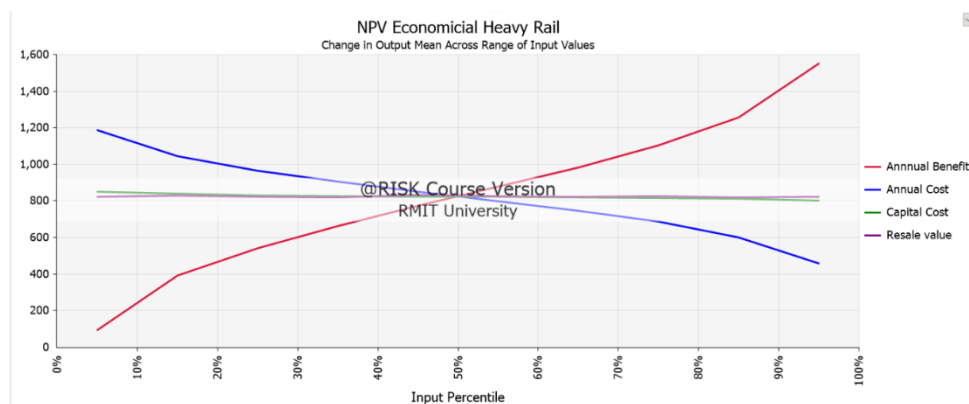
Figure 16: New heavy rail (Option 1B) spider output statistics (economic analysis)
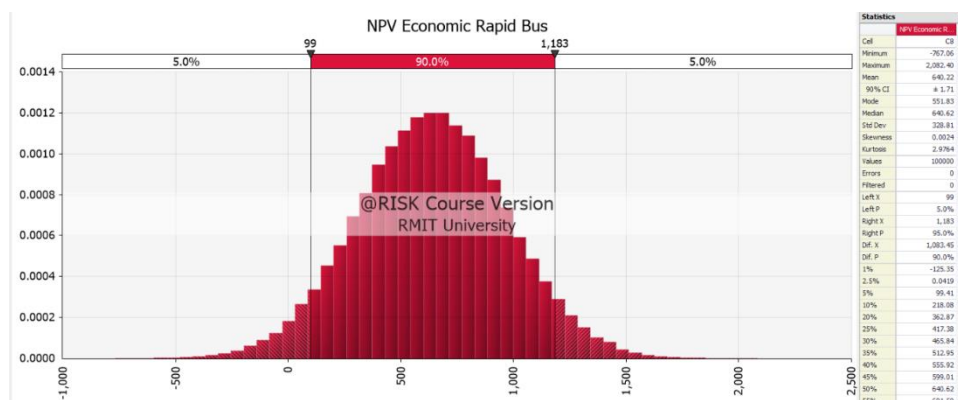
Figure 17: Rapid bus transport (Option 2) probability density (economic analysis)

