International Journal of Technology (2015) 1: 73-83
ISSN 2086-9614

FORECASTING DEMAND ON MEGA INFRASTRUCTURE PROJECTS: INCREASING FINANCIAL FEASIBILITY

Albert Eddy Husin[1*], Mohammed Ali Berawi[1], Suyono Dikun[1], Tommy Ilyas[1], Abdur Rohim Boy Berawi[2]

[1]*Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Kampus UI Depok, 16424, Indonesia*
[2]*Center for Sustainable Infrastructure Development (CSID), Faculty of Engineering, Universitas Indonesia, Kampus UI Depok, 16424, Indonesia*

(Received: August 2014 / Revised: January 2015 / Accepted: January 2015)

ABSTRACT

Indonesia is a country with large and dynamic economic activities reflected by an average economic growth reaching 6% per annum. Sunda Street Bridge (SSB) is one of the mega projects offered by the Indonesia government that would spend about US$ 25 billion. In line with the SSB main function as an efficient mean for transporting people and goods between two major islands in Indonesia, potential additional functions have been explored including installation of liquid and gas pipes, fiber optics, industrial area development and renewable energy utilization. This research establishes the approach to forecast demand in the case of conceptual design. The SSB is associated with innovations to determine the functions using value engineering methods. The approach involves forecasting demand with a System Dynamics simulation model that could provide a reliable estimate and generate scenarios to compare the financial feasibility of the project before and after the process involving innovation of project functions. Analysis involving demand forecasting with the System Dynamics Approach has confirmed that the Sunda Strait Bridge development with additional functions would increase the revenues of the overall project up to US$61.59 Million, in order to obtain an increased Internal Rate of Return (IRR) of the overall project up to 7.56% with a positive Net Present Value (NPV).

Keywords: Demand forecast; Financial feasibility; Innovation; Mega infrastructure project; System dynamics

1. INTRODUCTION

Based on the Global Competitiveness Report (2013-2014), the vital role of the infrastructure sector, as indicated by the sector's contribution to the four pillars that form the basis of a country's factor-driven competitiveness:1) public and private institutions, 2) infrastructure, 3) macroeconomic framework and 4) health and education, (Schwab, 2013). In order to achieve an acceleration of economic development, the Government of Indonesia, through the National Medium Term Development Plan (RPJMN) 2010-2014, is targeting a gradual economic growth rate from 5.5%–5.56% in 2010 to 7.0%–7.7% in 2014 or at an average growth rate of 6.3%–6.8% in 5 years.

The Sunda Strait Bridge (SSB) project will connect the islands of Sumatra and Java with a

[*] Corresponding author's email: iralbert.eddy@ui.ac.id, Tel. +62-21-7270029, Fax. +62-21-7270028
Permalink/DOI: http://dx.doi.org/10.14716/ijtech.v6i1.782

length of ± 30 kilometers and as a mega infrastructure project will entail an investment of US$11 Billion (PPP Book, 2010). The SBB project will became a strategic infrastructure development project in the Sunda Strait at an estimated increased cost of US$25 Billion (PPP Book, 2013). The SSB project has been on offer to investors since 2010. The status of the "potential project" was upgraded in 2011 to be a "ready for offer" project. However, in 2013 the status was lowered back into being a "potential project". This indicates there is an opportunity for re-planning the project to increase its investment potential. The case study in this research for the conceptual design of the SSB project involves the first toll road bridge in the world, which would be multi-functional, (Berawi & Susantono, 2013). The location of the SSB project is shown in Figure 1.

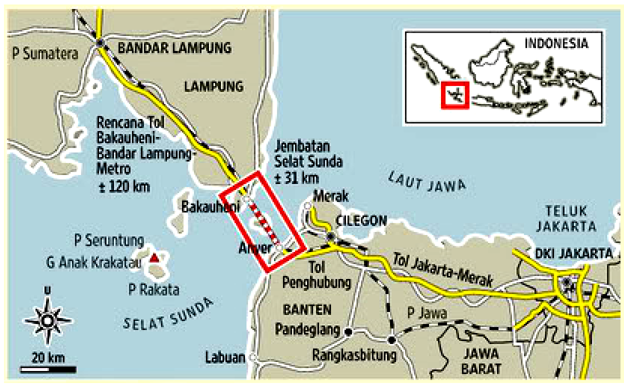

Figure 1 Location of Sunda strait bridge

It is necessary in order to forecast demand that efforts are put forward to estimate the lifecycle cost of the project so as to provide the financial feasibility report to support the project's economic significance. There are several approaches to forecasting demand for the project, one of which is by using a System Dynamics Model.

