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FEASIBILITY ANALYSIS OF TRANS-SUMATERA TOLL ROAD USING VALUE ENGINEERING METHOD

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ABSTRACT

The Trans-Sumatera Toll Road (TSTR) Infrastructure Project is planned to stretch from Bakauheni to Banda Aceh (2527 kilometers), with an estimated investment about IDR 290 trillion. The value engineering method is applied to the TSTR project by creating six additional functions for a toll road: motorcycle lane integration, rest area development, dry port integration, median railways integration, tourism park development, and fiberoptic networking. The feasibility analysis is constructed using a system dynamic approach to three toll tariff scenarios. The result reveals that the additional functions have improved the financial feasibility of TSTR project, with the internal rate of return for the three proposed scenarios ranging from 8.28% to 13.77%.

Keywords: Feasibility study; Trans-Sumatera Toll Road, System dynamic; Value engineering

1. INTRODUCTION

Indonesia is a developing country with a population reaching 242.3 million people in 2013, with a gross domestic product (GDP) of US $878.2 billion (World Economic Forum, 2013). Global competitiveness index (GCI) research and a 2013-2014 survey place Indonesia 38th of 148 countries with respect to general competitiveness. The GCI has twelve fundamental pillars that are used in the assessment of the competitiveness of a given country, one of which is infrastructure. Regarding this particular pillar, the infrastructure in Indonesia is 61st of 148 countries with a score of 4.17, where the topmost position is held by Hong Kong (6.47), followed by Singapore (6.41), Germany (6.24), France (6.21), and Saudi Arabia (6.20). Among the ASEAN countries, Indonesia's infrastructure is still below Malaysia’s (5.19), in position 29; Thailand’s (4.53), in position 47; and Brunai Darussalam’s (4.29), in position 58.

The competitiveness of Indonesia's economy greatly depends on the availability of infrastructure supporting the domestic connectivity of economic centers, as well as external connectivity to the main destination market (Indonesia Infrastructure Initiative, 2012). The Master Plan for the Acceleration and Expansion of Indonesia's Economic Development (MP3EI) divides the development of regional economic potentials into six corridors, one of

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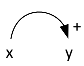
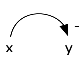
which proposes that Sumatera should act as the economic gateway in the western part of Indonesia. The Trans-Sumatera Toll Road (TSTR) is planned to stretch from Bakauheni to Banda Aceh along the East route for ± 2,713 kilometers, with a total investment of IDR 330 trillion (Ministry of Public Works, 2011). This toll road will link eight provinces, Aceh, West Sumatera, Riau, Jambi, South Sumatera, Bengkulu, and Lampung, with seven central national cities, five airports, and six major seaports. The Trans-Sumatera Toll Road is also projected to be the part of Asian Highway Network, which will be the linking artery in the Southeast region, and included in the Master Plan on ASEAN Connectivity (MPAC).

The high investment in toll roads and the low finance interest rate of return (FIRR), which is only about 7.79%, make it difficult to attract private investors to the project. This necessitates alternatives, ideas, elegant methods, and creative and innovative efforts to add functions and benefits to the project. Value engineering (VE) is a systematic process used by a multidisciplinary team to increase the value of a project by analyzing the functions (SAVE *International Value Standard*, 2007). The VE method has already been systematically tested in analyzing the functions of a system in order to generate the optimum output for a project, either in terms of quality, technology, efficiency, or innovation (Abdul Rahman & Berawi, 2002; Berawi & Woodhead, 2005a; Berawi & Woodhead, 2005b; Berawi & Woodhead, 2005c; Woodhead & Berawi, 2008; Berawi, 2009). In addition to generating cost efficiency, VE is also a method of analysis that is capable of providing innovation and competitive advantages to a project or a product in the context being discussed (Berawi, 2006; Berawi, 2009; Woodhead & Berawi, 2008). Value engineering considers the relationships between values, functions, and cost in a wider perspective to create added values for a particular project. According to SAVE international value standards (2007), value is an expression of the relationship between functions and resources. The relation is as follows:

$$Value = \frac{Function}{Cost} \tag{1}$$

Additional value engineering for the TSTR Project was performed via roadway/route engineering based on potentials of each province. This engineering also planned six added functions as a result of the creation of innovative functions that are believed to improve the feasibility of the project. This research aims to analyze the revenue potentials of each added function of the TSTR project and analyze the feasibility of investment in the added functional engineering of the TSTR project. The revenue analysis will be conducted by using a system dynamics approach, which is capable of finding solutions to complex non-linear problems and providing a reliable estimation for the Trans-Sumatera Toll Road engineering. In performing system dynamic modeling, systems are visualized using a causal loop diagram (CLD) and a stock and flow diagram (SFD). The symbols used in a CLD are listed in Table 1.

