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PROJECT FINANCE AND RISK MODELING USING A SYSTEM DYNAMICS APPROACH: A TOLL ROAD PROJECT

Lukas B. Sihombing[1, a]

[1]Universitas Indonesia, Depok, Indonesia

[a]lukas_sihombing@yahoo.com

*Corresponding author's email : lukas_sihombing@yahoo.com

Abstract

In a build, operate, and transfer (BOT) scheme, as Project Finance (PF), equity investors are concerned about the adequacy of their returns. On the other hand, the timeliness of the project debt service payments focuses to the lenders. Consequently, an important role is played by PF and risk modeling to ensure that structure of the project management is a prerequisite. Nevertheless, the complexity of future infrastructure project will become more complicated. Not only will the limitations of stakeholders to understand others when evaluating a project will become more prevalent, but also the competition force the bidders to become increasingly innovative in their financing modeling. The aim of this paper is to propose a new technique to calculate project finance and risks using System Dynamics (SD) approach with sysdea modeling. The model builds confidence and its policy implications. This paper results is PF and risk modeling should use an SD approach in toll road projects.

Keywords: Build, operate, and transfer (BOT); Project finance modeling; Risk analysis; System dynamics; Toll road

1.0 INTRODUCTION

In 1291 A.D., the development of project financing began, when Devon silver mine explorations was funded by the English Crown, where the bankers conducted concession mining, namely the results obtained from silver mines per year were a reversion of concessions. Another funding project was when travel ships (ship voyages) were funded until the 17th century, where the Treaty of Concession was the return of the cargo that would be disbursed and repayment of travel was divided among the investors. Then, project finance became popular for oil drilling In the 1970's [1].

According to Akbiyikli, Eaton, and Turner [2], project finance (PF) is "one method of financing large-scale, capital-intensive projects, in which traditionally only the cash flows generated by the project serve as the source of loan repayment and only the project assets serve as collateral for a nonrecourse loan".

Nowadays, the development of project finance in Indonesian toll road infrastructure projects is in a build, operate, and transfer (BOT) scheme. Firstly, BOT involved a private company which began in 1987, when the private company participated to build North-South Link (NSL) toll roads that were 19.03 km in length; the operator was PT. Citra Marga Nusaphala Persada (CMNP) [3]. Then, the Government of Indonesia (GoI) developed various schemes such as: Support BOT/Hybrid, Operation &

Maintenance/Lease, and Assignment to State-Owned Enterprise (SOE) [4].

To evaluate the project finance with those schemes, project modeling is becoming extremely important. In the modeling, lenders are very concerned about the timeliness of project debt service payments; equity investors are also concerned about the adequacy of their returns. Cash flow modeling is used to address both sets of concerns [5].

However, according to Vinter [6], infrastructure projects in the future will become more complicated because of the growth of international competition. Competition will press the bidders to become more and more innovative in funding techniques. In addition, the financial modeler of building financial models, as an evaluation and negotiation tool, should be able to collaborate with stakeholders, such as lenders, sponsors, concessioners, as well as consultants [7]. A complex programming without making the model hopelessly complex and cumbersome, with many macros to deal with circular references and with long and complicated formulas, is a difficult challenge in creating a project finance [8].

Nowadays, project finance modeling uses Microsoft Excel to evaluate the Net Present Value (NPV) and Internal Rate or Return (IRR) [8]. As for calculating the risks, it uses the software Crystal Ball and @Risk.

In this paper, an innovative funding technique is used to overcome the complexity of the project as well as high risks in the funding of infrastructure projects by using a System Dynamics (SD) approach. The purpose of this paper is to use an SD approach to evaluate project finance and risks through cases of calculation of toll roads in Indonesia.

2.0 THE PREVIOUS METHOD OF PROJECT FINANCE AND RISK MODELING FOR INFRASTRUCTURE

According to Bodner [8], typically have two distinct objectives of project finance models. The first, in a transaction, is to structure the debt and equity that will be issued, including the manner in which the debt will be repaid as well as the size and the tenor of the debt. The second, in different time periods of the project life, is to assess specific risks after the defined financial structure is given. Project finance models should also be able to compute the value of the project over time as the risks change and assess the effects of different types of refinancing.

In addition, the development phase, the construction phase, the operation phase, the debt repayment phase, and possibly a refinancing phase, one of the essential elements of a project finance model is that different calculations are made for distinct phases of the project. The sources and uses of funds statements are not after the project begins operation, but computed during the development and construction phase.

Then for a model of project finance, the dividends paid to the owner of the SPV (sponsor) is the final part of the cash flow waterfall, meaning that dividends are not defined from a dividend payout ratio, dividends per share, or some other algorithms, but rather they are not paid either reserved elsewhere or the residual cash flow. Cash flows in a project finance model that effectively modeling involves the cash flow waterfall in the cash flow analysis, the debt schedule integration, as well as launching the model from uses of a funds analysis and the sources. Finally is the balance sheet, part of the output rather than a mechanical calculation. All of the accounts, already defined elsewhere in the model; and the balance sheet simply tabulates these accounts, such as plant balance, debt service reserves, senior debt balance, subordinated debt balance, and common equity balance are. Meanwhile, the methods previously used to analyze the PF model are shown in Table 1.

From the methods which are used to evaluate the toll road financing modeling previously, there are two methods such as the Latin Hypercube Simulation and the Simulation Cash Flow Model that use Excel and @Risk, but those methods have a weakness because they cannot anticipate if there is a financial impact of any regulations from different perspectives or angles before issuing it. A real option analysis framework cannot anticipate the likelihood of a decrease after year 34, as the investor gets closer to the end of the concession life. There is not much time left in the operation stage for the investor to capture additional revenues to recover the extra expansion costs. Therefore, to cover the weakness, a System Dynamics method is used to calculate the cash flow.
costs. The basic cash flow model of a PF toll road can be seen in (Eq. 1) until (Eq. 13).