System Dynamics is a method that combines theory, method, and philosophy to analyze the behavior of a system (Forrester, 1998). Some of the advantages of a System Dynamics Model are as follows:

1. The mental model is flexible. (Sterman, 1992)
2. Recent trends in System Dynamics aim at changing those mental models that people use to represent the real world. (Forrester, 1989).
3. A System Dynamics Model can therefore be more informed about its problem space. (Caulfield, 2002).

2. METHODOLOGY

The research methodology used in designing a demand forecasting model that is objective and reliable for mega infrastructure projects is based on a comprehensive literature review for data collection and System Dynamics. Figure 2 shows the flow of the overall research framework consisting of the following steps:

1) Identify the parameters of demand forecasting for the conceptual design functionality of mega infrastructure projects, in this instance, with a case study of the Sunda Strait Bridge, and divide the parameters into two categories. The first category is the initial design project for the SSB (Wangsadinata, 1997) with a single main transportation function. The second category consists of a multi-functional use obtained from value engineering innovation.

2) Calculate the quantity of demand for each project function using System Dynamics. The shape of the output of this model is in the form of revenue and cost estimates for a 27-year period dating from 2024 to 2050.
3) After conducting a simulation model of the base model and if the results of the simulation model validation are accurate, the verification of the reliability and accuracy of the demand forecasting model, which is based on the SSB project as a case study of a mega infrastructure project, will occur.
4) Project the financial feasibility analysis using the LCC (Life Cycle Cost) method performed after the data is obtained from estimates of income and costs. Lastly, then the financial feasibility of mega infrastructure project targets can be determined.

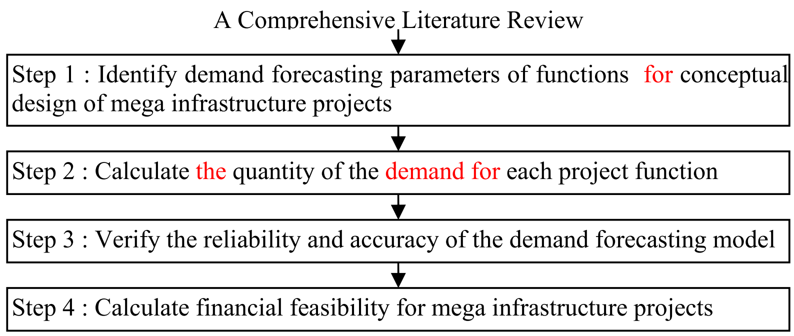

Figure 2 Flow of the overall research framework

3. DEMAND FORECASTING MODEL OF THE SUNDA STRAIT BRIDGE (SSB)

This model aims to represent the economic factors of the SSB. With this System Dynamics Model, the purpose is to forecast the value of income and the cost of the SSB. In addition, this model is used to determine the following two conditions. The first condition is a model of innovation for the SSB project without the addition of Value Engineering. This means the SSB project's initial design only serves as a toll road bridge. The first condition is going to be a model simulation entitled "Do-Nothing". The second condition is a model of the conceptual design of the SSB project resulting from the process of innovation. The second condition is that a model simulation is entitled "Do-Something". Thus, through forecasting demand using System Dynamics, the advantages and disadvantages for each model simulation of the SSB design can be forecast.

3.1. Causal Loops Model SSB

Causal loops of a System Dynamics model for the SSB project are formulated through the collective thinking. This model represents each of the functions that exist in the SSB project as shown in Figure 3. The shape of the output of this model is in the form of income and cost estimates for approximately 27 years. The model, as shown in Figure 3, is composed of several subsystems, namely: (1) Population Subsystem, (2) Economic Growth Subsystem, (3) Industrial Sector Subsystem (4) Tourism Sector Subsystem, (5) Renewable Energy Subsystem and (6) Transmission Pipe Subsystem.