Table 1 Symbols in *Causal Loop Diagram*

No	Symbol	Meaning
1	Cause ⟶ Effect	The upstream shaft of the arrow is the cause and the end of the arrowhead is the effect
2	⟶	Physical flow
3	– – – – – – – ►	Information flow
4		One direction causal-effect relationship
5		Opposite direction causal-effect relationship

(Source: Sterman, 2000)

2. RESEARCH METHODOLOGY

The process of this research begins with identifying problems in the Trans-Sumatera Toll Road. To reinforce the background of this research, a literature review on the concept of value engineering for infrastructure projects was performed. There are two objectives. The first objective is to define a revenue projection of each additional function of the TSTR. This is performed by analyzing the revenue generating factors and then arranging them into a causal loop diagram (CLD). Subsequently, a simulation model will be analyzed, and then, the results will be modeled in a software program. After the revenue projection for each TSTR function is generated, the life cycle cost (LCC) is analyzed to determine the feasibility of the TSTR functions. Furthermore, some functional scenarios are constructed to determine the effectiveness of each added function. Finally, a focus group discussion of the feasibility of the Trans-Sumatera Toll Road Project investment was conducted.

2.1. Conceptual Design of the TSTR Project Engineering

The creativity and idea generation needed for the TSTR conceptual design is directed by creating additional functions for the TSTR that consider all existing potentials surrounding the Trans-Sumatera Toll Road infrastructure project. The results of this creative step will be the materials used in formulating the FAST diagram of the additional functions, i.e., the supporting functions (data transmission/telecommunication and tourism industry development) and the supporting processes (fiber optic construction, service and rest area construction, median railway construction, dry port/inland port construction, motorcycle lane construction, and plantation development), as shown in Figure 1.

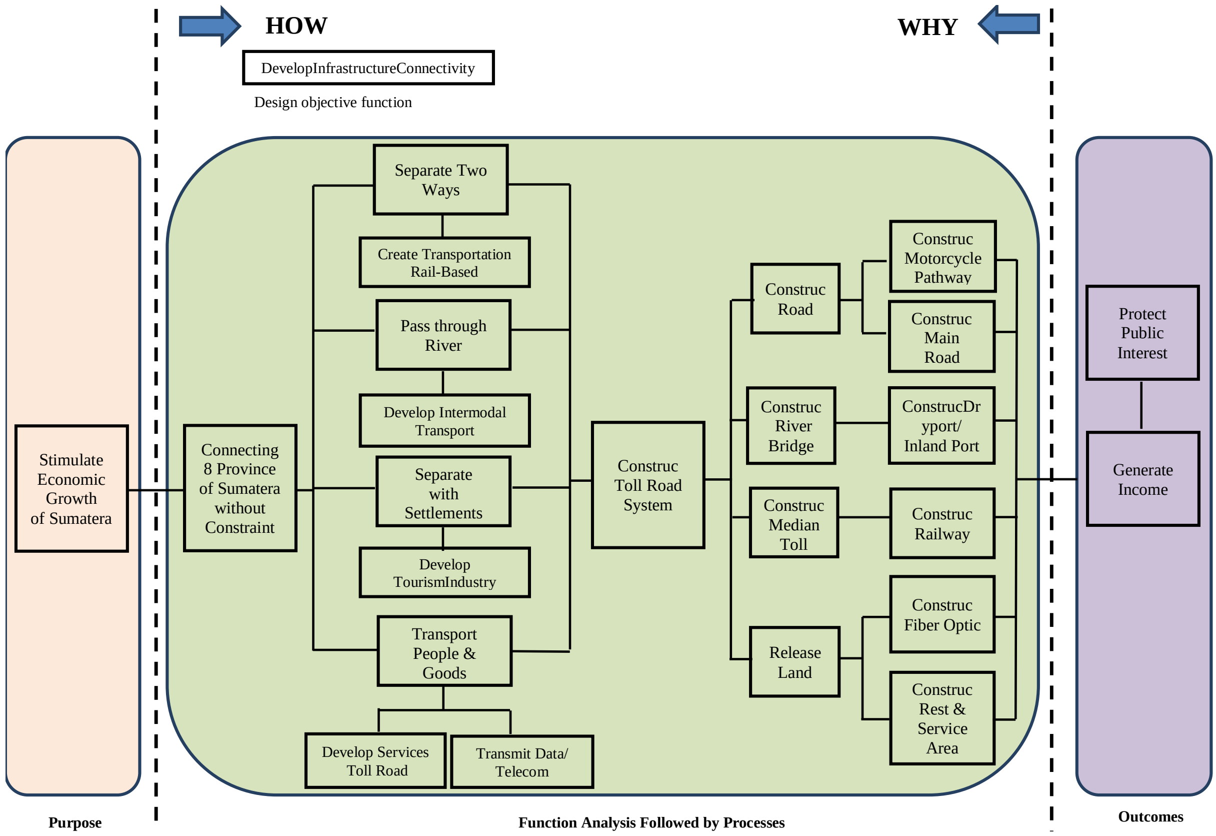


Figure 1 FAST Diagram of the TSTR Project

Figure 2 shows the proposed toll route, integrating additinal functions in the TSTR project. The selected route was choosen based on each region's population, potential, and leading sectors using the location quotient (LQ) method.

