Financial and Economic Feasibility Study of Tempel - Yogyakarta - Samas Urban Railway Line

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Abstract. The government of the Special Region of. Yogyakarta proposed the development of the Tempel – Yogyakarta – Samas railway line. This study aimed to determine the financial and economic feasibility. Investment costs and income were calculated for the 50 years concession period from 2024 to 2073. The financial feasibility study was carried out with the parameters of Net Present Value (NPV), Internal Rate of Return (IRR), Benefit Cost Ratio (BCR), and payback period. Subsequently, an economic feasibility study was performed with ENPV and EIRR parameters. A financial feasibility study of the Tempel – Samas railway lane was feasible under a scenario using the government's support such as land acquisition, Viability Gap Fund (VGF) that consists of 40% of infrastructure cost, and train ticket subsidy. Economic feasibility indicators show the economic feasibility with ENPV IDR 25,616,108,257,312 and EIRR 15.85%.

1 Introduction

The need for public transportation in Yogyakarta increases as the roads in Yogyakarta became congested. The congestion itself is a result of population growth and the urban sprawl. There are two million trips and congestion is projected to get worse [1]. To minimize these problems, the government of the Special Region of Yogyakarta in, planned the development of urban railway networks such as Yogyakarta International Airport – Yogyakarta – Brambanan line, Yogyakarta International Airport – Parangtritis Line, and Tempel – Yogyakarta – Samas Line [1, 2]. From the three planned lines, Yogyakarta International Airport – Yogyakarta – Brambanan Line is already operational and others are not yet under the construction.

From Yogyakarta's Transportation problems, Governor's Regulation No.8 of 2017, and the Yogyakarta Transportation Master Plan, a financial feasibility study on the planned urban railway network is needed. The Yogyakarta Transportation Master Plan timeline shown that the Tempel – Yogyakarta – Samas Line is already behind schedule. It should have been in the land acquisition stage in 2021 [1]. A financial feasibility study has to be carried out in the context of planning the development of the railway network.

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Table 1. Passengers forecast for each corridor, 2017–2037 [4]

Station		Year (Passengers/day)				
Origin	**Destination**	**2017**	**2022**	**2027**	**2032**	**2037**
Tempel	Ngebong	72,402	127,587	224,836	396,209	698,205
Ngebong	Medari	72,402	127,587	224,836	396,209	698,205
Medari	Sleman	26,874	47,357	8,454	147,063	259,156
Sleman	Pangukan	49,638	87,472	154,145	271,636	478,680
Pangukan	Beran	49,638	87,472	154,145	271,636	478,680
Beran	Mlati	72,402	127,587	224,836	396,209	698,205
Mlati	Kutu	67,253	118,513	208,845	368,030	648,547
Kutu	Kricak	67,253	118,513	208,845	368,030	648,547
Kricak	Yogyakarta	39,446	69,512	122,495	215,863	380,396
Yogyakarta	Ngabean	39,446	69,512	122,495	215,863	380,396
Ngabean	Dongkelan	51,277	90,362	159,236	280,608	494,491
Dongkelan	Winongo	39,543	69,683	122,797	216,394	381,333
Winongo	Cepit	38,474	67,800	119,478	210,546	371,027
Cepit	Bantul	36,758	64,775	114,148	201,153	354,474
Bantul	Palbapang	35,365	62,321	109,823	193,532	341,045
Palbapang	Samas	31,971	56,340	99,284	174,959	308,314

2 Literature Study

2.1 Forecast Demand Tempel – Yogyakarta – Samas Line

The demand for Tempel – Yogyakarta – Samas Urban Railway Line has been forecasted by the government of the Special Region of Yogyakarta. There are 17 stations from Tempel to Samas, those are Tempel Station, Ngebong Station, Medari Station, Sleman Station, Pangukan Station, Beran Station, Mlati Station, Kutu Station, Kricak Station, Yogyakarta Station, Ngabean Station, Dongkelan Station, Winongo Station, Cepit Station, Bantul Station, Palbapang Station, and Samas Station [3]. From those stations, passengers forecast for each corridor are shown in the following (Table 1).

2.2 Urban Railway Investment Cost

Investment cost is a component of investment that has a negative value or inflict a financial loss [5]. Investment costs of a mass transportation project consist of construction costs, land acquisition costs, also operation and maintenance costs [6]. In the financial feasibility study, investment costs that need to be calculated are sunk cost, depreciation cost, debt and interest, engineering fee, land acquisition cost, construction cost, interest during construction, construction capital, operation and maintenance cost, renewal or replacement cost, contingencies, and intangible cost [5].