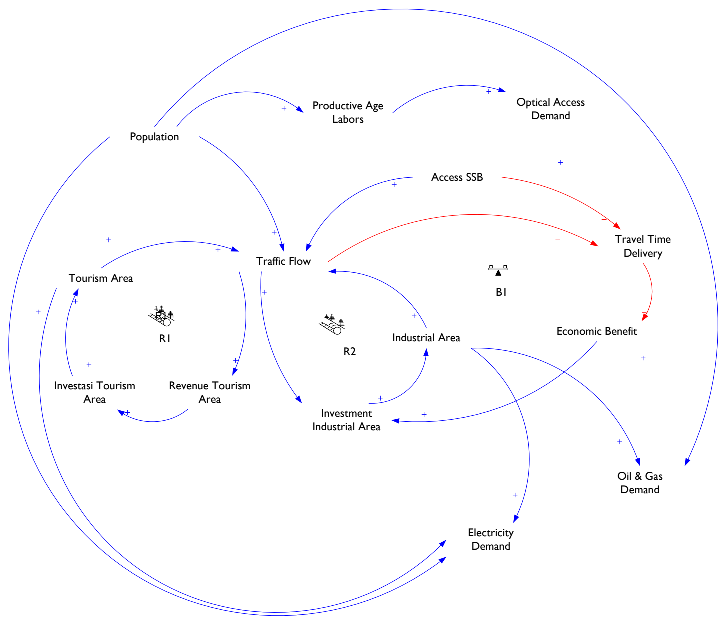

Figure 3 Causal loop diagram for forecasting demand of SSB

1) Population Subsystem

SSB's main function is to connect the islands of Sumatra and Java. Thus, population limitations only concern the islands of Sumatra and Java. Just as the behavior of the national population is influenced by various factors, so too is the population of the respective islands is also influenced by the birth rate, death rate, immigration, and emigration factors. Thus, the growth or decline in the population of both islands can be determined. This population subsystem will affect the demand for electricity, petroleum, and gas in Java-Sumatra, the the number of tourists will determine the tourism sector subsystem for Java and Sumatra. However, in this model, there is no feedback loop that affects the initial population.

2) Economic Growth Subsystem

The Economic Growth Subsystem represents a form of economic growth benefits from the presence of the SSB. The economic sectors covered herein are limited to the economic growth of the industrial sector alone, as one of the major innovations in Value Engineering SSB in relation to the industrial development which is expected to develop around the bridge, notably in Lampung and Banten. In this subsystem, the effect of the SSB can be seen in the form of faster delivery, which will enable the increased production capacity of the industrial areas. An increase in production capacity means a higher profit margin. However, negative feedback from the industrial sector notes that when the volume of goods production and related transportation activity increase, this results in an increased number of vehicles on the SSB, which would cause congestion and traffic jams.

3) Industrial Sector Subsystem

The Industrial Sector Subsystem describes quantitatively the growth of the industrial sector and the number of assets. This subsystem is influenced by the increased size of population in Java and Sumatra, which assumes that the industrial sector is also growing. In this subsystem, the dependent variable is industrial land. As industrial production increases, it will spur the industrial sector to increase factory expansion in order to increase production capacity. This will affect the real estate prices and the availability of affordable industrial land in Lampung and Banten.

4) Tourism Sector Subsystem

The Tourism Sector Subsystem represents tourism development in Sangiang. When Sangiang will be opened for tourism, of course, depends on the public interest, resulting in.increased revenue from tourism. This will result in increased investment in Sangiang, whose entrepreneurs can add recreational facilities and accommodation. But the addition of these hospitality facilities will reduce the availability of open land in Sangiang, which could damage ecosystems and natural beauty. This environmental impact is could reduce the number of tourists.

5) Renewable Energy Subsystem

The Renewable Energy Subsystem is simulated only for tidal turbines, because wind turbines will only be used for the internal electricity needs of the SSB. The causal loop related to renewal energy is influenced by the population of Java and Sumatra. The greater population size will increase the number of industries in Java and Sumatra, the number of households of Java and Sumatra, and the Sangiang tourism infrastructure and related hospitality facilities. These three factors determine the electricity needs of Java and Sumatra. The greater the power requirements, the greater the need for an increase in power generation capacity of the tidal turbine would be next to the SBB. Greater capacity will allow an increase in the number of industrial facilities in Java and Sumatra with a comparable increase in the number of households and necessary supporting infrastructure facilities.

6) Transmission Pipe Subsystem

The Transmission Pipe Subsystem originates with the factors related to oil and gas needs in Java and Sumatra. The need for oil is assumed to be influenced mostly by the industrial sector. The greater the need for oil and gas, the commensurate increase in the size of the pipeline across the SBB would need to occur. Increasing the volume of oil shipments to enable the expansion of existing industries is dependent on the availability and increased production capacity of oil and gas supplies.