Figure 2 TSTR Route Engineering Plan

Table 2 Recapitulation of the Cost of Investment for the TSTR Project Engineering

No	Component/Function	Location	Existing Plan	TSTR Design Engineering
			TSTR by BPJT (IDR Million)	TSTR by CSID (IDR Million)
1	Toll Road	Eight Provinces in Indonesia	IDR 338,560,054.00	IDR 290,750,000.00
2	Integration of Special Lane for Motorcyle	Bakauheni - Bandar Lampung		IDR 301,767.00
3	Rest Area Development	156 Rest Area Points + 4 Special Rest Area Points		IDR 4,687,000.00
4	Dry Port Integration	Pekanbaru Dry Port		IDR 877,960.00
		Palembang Dry Port		IDR 109,754.00
5	Median Railways Integration	Pekanbaru Dry Port - Dumai Port		IDR 8,332,024.00
6	Recreational Area Development (Theme Park, Medan)	Medan		IDR 28,300,198.00
7	Fiber Optic Line Integration	Medan - Pekanbaru		IDR 145,240.00
		Total	IDR 338,560,054.00	IDR 333,499,953.00

Based on the above routes, the cost of the TSTR project investment is shown in Table 2, including the comparative estimated cost for single-function toll road created by the government (BPJT). The estimated cost of the construction of the toll road is calculated based on the average bechmarked cost found by the BPJT in 2012, whereas additional functions are estimated based on the study cases, which have been adapted to the development plans of each function.

2.2. TSTR Revenue Simulation: Causal Loop Diagram

A system dynamic simulation begins with a causal loop diagram (CLD). The CLD, in this modelling, is developed into three sub-categories: the main functions category, consisting of the toll road and rest area functions; the additional functions category, consisting of dry port integration, median railways integration, tourism, and fiberoptic functions; and economic category, an external factor influencing both functions. The CLD of the revenue simulation for TSTR Project can be seen in Figure 3.