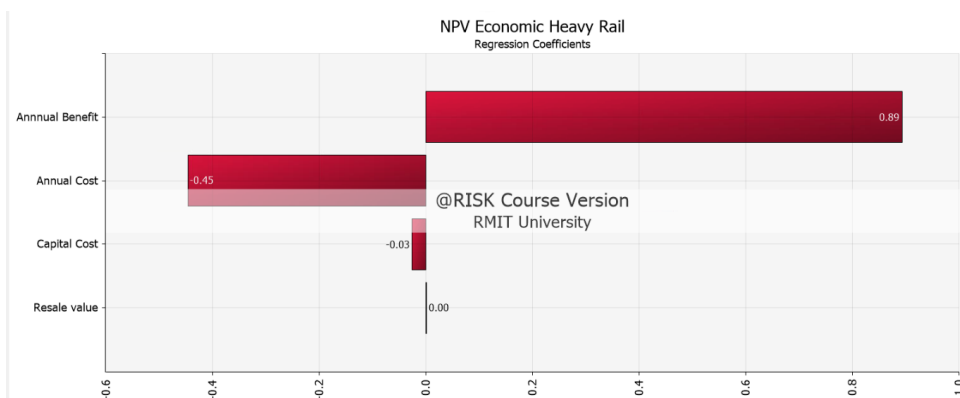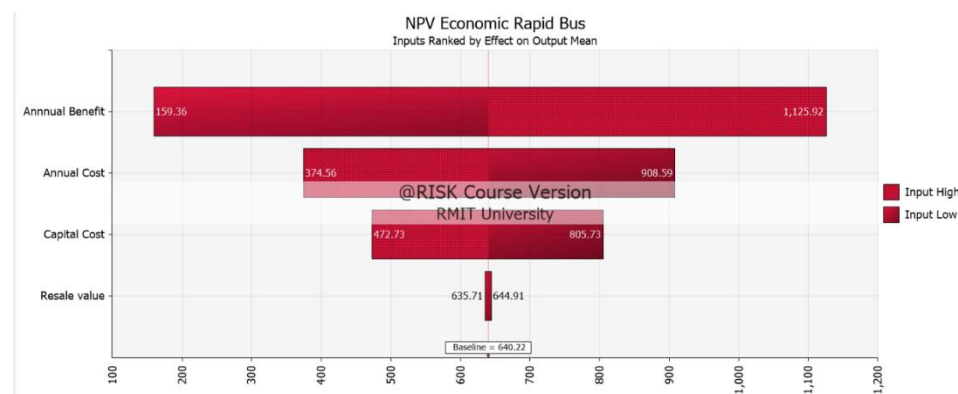*Figure 18: Rapid bus transport (Option 2) tornado output statistics (economic analysis)*
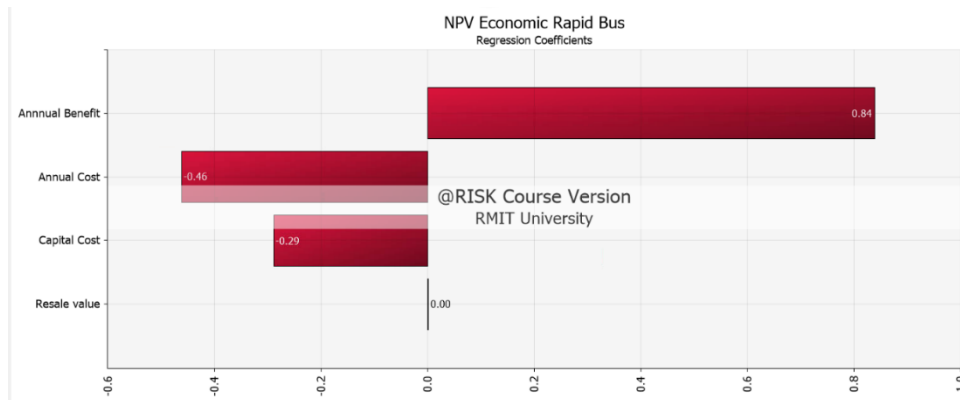
Figure 19: Rapid bus transport (Option 2) tornado regression coefficient (economic analysis)
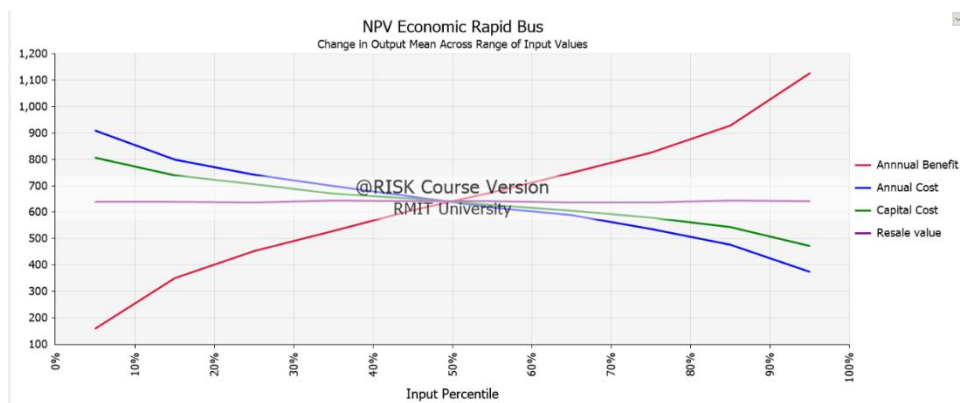
Figure 20: Rapid bus transport (Option 2) spider output statistics (economic analysis)

7 Non-Economic Impact Assessment

In this assessment, the best two options out of all available project options will be chosen and compared between each other. New heavy rail line (**Option 1B**) and bus rapid transit (**Option 2)** will be chosen for project options, where environment and variable capital cost are the chosen categories to be explored further in this task.