3.2. Stock and Flow Diagram

The stock and flow diagram of each subsystem with modules plus some complementary aspects is shown in Figure 4.

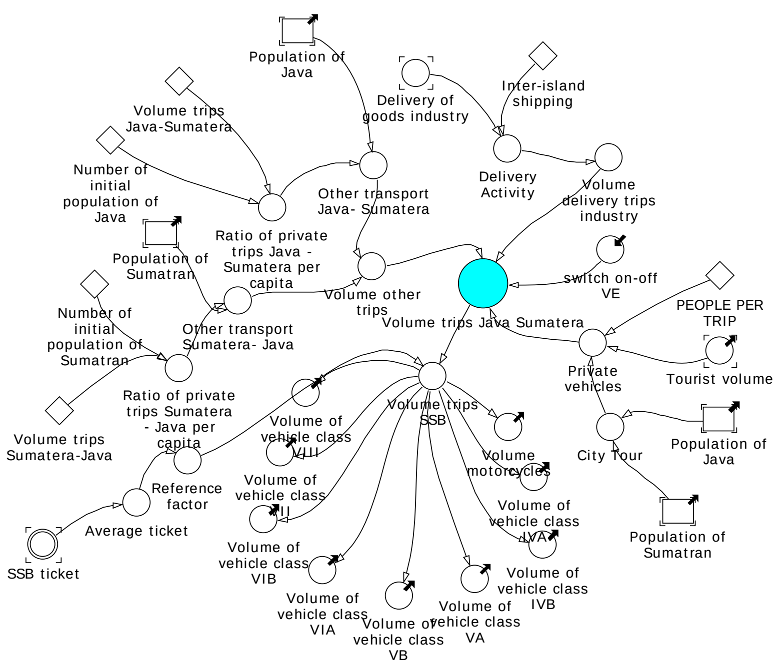

Figure 4 Base model of SSB

The stock and flow diagram is the basis for the subsequent simulation. At this stage, the base model of SSB is run to simulate the change using the scenario entitled, "Without the existence of SSB". Thus, the model will feature a variety of conditions and variables that indicate how change will affect the development of Java and Sumatra.

After the simulation is run, then data was obtained as follows.

1. The number of users who cross the Sunda Strait if the “Ro-Ro” vessels is estimated to be 2,769,963 people per year in 2050.
2. The population of the island of Java in 2050 is estimated to be 141,555,724 people and 51,221,363 people for Sumatra.
3. The power requirement of Java and Sumatra in 2050 needs to increase to 110,891,814.9701 MWh.
4. If Sangiang is opened to the public without infrastructure development the number of tourists could be equal to 19,757 visitors per year.
5. The need oil for Java and Sumatra in 2050 will amount to 2,366,954,024 BOE per year, while gas demand for Java and Sumatra in 2050 could be as high as 364,228,280,042 BOE per year.
6. The number of phone lines using fiber optic cables is projected to be 476,429 phone line unit in 2050.

The SD-based forecasting demand model for the SSB project is shown in the 9 stock and flow diagrams in Figure 5. These diagrams include simulations for population, transportation, energy, economic, transmission pipeline, industrial infrastructure, fiber optic cables, tourism, and income forecasts.

3.3. Cost and Revenues Estimate

After performing the basic model simulation and depending on if the results of the validation of simulation models are accurate, then the model is used to perform forecasting models for the next 27 years. Estimate of costs and revenues is performed in accordance with the lifecycle cost of the evaluation function as a stage in implementing the VE and this is intended to obtain a decision based on benchmarking (Berawi & Woodhead, 2008). The result of the benchmarks of each function can be seen in Table 1.

The cost of transport functions in the SSB conceptual design is used a benchmark in comparison with the Messina Bridge in Italy in order to calculate the initial costs of a similar transportation facility and technology. The bridge structure is divided into two types: 7.4 km-long suspension bridge and 21.4 km-long reinforced concrete viaduct bridge.

3.3.1. Simulation Model "Do-Nothing"

In this scenario, there SSB using the initial design that serves as a transportation alone and without using Value Engineering. In this scenario will be seen how the increase of the total revenues generated from the SSB. Figure 6 shows the results obtained by the transportation sector revenue "Do-Something" is US $ 15,541.65 million and scenarios "Do-Nothing" is US $ 8,495.58 million.