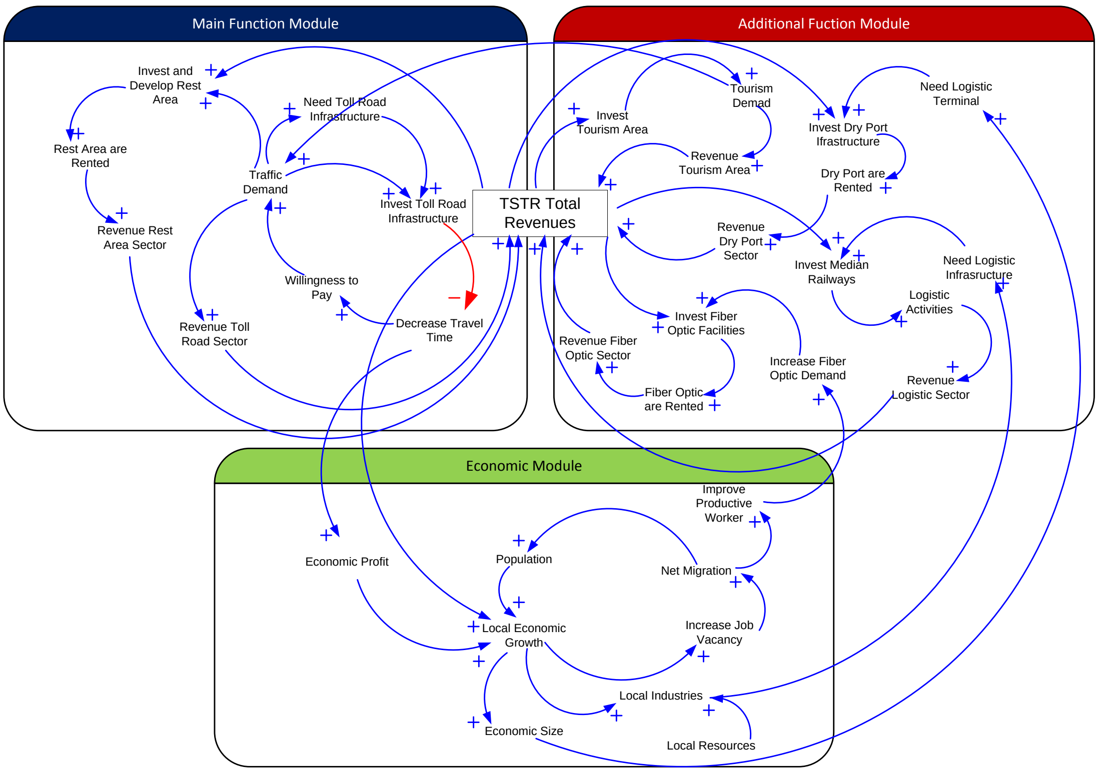


Figure 3 Causal Loop Diagram for TSTR project revenue

3. REVENUE MODEL SIMULATION OF TSTR PROJECT ENGINEERING

A simulation/modeling of the TSTR system is conducted based on the causal loop diagram (CLD) of the revenue of the project. In this revenue simulation, the concept of *supply and demand* dominates the analysis of each function's potential. This simulation is divided into two parts; the first part is the function of the toll road as the main source of revenue, and the second part is the functions intended to be added to the TSTR system, i.e., motorcycle lane integration, rest area development, dry port integration, median railways integration, tourism park development, and fiber optic networking. Three tariff scenarios for each function will be tested in this simulation to determine the revenue potentials that will be generated by each function. This simulation will start in 2016, when the first phase of TSTR construction is slated to begin, and construction is predicted to finish in 2060.

3.1. TSTR Life Cycle Cost Analysis (Single-Function)

After translating the causal loop diagram into a stock and flow diagram, a simulation is performed to determine the demand potentials for each TSTR function. This simulation generated several outputs in the form of demand-to-revenue-potentials projections, which will be adapted to the planned tariff scenarios. The Trans-Sumatera Toll Road is planned to stretch along the East Route of Sumatera Island and also along two connecting corridors from the western part of Sumatera to the eastern part. The toll road will be divided into 22 segments, for which the travel volume will be projected in this simulation. Based on the results of the travel-volume forecasting, the segment having the highest travel volume is Palembang - Pangkalan Balai - Sekayu; Medan - Tebing Tinggi - Pematang Siantar; Bandar Lampung - Metro - Kota Bumi; and Medan - Langsa. While for the segment with the lowest travel volume forecasting is Lubuk Linggau - Bengkulu; Sigli - Banda Aceh; and Tebing Tinggi - Lima Puluh. The travel volume forecasting will have a great influence on the revenue potentials.

Furthermore, toll tariff scenarios will be used in forecasting the revenue potentials of the main function of the toll road. In this revenue simulation, three tariff scenarios are examined. Those tariff scenarios are grouped into the main corridor tariff and the connecting corridor tariff. The scenarios are based on the average tariff of PT Jasa Marga, which is IDR 150/km. The three tariff scenarios are as follows:

1. Low-tariff scenario	:	Main Corridor	:	IDR 150/km
		Connecting Corridor	:	IDR 300/km
2. Intermediate-tariff scenario	:	Main Corridor	:	IDR 300/km
		Connecting Corridor	:	IDR 300/km
3. High-tariff scenario	:	Main Corridor	:	IDR 300/km
		Connecting Corridor	:	IDR 600/km

The revenue projection results for the three tariff scenarios can be seen in Figure 5.

After performing the revenue projection for the three tariff scenarios, lifecycle cost (LCC) analysis is performed. LCC analysis will be conducted for a period of 40 years, starting from the first year of operation for each TSTR segment planned. The LCC analysis was conducted using a discounted rate of 6.81% (average of the Bank of Indonesia rate over the last 7 years). A negative net present value (NPV), indicated by the bracket, shows that the investment will not meet the break-even point during the 40-year simulation. The results of the LCC analysis are shown in Table 3.