Table 2. Percentage of investment costs for each maintenance component [10]

No.	Component of Maintenance	Percentage of Investment Cost
1	Annual railway line maintenance	0.2%
2	Five-years railway line maintenance	0.5%
3	Annual railway station maintenance	0.4%
4	Five-years railway station maintenance	1.0%
5	Mechanical and electrical maintenance	1.0%
6	Trains maintenance	$0.3x10^{-6}$

The construction of the urban railway in Indonesia especially for the elevated railway line of LRT Jabodebek cost about IDR 235,880,000,000 per kilometer, for at grade railway line as estimated by the Department of Transportation of the Special Region of Yogyakarta cost about IDR 43,842,710,250 per kilometer [7]. The construction cost of signaling, telecommunication, trackwork, and electrical for the elevated railway line of LRT Jabodebek, cost around IDR 147,630,000,000 per kilometer. The construction cost of signaling, telecommunication, and electrical for at grade line of Yogya-Solo electrification cost around IDR 20,000,000,000 per kilometer. Estimated cost according to the Department of Transportation of the Special Region of Yogyakarta for the cost of station construction is around IDR 6,820,000 per square meter [4].

The operation and maintenance costs of railway operation must be calculated. Railway operation costs are calculated from the train operating cost components, such as direct fixed costs, direct variable costs, indirect fixed costs, and indirect variable costs [8, 9]. Maintenance costs can be calculated from the percentage of investment or construction cost. The percentage of maintenance costs are shown in the following (Table 2).

2.3 Urban Railway Revenue and Benefits

In contrast to the investment cost, revenue is a component of the investment that has positive value or provides benefits to the reviewed side. On the investor's side, revenues are direct benefits that come from ticket payments, track access charges, and other commercial revenues. While, on the user/passenger's side, the benefits of the urban railway are reduced travel costs, reduced time travel, and others benefits. Other benefits of the urban railway that have impacts on the area around the station are increased property prices, increased visitors to commercial areas, and other benefits [11].

The fare for urban railway tickets is not only based on operational cost, the Ability to Pay and Willingness to Pay or ATP-WTP needs to be calculated to determine ticket fare [12]. The ATP-WTP study of the urban railway in Yogyakarta shows that the average ability to pay are IDR 400.01 per kilometer for non-student passenger and IDR 210.45 per kilometer for student passenger [13]. In addition to ticket fares, the potential benefits of urban railway are revenues from property development and space rental [14]. Revenue

Table 3. Revenue unit price for property development [4]

Revenue Item	Unit	Unit Price (IDR)
1. Parking ticket a. Motorcycle b. Car	unit unit	5,000 15,000
2. Advertisement a. Big size advertisement board b. Small size advertisement board	unit/month unit/month	5,000,000 2,500,000
3. Space rental for tenants	m^2/month	240,000
4. Apartment rental	m^2/ month	80,000

from property development such as parking tickets, advertisements, space rental for tenants, and apartment rentals are shown in the following (Table 3).

2.4 Financial and Economic Feasibility

The objective of the financial feasibility study is to examine the feasibility extent of the project, so the limited resources can be allocated appropriately, efficiently, and effectively [5]. While, the objective of the economic feasibility study is to assure the economic benefits from infrastructure development are worth more than its economic costs [15]. The main focus of a financial feasibility study is to find out the profits of project operations, while economic feasibility study focuses on the benefits of a project for the general public as a whole.

3 Methodology

This study proposed five different scenarios. Scenario 1 with pessimistic passenger forecast, scenarios 2 and 4 with moderate passenger forecast, while scenario 3 and 5 with optimistic passenger forecast. Scenarios 4 and 5 are calculated with government supports such as land acquisition, Viability Gap Fund (VGF) that consists of 40% of infrastructure cost, and train ticket subsidy. The operation of urban railway in each scenario must to be simulated so that the amount of the train and its stamformation can be determined.

The investment costs and revenues or benefits must be calculated. All investment costs must be calculated in accordance with the rate of the inflation. The inflation rate used in this study was 1.77, which based on the average of the linear trend analysis data from 2022 to 2072. Then examine the financial indicators used in the financial feasibility study in each scenario, such as.

1. Net Present Value (NPV)/Economic Net Present Value (ENPV)

NPV/ENPV is used to calculate the profit of a project in a certain time period. NPV is used in financial feasibility study, while ENPV is used in economic feasibility study.

The positive value of NPV/ENPV indicates that the project will be profitable.

$$NPV = \sum_{t=0}^{N} \left[\frac{B_t - C_t}{(1+r)^t} \right] \quad (1)$$

NPV = NPV value (IDR)
B_t = revenues year t (IDR)
C_t = costs year t (IDR)
r = interest rate (disconto rate) (%)
N = project period (years)

2. Internal Rate of Return (IRR)/Economic Internal Rate of Return (EIRR)

IRR is used to determine the interest rate when NPV = 0. The IRR value will be financially feasible if the IRR value is greater than the discount rate, 9,64%.

$$NPV = \sum_{t=0}^{N} \left[\frac{B_t - C_t}{(1+r)^t} \right] \quad (2)$$

i = IRR value (%)
B_t = revenues year t (IDR)
C_t = costs year t (IDR)
N = project period (years)

3. Benefit Cost Ratio

BCR is a comparison between Present Value Benefit (PVB) and Present Cost Value (PCV). The project is determined to be financially feasible if the BCR value > 1.

$$BCR = \frac{\sum_{t=0}^{N} \left[\frac{B_t}{(1+i)^t} \right]}{\sum_{t=0}^{N} \left[\frac{C_t}{(1+i)^t} \right]} \quad (3)$$

BCR = BCR value
B_t = revenues year t (IDR)
C_t = costs year t (IDR)
i = interest rate (%)
N = project period (years)

The economic feasibility of financially feasible scenarios can be examined through the examination of economic benefits. The economic benefits of urban railway development can be calculated by examining the generalized cost that consists of vehicle operational costs, travel time costs, and pollution costs. After that, the ENPV and EIRR are examined to determine the economic feasibility. The following is a calculation of the generalized costs [16].