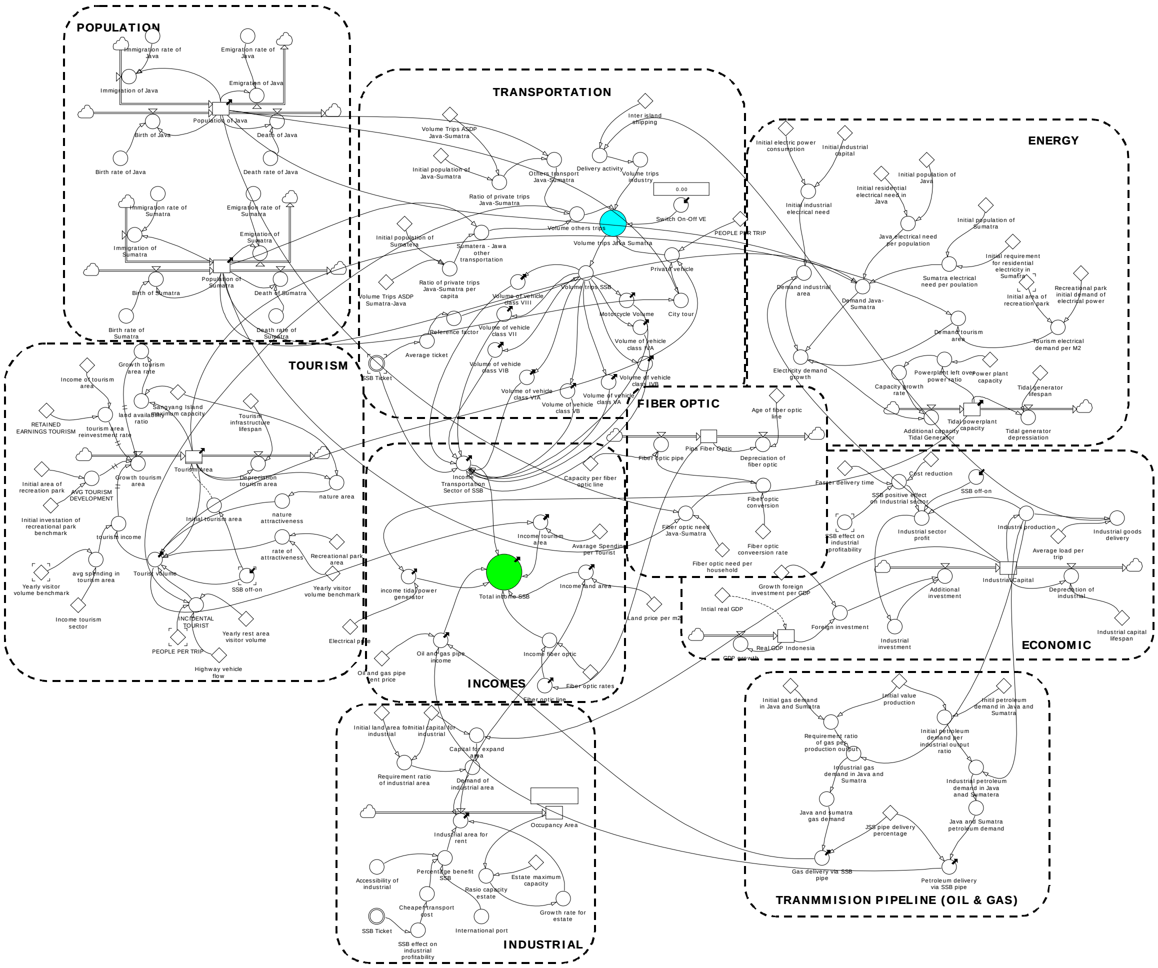

Figure 5 SD-based forecasting demand model for SSB project

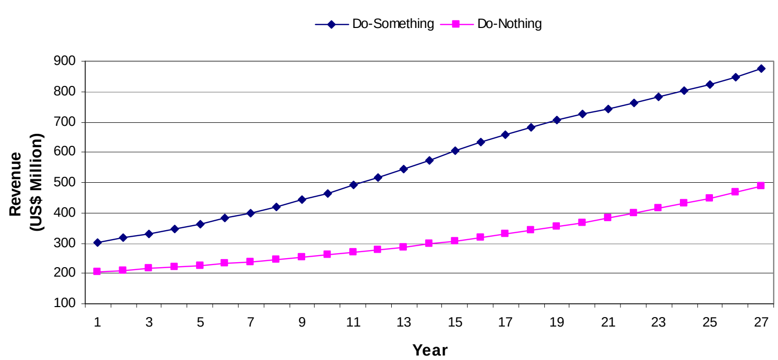

Figure 6 Revenue of transportation function in SSB

Table 1 Benchmarking for each function

Function	Description	Benchmarking
Transportation	• Suspension bridge 7.4 km • Concrete viaduct bridge 21.4 km	• Messina Bridge – Italy • Wangsadinata (1997) • ASDP Ferry Indonesia (2012) • Indonesia Highway Corporation (2012)
Energy		
Tidal Power	• Current around 2m/s • Turbine efficiency 35% • Capacity 551 MW	• Blue Energy (2010) • Devine Tarbell & associates, Inc. (2008) • Harmmons (1993) • Regulation of The Minister of Energy and Mineral Resources, Indonesia, Number 4 (2012)
Wind Power	• Capacity 464 KW	Shenzhen Huaxiong International China, (2012)
Oil & Gas Distribution	• 3 Φ 42" for oil • 3 Φ 42" for gas and storage warehouse 300.000 BOE	• Parker (2004) • The Minister of Energy and Mineral Resources (ESDM) , Indonesia (2012)
Tourism		
Hanging Train	29 KM	• Wuppertal Schwebebahn, Germany • Arief (2013)
Cable Car	8 KM	• Cable Car, Genting Highlands, Malaysia (1997) • Arief (2013)
Resort & Theme Park	126 Ha	• Hong Kong Disneyland Resort
Telecommunication	Fiber Optic along 29 KM	• PT.Telkomunikasi Indonesia (2010) • Williams (2010) • Ware (2013)