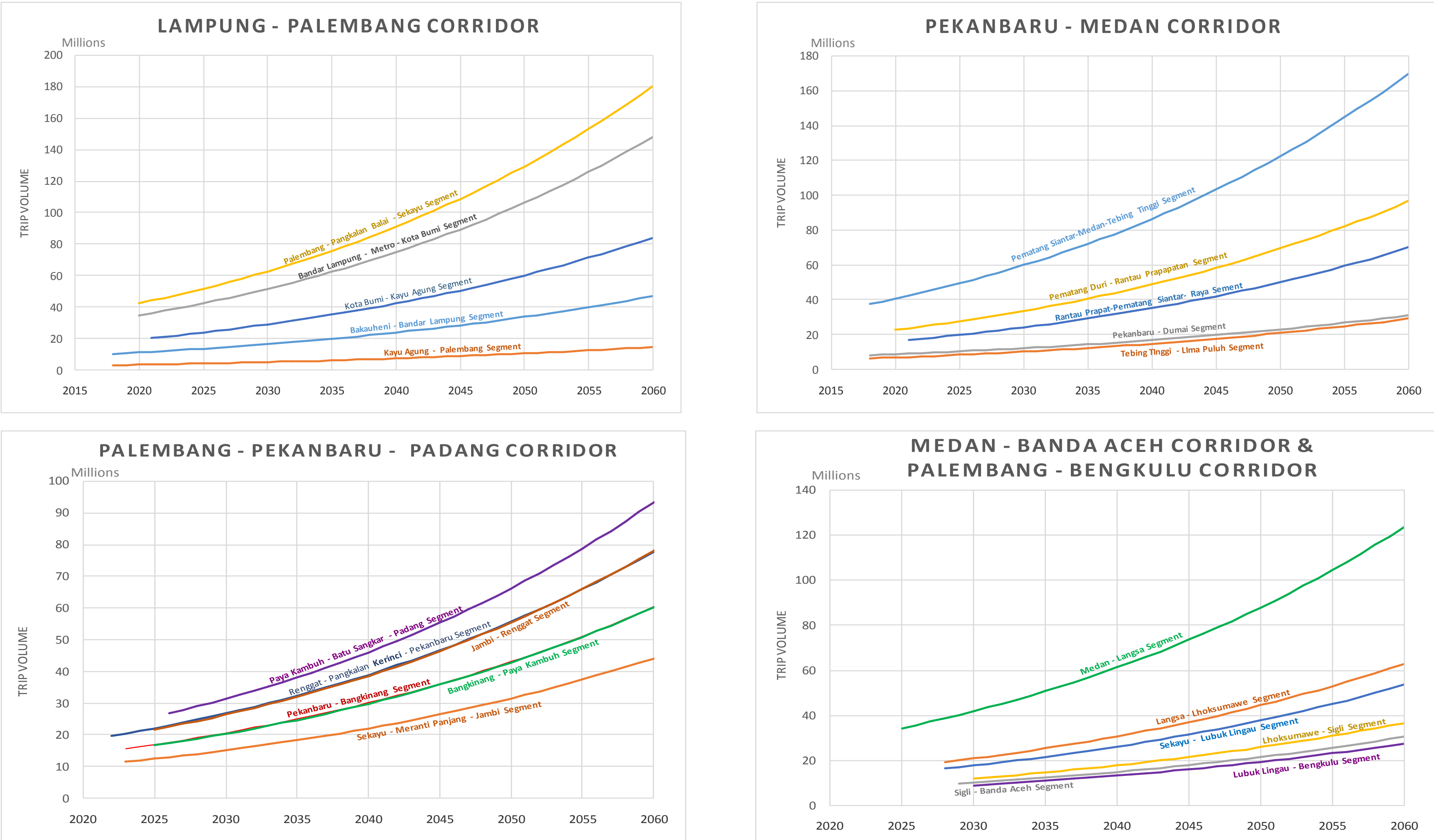


Figure 4 Results of Segment Travel Volume Forecasting Simulation for the Trans-Sumatera Toll Road

Table 3 Lifecycle Cost Analysis of Toll Road Functions (40-year simulation)