Method:

The method utilised in this assessment is rank-sum method, where this method would rank each criterion based on its importance and rate the option's potential performance on each criterion. This method will compute both qualitative and quantitative analysis on criteria of each category. On the other hand, the proposed method will evaluate the effectiveness of options on reducing, handling, or overcoming risks to/from environment (Usually unexpected events). For each chosen category there will be *n* criteria chosen in the analysis, and hence the ranking system shown below

Risk/Criterion Importance Ranking System:

The ranking system utilised for each criterion by viewing its importance towards the project is presented below

$$(Very\ Important)\ 1-2-3-4-5-6-\ldots-\text{nth}\ (Least\ Important)$$

While, the rating system for each criteria's performance would utilise formula below

$$R\ (Rating) = (n-r_i+1)$$

Followed by weighting the rating on each criterion by

$$W = R/SumR,\ \text{where SumR = the sum of all ratings}$$

Option's Effectiveness Level Scoring System:

The option's effectiveness level on responding to each criterion will scored from 1 to 10 as shown below

$$(Very\ Ineffective)\ 1-2-3-4-5-6-7-8-9-10\ (Very\ Effective)$$

Then, the procedure to choose the optimal project option is by choosing an option with the highest total weighted effectiveness score, where the weighted score is

$$Weighted\ Score = W*Score$$

Category: Environmental

Table 12: Rank sum method (Environmental)

Serial No. (n)	Criteria (Environmental)	Rank position (1st,2nd, …)	Rank score (r_i = 1,2,3...)	Rating $R=(n-r_i+1)$	Weight(W) $W = R/SumR$
1	Air Quality	4th	4	10	0.10989011
2	Water Quality	5th	5	9	0.098901099
3	Flood Risk	9th	9	5	0.054945055
4	Flora	7th	7	7	0.076923077
5	Fauna	10th	10	4	0.043956044
6	Archaeological	8th	8	6	0.065934066
7	Cultural Heritage	11th	11	3	0.032967033
8	Agriculture	12th	12	2	0.021978022
9	Mineral resources	13th	13	1	0.010989011
10	Population displaced	6th	6	8	0.087912088
11	Existing noise-incompatible land use	2nd	2	12	0.131868132
12	Future noise-incompatible land use	3rd	3	11	0.120879121
13	Vibration	1st	1	13	0.142857143
				SumR = 91	

Table 13: Rank sum method (Environmental) for each option.

S.NO.(n)	Criteria (Environmental)	Weighting (previous)	Score (out of 10)		Weighted Score	
			Option 1B (New Heavy-Rail)	Option 2 (Bus Rapid Transit)	Option 1B (New Heavy-Rail)	Option 2 (Bus Rapid Transit)
1	Air Quality	0.10989011	8	7	0.879120879	0.769230769
2	Water Quality	0.098901099	8	8	0.791208791	0.791208791
3	Flood Risk	0.054945055	9	7	0.494505495	0.384615385
4	Flora	0.076923077	8	7	0.615384615	0.538461538
5	Fauna	0.043956044	9	9	0.395604396	0.395604396
6	Archaeological	0.065934066	9	9	0.593406593	0.593406593
7	Cultural Heritage	0.032967033	9	8	0.296703297	0.263736264
8	Agriculture	0.021978022	6	7	0.131868132	0.153846154
9	Mineral resources	0.010989011	5	6	0.054945055	0.065934066
10	Population displaced	0.087912088	7	7	0.615384615	0.615384615
11	Existing noise-incompatible land use	0.131868132	4	5	0.527472527	0.659340659
12	Future noise-incompatible land use	0.120879121	6	6	0.725274725	0.725274725
13	Vibration	0.142857143	3	4	0.428571429	0.571428571
	Total Score				**6.549450549**	6.527472527

Category: Variable Capital Cost

Table 14 : Rank sum method (Variable Capital Cost)

Serial No. (n)	Criteria (Variable Capital Cost)	Rank position (1st,2nd, …)	Rank score (r_i = 1,2,3...)	Rating $R=(n-r_i+1)$	Weight(W) $W = R/SumR$
1	Site acquisition	4th	4	5	0.138888889
2	Relocation of new facilities	8th	8	1	0.027777778
3	Relocation of existing infrastructure	6th	6	3	0.083333333
4	Site reparation	7th	7	2	0.055555556
5	Access	3rd	3	6	0.166666667
6	New infrastructure	5th	5	4	0.111111111
7	Traffic disruption	2nd	2	7	0.194444444
8	Site constraint	1st	1	8	0.222222222
				SumR = 36	