Industrial	• 2.000 Ha in Java • 3.000 Ha in Sumatra	• Indonesia Investment Coordinating Board (2012) • Kompas (2013)

3.3.2. Simulation Model "Do-Something"

The scenario of the "Do Something" simulation model for the SSB results in Value Engineering for new functions in the industrial, tourism, tidal power and transmission pipeline sectors. The difference occurs between the variable revenue of the aforementioned sectors in the "Do-Nothing" with "Do-Something" simulation models Simulation results comparing the total revenues of the two scenarios are shown in Figure 7. The overall revenue results in the "Do-Something" simulation model amounted to US$ 61,529.02 million, whereas the "Do-Nothing" simulation model is only US$ 8,495.58 million.

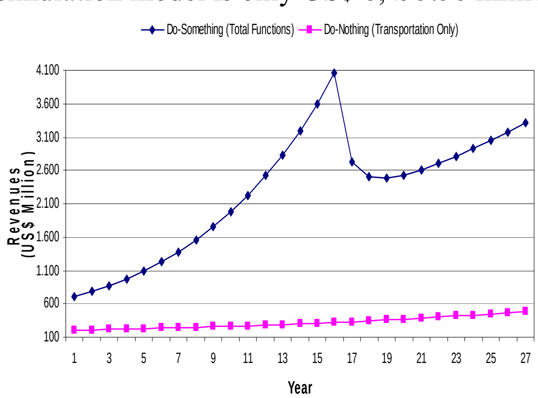

Figure 7 Total revenues SSB

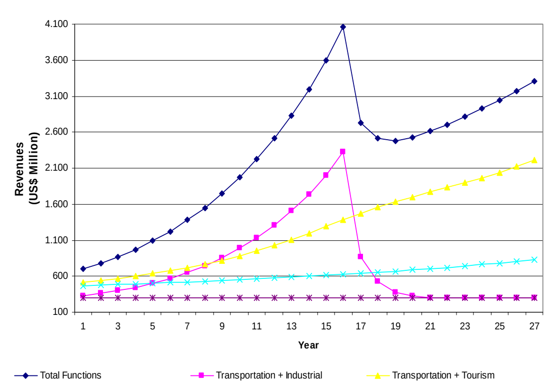

Figure 8 SSB revenues ratio varies with the additional functionality

Figure 8 shows that the SSB revenue ratio varied with the additional functionality beyond the transport function. As a function of the highest revenues, a function of transport with industry sector, a function of transport with tourism sector and a function of transport with energy, the four best results obtained were placed in rank order.