		Toll Road Section	Length	Tariff Scenario 1		Tariff Scenario 2		Tariff Scenario 3	
				NPV	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**
Pekanbaru - Medan (Main Corridor)			**547.2**	**Tariff IDR 150/km**		**Tariff IDR 300/km**		**Tariff IDR 300/km**	
1	1	Bakauheuni - Bandar Lampung	85.8	IDR (4,166,077,903)	4.31%	IDR 3,814,021,548	8.55%	IDR 3,814,021,548	8.55%
	2	Bandar Lampung - Metro - Kota Bumi	102.3	IDR 14,795,672,225	11.92%	IDR 39,284,113,454	17.32%	IDR 39,284,113,454	17.32%
	3	Kota Bumi - Kayu Agung	185.3	IDR 1,800,180,783	7.21%	IDR 31,596,994,241	12.32%	IDR 31,596,994,241	12.32%
	4	Kayu Agung - Palembang	63.8	IDR 1,266,756,648	7.67%	IDR 11,574,881,369	13.04%	IDR 11,574,881,369	13.04%
	5	Palembang - Pangkalan Balai - Sekayu	110	IDR 13,662,702,578	11.30%	IDR 43,510,685,822	18.63%	IDR 43,510,685,822	18.63%
Palembang - Pekanbaru (Main Corridor)			**494.8**	**Tariff IDR 150/km**		**Tariff IDR 300/km**		**Tariff IDR 300/km**	
2	A	Sekayu - Meranti Panjang - Jambi	151.5	IDR (11,040,904,585)	2.87%	IDR 2,130,740,730	7.37%	IDR 2,130,740,730	7.37%
	B	Jambi-Renggat	184.9	IDR 4,754,905,777	7.76%	IDR 40,777,837,943	13.17%	IDR 40,777,837,943	13.17%
	C	Renggat - Pangkalan Kerinci - Pekanbaru	158.4	IDR 881,851,982	7.03%	IDR 26,389,732,806	11.99%	IDR 26,389,732,806	11.99%
Pekanbaru - Medan (Main Corridor)			**581.4**	**Tariff IDR 150/km**		**Tariff IDR 300/km**		**Tariff IDR 300/km**	
3	A	Pekanbaru - Pematang Duri - Dumai	133.2	IDR 12,283,985,054	10.22%	IDR 43,444,305,962	16.55%	IDR 43,444,305,962	16.55%
	B	Pematang Duri - Rantau Prapat	191	IDR 201,852,934	6.86%	IDR 28,428,668,671	11.99%	IDR 28,428,668,671	11.99%
	C	Rantau Prapat - Pematang Siantar - Raya	135	IDR (4,127,838,397)	5.39%	IDR 12,595,131,889	10.35%	IDR 12,595,131,889	10.35%
	D	Pematang Siantar- Tebing Tinggi - Medan	93.08	IDR 10,626,211,339	10.90%	IDR 34,429,184,779	17.60%	IDR 34,429,184,779	17.60%
	E	Tebing Tinggi - Lima Puluh	29.12	IDR (2,450,533,773)	1.57%	IDR (1,143,375,532)	4.88%	IDR (1,143,375,532)	4.88%
Banda - Aceh Medan (Main Corridor)			**480.2**	**Tariff IDR 150/km**		**Tariff IDR 300/km**		**Tariff IDR 300/km**	
4	A	Medan - Langsa	118	IDR 9,098,487,655	9.68%	IDR 37,179,559,120	16.16%	IDR 37,179,559,120	16.16%
	B	Langsa - Lhoksumawe	136.8	IDR (280,011,728)	6.72%	IDR 22,839,562,421	12.27%	IDR 22,839,562,421	12.27%
	C	Lhoksumawe - Sigli	145.5	IDR (9,302,587,658)	3.61%	IDR 7,911,233,100	8.78%	IDR 7,911,233,100	8.78%
	D	Sigli - Banda Aceh	79.9	IDR (6,228,181,870)	2.61%	IDR (435,894,122)	6.58%	IDR (435,894,122)	6.58%
Pekanbaru - Padang (Connecting Corridor)			**212.9**	**Tariff IDR 300/km**		**Tariff IDR 300/km**		**Tariff IDR 600/km**	
5	A	Pekanbaru - Bangkinang	50.4	IDR 463,684,259	7.06%	IDR 463,684,259	7.06%	IDR 12,103,309,257	11.96%
	B	Bangkinang - Paya Kambuh	72.5	IDR 2,730,040,838	7.78%	IDR 2,730,040,838	7.78%	IDR 21,932,227,768	12.97%
	C	Paya Kambuh - Batu Sangkar - Padang	90	IDR 26,951,580,097	12.41%	IDR 26,951,580,097	12.41%	IDR 75,391,766,762	19.65%
Palembang - Bengkulu (Connecting Corridor)			**211.1**	**Tariff IDR 300/km**		**Tariff IDR 300/km**		**Tariff IDR 600/km**	
6	A	Sekayu - Lubuk Lingau	116.1	IDR 13,913,698,817	9.55%	IDR 13,913,698,817	9.55%	IDR 54,744,432,342	15.37%
	B	Lubuk Lingau - Bengkulu	95	IDR (5,350,921,112)	5.13%	IDR (5,350,921,112)	5.13%	IDR 12,581,218,626	9.81%
				Average IRR	**7.25%**	**Averege IRR**	**11,34%**	**Average IRR**	**12.61%**

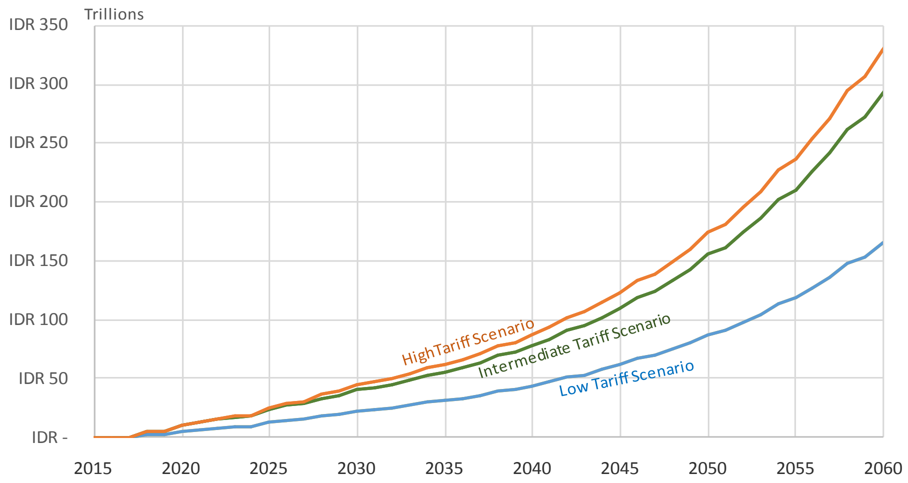


Figure 5 Revenue Projection for the Trans-Sumatera Toll Road

For the low-tariff scenario, eight of 22 segments of TSTR give negative net present values (NPVs), indicating that the internal rate of return (IRR) is still under the discounted rate and that they are not financially feasible. For the intermediate-tariff scenario, 19 of 22 segments of TSTR have positive NPVs. This scenario is better than the previous scenario, with an average IRR of 11.34%. For the high-tariff scenario, 20 of 22 segments of the TSTR have positive NPVs. The average IRR in this high-tariff scenario is 12.61%. In this scenario, the Tebing Tinggi - Lima Puluh and Sigli - Banda Aceh segments still have negative NPVs. Tariff engineering may be proposed for the two segments in order to make them financially feasible, in addition to extending the period of concession.