Table 15: Rank sum method (Variable Capital Cost) for each option

S.NO.(n)	Criteria (Variable Capital Cost)	Weighting (previous)	Score (out of 10)		Weighted Score	
			Option 1B (New Heavy-Rail)	Option 2 (Bus Rapid Transit)	Option 1B (New Heavy-Rail)	Option 2 (Bus Rapid Transit)
1	Site acquisition	0.138888889	8	7	1.111111111	0.972222222
2	Relocation of new facilities	0.027777778	8	6	0.222222222	0.166666667
3	Relocation of existing infrastructure	0.083333333	8	7	0.666666667	0.583333333
4	Site preparation	0.055555556	7	6	0.388888889	0.333333333
5	Access	0.166666667	9	8	1.5	1.333333333
6	New infrastructure	0.111111111	8	7	0.888888889	0.777777778
7	Traffic disruption	0.194444444	7	6	1.361111111	1.166666667
8	Site constraint	0.222222222	7	7	1.555555556	1.555555556
	Total Score				**7.694444444**	6.888888889

From the assessment above, new heavy rail is superior to bus rapid transit in both areas explored. Therefore, new heavy rail is more effective compare to bus rapid transit in handling risks in each category.

8 Discussion and recommendation

Economic perspectives:

Based on economic analysis, at inflation rate of 7 % the new heavy rail (**Option 1B)** is a feasible option to go with because it has far high Net Present Value in both financial and economic category as compare to bus rapid transit **(Option 2)**. The Benefit Cost Ratio value for both options are quite similar in both financial and economic category, so for feasibility NPV was chosen.

Non-Economic perspectives:

Based on non-economic analysis, the new heavy rail **(Option 1B)** produces effectiveness that surpass bus rapid transit **(Option 2)** on both environmental and variable capital cost criteria. Furthermore, it is believed that bus rapid transit will only provide short-term benefit as it will reaches capacity in 2026 (Infrastructure Australia, 2020). Furthermore, in long-term, **Option 2** will consume more land in expanding bus rapid transit. In term of connectivity, speed, and range of travel, new heavy rail is far more efficient than bus rapid transit. On the other hand, new heavy rail would consume less land and provide long-term benefits that will returned to the community. Additionally, it is feared that bus rapid transit will potentially increase CO_2 emission and road congestion. Therefore, the team choose new heavy rail approach **(Option 1B)** as the optimal option to be implemented for this project due to its abilities that provide better capacity, and long-term benefits. Furthermore, since the construction phase of the project hasn't commenced (in late 2020 or in early 2021), it is recommended to perform continuous analysis, as unthinkable factors may appear, and consider the impact of COVID-19 to the analysis to achieve realistic and succulent piece of data analysis.

9 Conclusion

In conclusion, by undertaking economic and non-economic appraisal on Morley-Ellenbrook Line METRONET project, the team reveal that both result and project are feasible. The calculations in economic and financial assessments provide absolute knowledges towards the evaluation of the project's merit by comparing results between of all feasible project options, while non-economical assessment focuses on non-market factors to identify the effectiveness of each feasible option when being exposed to hazards or risks, and hence adding logical sense of judgements in economic/calculations. The team agreed that by undertaking project **Option 1B** *(new heavy rail)*, Morley-Ellenbrook Line METRONET project will be successful in the future. It is believed that more than 85% of the project benefits are contributed from travel time savings for road users and public transport (Infrastructure Australia, 2020). From economic assessment, even though, the benefit cost ratio for **Option 1B** is slightly lower than **Option 2**, the NPV value for **Option 1B** is significantly higher than **Option 2**. Furthermore, **Option 1B** provide better effectives (e.g. fast travel time, better connectivity, and efficient land use) and maintain long-term benefits, while **Option 2** only provide short-term benefits and is less efficient (e.g. meet capacity in 2026 and consume more land in the future). Hence, project **Option 1B** *(new heavy rail)* is chosen recommended to be undertaken for this project.

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