Table 2 The result of estimated cost and revenues for SSB project

FUNCTION	SSB (Do-Nothing) CAPACITY	SSB (Do-Nothing) COST (US$ Million)	SSB (Do-Nothing) REVENUE (US$ Million)	SSB (Do-Something) CAPACITY	SSB (Do-Something) COST (US$ Million)	SSB (Do-Something) REVENUE (US$ Million)
TRANSPORTATION	2.179,603 trips/year	10,796.04	8,495.58	4,151,183 trips/year	10,796.04	15,541.65
RENEWABLE ENERGY						
- Tidal Power	-	-	-	551 MW	735.97	6,395.89
- Wind Power	-	-	-	464 KW	1.08	
TOURISM						
- Hanging Train	-	-	-	29 KM	1,356.75	1,193.90
- Cable Car	-	-	-	8 KM	163.83	1,193.90
- Hotel						65.23
- Resort + Theme Park	-	-	-	1.260.000 m^2	2,638.37	23,214.74
TRANSMISSION PIPELINE						
- Oil	-	-	-	3 Φ 42”	197.99	989.28
- Gas	-	-	-	3 Φ 42” + Gas storage warehouse 300,000 BOE	208.79	1,024.84
FIBER OPTIC	-	-	-	36 channels/year	0.46	10.73
INDUSTRIAL	-	-	-	2,272.73 ha/year	3,645.83	11,894.37
TOTAL		10,796.04	8,495.58		19,749.43	61,529.02

The demand forecasting results of this research are shown in Table 2, which indicates that the SSB project in the "Do-Something" scenario had estimated overall revenues of US$ 61,529.02 million with a total cost of US$ 19,749.43 million, while the "Do-Nothing" scenario only amounted to US $ 8,495.58 million with a total cost of US$ 10,796.04 million. So it can be ascertained that the financial viability of the SBB project is increased in the “Do-Something” scenario. The summary of lifecycle cost analysis is shown in Table 3.

Table 3 Lifecycle cost analysis summary

FUNCTION COMPONENTS	CONSTRUCTION COST (US$ Million)	O&M COST 2024-2050 (US$ Million)	REVENUE 2024-2050 (US$ Million)
Transportation	10,796.04	2,201.98	15,541.65
Energy	1,143.78	562.13	8,414.50
Telecommunication	0.46	0.93	10.73
Tourism	4,163.31	108.74	25,667.77
Industrial Area	3,645.83		11,894.37
Total	19,749.43	2,873.78	61,592.02

3.4. Analysis of Financial Feasibility

In analyzing the financial feasibility of the SSB project uses the Lifecycle Cost analysis (Berawi, et al., 2014). The rate of inflation for each function is increased in accordance with their respective sectors. For example, in the transport sector, the transport fares and train tickets fares as well as the cost of the transport of goods is increased in accordance with the transportation sector inflation rate of 1.63% (Bank of Indonesia and BPS). IRR and NPV for each function and total functions are calculated as shown in Table 4.

Table 4 Incremental Return On Revenue (ROR) analysis and capital share

FUNCTION COMPONENTS	CAPITAL SHARE	INITIAL COST		IRR	
		Before (US$ Million)	After (US$ Million)	Before	After
Tourism	31.60%	4,163.31	7,574.86	12.40%	7,56%
Energy	14.55%	1,143.78	2,714.61	17.19%	7,56%
Industrial Area	11.25%	3,645.83	4,860.39	10.26%	7,56%
Telecommunication	0,02%	0.46	2.99	29,13%	7,56%
Transportation		10,796.04	4,596.59	1,30%	7,56%

4. CONCLUSION

The total revenues for the SSB project with the transportation function only or the "Do-Nothing" scenario is estimated to be US$8,495.58 Million. The total revenues for the SSB project with additional functions or the "Do-Something" scenario is estimated to be US$ 61,529.02 Million. The lifecycle cost analysis using the IRR and NPV approach confirms that the development of the SSB project with additional functions increases the Internal Rate of Return for the whole project by 7.56% that would provide a positive NPV value. So it can be ascertained that the financial viability of the SSB project would increase with additional functionality innovation.

5. ACKNOWLEDGEMENT

This research is fully supported by research grants from Universitas Indonesia and Ministry of Education of the Republic of Indonesia.