3.2. TSTR Lifecycle Cost Analysis (Multi-Function)

Before performing the TSTR lifecycle cost analysis for multiple function, a revenue projection is created for each added TSTR function. Figure 6 shows the projections for the six added TSTR functions. The most revenue among these added functions is generated by rest area development and tourism park development, while the fiberoptic networking and motorcycle lane integration provide the smallest contribution to the added functional engineering of the TSTR.

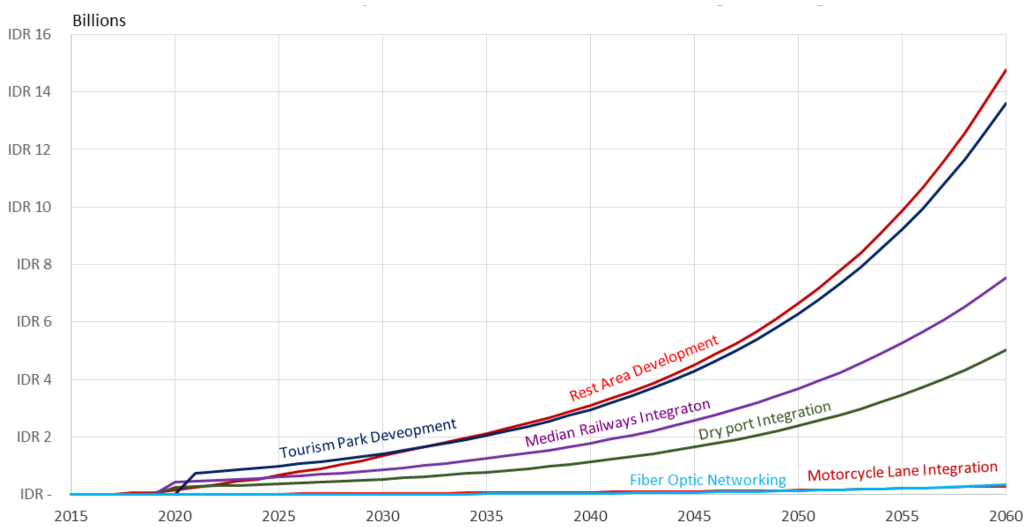


Figure 6 Revenue Projection for Added Function Engineering for TSTR

Furthermore, in order to examine the revenue contribution of each added TSTR function, the revenue weighting of other functions is performed and shown in Figure 7. The function of rest area development gives a revenue contribution of 34.39% of the total revenue of all added functions, and the function of tourism park development give a revenue contribution of 32.54%. The smallest revenue contribution among the added functions of TSTR is provided by the motorcycle lane integration and fiber optic networking functions.

Figure 8 presents the revenue comparison between a single-function TSTR and a multi-function TSTR. The figure shows that additional functions have improved the revenue projection of the TSTR by about 20%.

In addition, the lifecycle cost (LCC) analysis for the TSTR project is performed by selecting an optimum combination of additional functions. In the LCC analysis, eight function alternatives are presented, each of which will be subjected to the three tariff scenarios, as shown in Table 4.