Table 4. Parameters condition differences scenario 1, 2, and 3

Parameter Condition	Scenario 1	Scenario 2	Scenario 3
1. Land acquisition cost (IDR)	1,471,620,435,950	1,471,620,435,950	1,471,620,435,950
2. Passenger forecast percentage	15%	30%	60%
3. Construction cost (IDR)	13,346,110,325,836	13,346,110,325,836	13,410,408,991,486
4. Viability Gap Fund (IDR)	-	-	-
5. Rolling stock procurement (IDR)	1,138,029,480,548	1,138,029,480,548	1,707,044,220,822
6. Ticket fare/km (IDR)	400	400	400
7. Ticket fare subsidies/km (IDR)	400	400	400
8. Operation & maintenance cost (2027) (IDR)	28,726,571,587	29,037,740,466	30,828,839,988
9. Revenue (2027) (IDR)	104,390,675,149	207,888,150,299	413,664,350,597

4 Results and Discussions

Five proposed scenarios have different parameter conditions for each aspect, such as land acquisition cost, passenger forecast percentage, construction cost or Viability Gap Fund (VGF), rolling stocks procurement, ticket fare and its subsidies, operation and maintenance cost, and revenue [17–19]. The differences in parameter conditions in each scenario are presented in the following (Table 4).

Scenarios 4 and 5 have different construction costs caused by the amount Viability Gap Fund (VGF). Scenario 4 represents 49% VGF of construction cost and scenario 5 represents 40%. Other parameter differences in scenarios 4 and 5 are government grants for ticket and the absence of land acquisition costs (Table 5).

The financial feasibility study was conducted by examining financial indicators of each scenario, such as NPV, IRR, BCR, and Payback Period. Financial indicators in scenarios 1, 2, 3, and 4 show that these scenarios were not financially feasible. The financial indicators in scenario 5 shown the last scenario proposed was financially feasible. NPV in scenario 5 was greater than 0, IRR was greater than the discount rate (9.64%), BCR was more than 1,00, and the Payback Period was calculated as under 50 years (Table 6).

Scenario 5 needs to be examined for its economic feasibility, so the VGF and subsidies can be provided for Tempel – Yogyakarta – Samas urban railway line. The economic feasibility indicators show that this urban railway line is economically feasible, with ENPV greater than 0, EIRR greater than the discount rate, and BCR greater than 1 (Table 7).

Table 5. Parameters condition differences scenario 4 and 5

Parameter Condition	Scenario 4	Scenario 5
1. Land acquisition cost (IDR)	-	-
2. Passenger forecast percentage	30%	60%
3. Construction cost	7,567,896,090,019	8,693,499,411,228
4. Viability Gap Fund (IDR)	5,778,214,235,816 (49% of construction cost)	4,716,909,580,258 (40% construction cost)
5. Rolling stock procurement (IDR)	1,138,029,480,548	1,707,044,220,822
6. Ticket fare/km (IDR)	700	700
7. Ticket fare subsidies /km (IDR)	300	300
8. Operation & maintenance cost (2027) (IDR)	29,037,740,466	30,828,839,988
9. Revenue (2027) (IDR)	357,333,948,128	712,555,946,256

Table 6. Financial feasibility indicators in each scenario

Indicators	NPV (IDR)	IRR	BCR	Payback Period	Financial Feasibility
Scenario 1	-14,864,485,456,763	0.53%	0.131	> 50 years	Not Feasible
Scenario 2	-13,275,937,522,960	2.77%	0.252	> 50 years	Not Feasible
Scenario 3	-11,069,191,339,088	5.09%	0.447	> 50 years	Not Feasible
Scenario 4	-2,733,951,023,503	7.80%	0.832	> 50 years	Not Feasible
Scenario 5	1,703,642,332,502	10.46%	1.092	41 years	Feasible

Table 7. Economic feasibility indicators scenario 5

Indicators	Results	Standard	Description
ENPV	25,616,108,257,312	> 0	Feasible
EIRR	15.85%	> 9.64%	Feasible
BCR	2.28	> 1	Feasible

5 Conclusion

Based on the financial and economic feasibility study, Tempel – Yogyakarta – Samas urban railway line is financially feasible if there are 60% passengers from passengers forecasted, land acquisition cost and 40% of construction cost financed by government, and there are ticket fare subsidies. This condition applied in scenario 5 with financial indicators showing financially feasible with NPV IDR 1,703,642,332,502, greater than 0, IRR 10.46%, greater than 9.64%, BCR 1.092, greater than 1, and Payback Period

41 years, less than 50 years. Tempel – Yogyakarta – Samas urban railway line is also economically feasible with ENPV IDR 25,616,108,257,312, EIRR 15.85%, and BCR 2.28.

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