6. REFERENCES

Alasad, R., Motawa, I., Ougunlana, S., 2013. A System Dynamics-based Model for Demand Forecasting in PPP Infrastructure Projects – A Case of Toll Roads. *Technology and Management in the Construction Journal International*, Volume 6(2), pp 791–798

Arief, J.G., 2013. *Analisis Life Cycle Cost Pengembangan Potensi Pariwisata pada Conceptual Design Proyek Jembatan Selat Sunda Dengan Pendekatan Value Engineering*, Thesis, Departement of Civil Engineering, Faculty of Engineering, Universitas Indonesia (in Bahasa)

ASDP Ferry Indonesia, PT., 2012. Tarif Tiket Terpadu Penyebrangan Antar Propinsi pada Pelabuhan Penyebrangan

Berawi, M.A., Woodhead, R.M., 2008. Stimulating Innovation using Function Models: Adding Product Value. *Value World*, Volume 31(2), 4–7

Berawi, M.A., Susantono, B., 2013. Developing Conceptual Design of Mega Infrastructure Projects: Creating Innovation and Added Value. *Value World*, Volume 36, 12(20)

Berawi, M.A., Susantono, B., Miraj, P., Gunawan, Berawi, A.R.B., Husin, A.E., 2014. *Financial Feasibility of the Development of the Sunda Strait Bridge Conceptual Design Using Value Engineering Methods*, ASEA-SEC-2, Bangkok, November 3–7, 2014

Business Monitor International, Indonesia Economic Growth, 2012

Caulfield, C.W., Maj, S.P., 2002. A Case for System Dynamics, *Global J. of Engineering Education*, Volume 6(1), p. 3, UICEE, Published in Australia

Coordinating Ministry for Economic Affairs, 2011. Masterplan for Acceleration and Expansion of Indonesia Economic Development 2011–2025

Devine Tarbell & Associates, Inc., 2008. *Review of Marine Energy Technology and Canada's R&D Capacity*, Toronto, CANMET Energy Technology Centre (CETC), Natural Resources Canada

Forrester, J.W., 1989. *The Beginning of System Dynamics*, Sloan School of Management, Massachusetts Institute of Technology , Cambridge, Massachusetts, U.S.A.

Forrester, J.W., 1998. *Designing the Future*, Universidad de Sevilla, Spain

Harmmons, T.J., 1993. Tidal Power, *Proceeding of The IEEE,* Volume 8(3), pp. 419–433, Scotland, UK

Indonesia Highway Corporation, 2012. Penyesuaian Tarif Tol pada Ruas Jalan Tol Jakarta-Cikampek (in Bahasa)

Martinez-Moyano, I J., Richardson, G.P., 2013. Best Practice in System Dynamics Modeling, *System Dynamics Review*, Volume 29(2): 102–123, p.108

Ministry of National Development Planning, Republic of Indonesia, 2010. Public Private Partnership Infrastructure Project Plan in Indonesia 2010

Ministry of National Development Planning, Republic of Indonesia, 2013. Public Private Partnership Infrastructure Project Plan in Indonesia 2013

Ministry of National Development Planning, Republic of Indonesia, 2010. The National Medium Term Development Plan (RPJMN) 2010–2014

Niu, H., Gillard, A.A., 1994. Using A System Dynamic Simulation Model to Forecast Long-term Urban Water Demand, *International System Dynamic Confrence*, 1994

Parker, N., 2004. *Using Natural Gas Transmission Pipeline Costs to Estimate Hydrogen Pipeline Costs*, Recent Work, Institute of Transportation Studies (UCD), UC Davis

SAVE International Value Standard, 2007. *Value Standard and Body of Knowledge*

Schwab, K., 2013. *The Global Competitiveness Report 2013–2104*, World Economic Forum Available Online at http://en.wikipedia.org/wiki/Global_Competitiveness_Report

Sik-wah Fong, P., Shen, Q., 2000. Is the Hong Kong Construction Industry Ready for Value Management, *International Journal of Project Management*, Volume 18(5), pp. 317–326

Sterman, J.D., 1992. *System Dynamic Modeling for Project Management*, Sloan School Management, MIT, Cambridge MA 02139, p. 3

Suryani, E., Chou, S.Y., Chen, C.H., 2012. Dynamic Simulation Model of Air Cargo Demand Forecast and Terminal Capacity Planning, *Journal at Science Direct, Simulation Modelling Practice and Theory*, Volume 28, pp. 27–41

Telekomunikasi Indonesia, PT., 2010. Annual Report

Wangsadinata, W., 1997. *Advance Suspension Bridge Technology and the Feasibility of The Sunda Strait Bridge*, Wiratman & Associates, Jakarta

Williams, D.J.M., 2010. *Broadband for Africa, Developing Backbone Communications Networks*, The World Bank, Washington D.C.