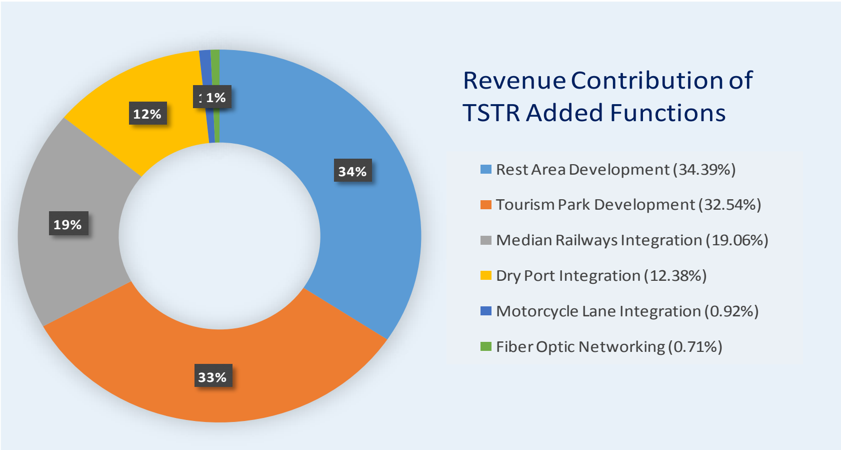


Figure 7 Revenue Contribution of Added TSTR Functions

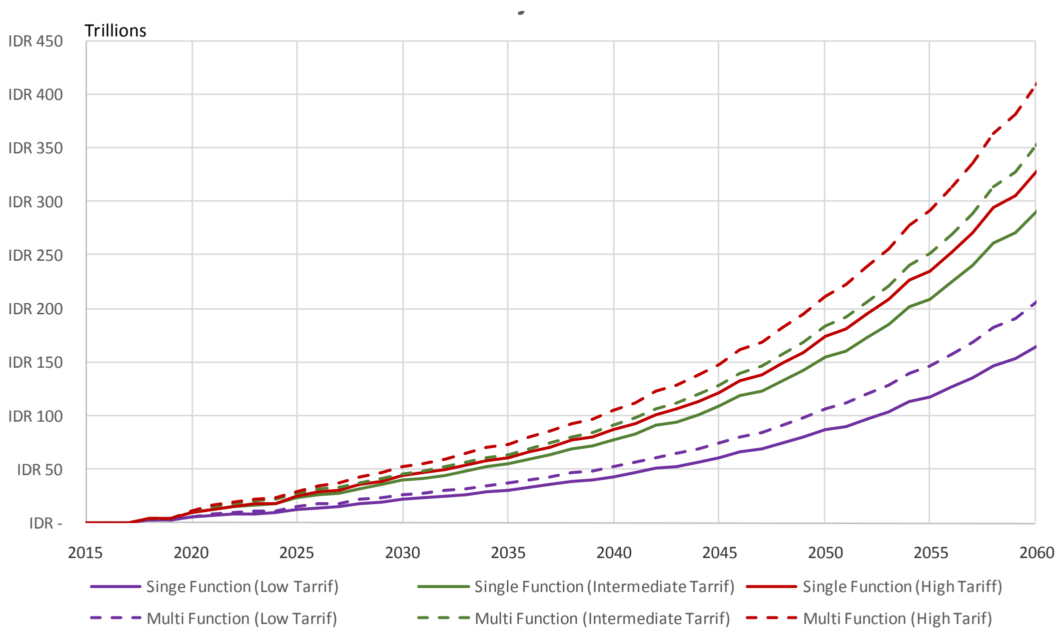


Figure 8 Revenue Projection for Single-Function and Multi-Function TSTR

Table 4 Cycle Cost Analysis Simulation based on Function Alternatives

Alternative	Cycle Cost Analysis based on Function Alternatives						
	Toll road	Rest area development	Tourism park development	Dry port integration	Median railways integration	Motorcycle integration	Fiber optic networking
A	√	√	√	√	√	√	√
B	√	√	√	√	√	×	×
C	√	√	√	×	×	√	√
D	√	√	√	×	×	×	×
E	√	√	×	√	√	√	√
F	√	×	√	√	√	√	√
G	√	×	×	√	√	×	×
H	√	×	×	×	×	√	√

The financial feasibility analysis of the above alternative functions is performed using three factors: internal rate of return (IRR), net present value (NPV), and payback period (PBP). Based on the internal rate of return and payback period parameters, it was found that Alternative E is most feasible; however, the best net present value is offered by Alternative A, as shown in Table 5.

Table 5 Financial Feasibility Comparison for All Alternatives

Alternatives	Low Tariff			Intermediate Tariff			High Tariff		
	NPV (Million)	IRR	PBP	NPV (Million)	IRR	PBP	NPV (Million)	IRR	PBP
A	IDR 83,743,843	8.29%	34.47	IDR 398,199,357	12.71%	20.72	IDR 501,149,460	13.77%	19.62
B	IDR 83,609,123	8.29%	34.46	IDR 397,025,087	12.70%	20.45	IDR 498,935,639	13.76%	18.65
C	IDR 76,617,476	8.22%	34.76	IDR 379,764,988	12.66%	20.52	IDR 471,407,089	13.63%	18.83
D	IDR 76,482,757	8.22%	34.76	IDR 378,590,718	12.65%	20.52	IDR 469,193,268	13.61%	18.88
E	IDR 78,811,227	8.30%	34.39	IDR 380,774,195	12.84%	20.22	IDR 471,231,753	13.82%	18.59
F	IDR 72,121,410	8.13%	35.27	IDR 375,411,362	12.58%	20.74	IDR 467,195,903	13.57%	20.00
G	IDR 67,054,074	8.13%	35.35	IDR 356,811,930	12.71%	20.54	IDR 435,064,376	13.60%	19.02
H	IDR 60,062,427	8.04%	35.36	IDR 339,551,832	12.66%	20.59	IDR 407,535,826	13.45%	19.19

4. CONCLUSION

The research shows that there are six additional functions of the TSTR Project that can generate additional revenue, namely rest area development, tourism park development, medial railways integration, dry port integration, motorcycle lane integration, and fiber optic networking. Three tariff scenarios have been simulated to test TSTR project investment feasibility based on the selected route and added functions. The results reveal that additional functions will improve the financial feasibility of the TSTR project by generating an internal rate of return for the three proposed scenarios that ranges from 8.28% to 13.77%.

5. ACKNOWLEDGEMENT

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