Basic Cash Flow Model of Toll Road PF

The first step in cash flow modeling is to determine the total investment cost in the construction phase, which consists of DED costs, construction costs, toll facility costs, land acquisition costs, and supervision

$$\mathrm{TIC_i} = \mathrm{TPC_i} + \mathrm{LAC_i}, \quad i = 0, \dots, t \qquad (1)$$

where TICi = total investment construction in year i; TPCi = Total Project Cost in year i; and LACi = Land Acquisition Cost in year i.

Table 1 Methods previously used to analyze the PF model

Author(s)	Method which is used for the PF Model	Method Strength	Method Weakness	Sector
[9]	Latin Hypercube Simulation and Simulation Cash Flow Model use Excel and @Risk.	It deals well large and complex systems problems.	It cannot anticipate if there is a financial impact of any regulation from different perspectives and angles before issuing it.	Toll road
[10]	"Project Type"-Based Simulation Approach	It gives hints for an effective reduction of the overall project risk by applying adequate risk management measures.	It cannot be ruled out that the portfolio has a breakdown.	Infrastructure projects
[11]	Real option analysis framework	In the toll road project, it can improve financial risk profile of the investor through limiting the downside risk of overinvestment and increasing the expected investment value in a highway project.	The investor gets closer to the end of the concession life, so it cannot anticipate the likelihood of a decrease after year 34. In the operation stage, there is not much time left for the investor to capture additional revenues to recover the extra expansion costs.	Toll road project
[12]	Copula-based approach	It is considerably more practical than the rating-based model in the absence of project-specific ratings to quantify default probability in infrastructure project financing.	It cannot predict deterministic future revenues for debt and corresponding annual debt service.	Infrastructure project
[13]	Simulations of stochastic processes	It is a realistic representation of the risks that can be integrated into the conventional cash flow based real estate investment management appraisal models.	It cannot be used for a specific application, and for the compilation of the empirical framework information is required.	Real estate investment
[14]	Excel tools for finance	It helps to visualize how financial problems are solved in the real world, and it enables problems to be solved from other courses or fields as their Excel skills are enhanced.	It cannot account for the optimization of risks.	Education program
[15]	MS Excel macro approach for the probabilistic S curve	More accurate than deterministic ones at probabilistic cash flows, and a decision maker can use the project evaluation with a higher level of accuracy.	The risk factors of the cash inflow, it cannot be integrated by some of the studied risk factors that have a higher effect on it, and it cannot provide a highly detailed cash flow.	Educational building

$TPC_i = DED_i + Const_i + TFal_i + Sup_i + Fin_i,$ i=0,…,t (2)

where DED_i = Design Engineering Definitive (DED) Cost in year i; $Const_i$ = Construction Cost in year i; $TFal_i$ = Toll Facility Cost in year i; Sup_i = Supervision Cost in year i; and Fin_i = Financial Cost in year i.

$Const_i$= Esc_i + $Cont_i + OH_i + IDC_i,$ i=0,…,t (3)

where Esc_i = Escalation Cost in year i; $Cont_i$ = Contingency Cost in year i; OH_i = Over Head Cost in year i, and IDC_i = Interest During Construction in year i.

In PF, the sources of funds from Equity and Debt

$Eqt_i = \%Eqt_i \times TPC_i,$ i=0,…,t (4)

where Eqt_i = Equity in year i; $\%Eqt_i$ = percentage of Equity in year i. Usually % Eqt is 30% from TPC_i.

$Debt_t = TPC_i - Eqt_i,$ i=0,…,t (5)

where $Debt_i$ = Debt in year i.

In the operation phase, there are calculations for Operation & Maintenance Costs, Depreciation Costs, Interest Costs, Taxes, and Revenue.

$EBITDA_i = Rev_i - O\&M_i,$ i=0,…,t (6)

where Rev_i = Revenue in year i; $O\&M_i$ = Operation &

Maintenance Costs in year i.

Rev_i=($TTariff_{(g,i)}$ × $Vol_{(g,i)}$) + other income, (7) i=0+construction i,….t

where $TTariff_{g,i}$ = Toll Tariff per group vehicle in year i, $Vol_{g,i}$ = Volume Traffic per group vehicle in year i; other income = income from advertising, rest area lease, etc. (if any).

$O\&M_i = TColl_i + TSev_i + Maint_i + G\&A_i + SPVOf_i + BTax_i,$ i=0+construction i,…,t (8)

where $TColl_i$ = Toll Collection Costs in year i; $TSev_i$ = Toll Service Costs in year i; $G\&A_i$ = General & Administration Costs in year i; $SPVOf_i$ = Special Purpose Vehicle Office Costs in year i (if any); $BTax_i$ = Building and Land Tax Costs in year i (if any).

$NID_i = EBITDA_i - Int_i - Tax_i - DA_i,$ (9) i=0+construction i,…,t

where NI_i = Net Income before Dividends in year i; Int_i = interest and principle payments in year i; Tax_i = Taxes in year i; and DA_i = Depreciation and Amortization Costs in year i.

$Div_i = NID_i \times \%Eqt_i,$ i = 0 +construction i,…,t (10)

where Div_i = Dividend Payments in year i.

$NI_i = NID_i - Div_i,$ i = 0 + construction i,…,t (11)

NPV for project:

$$NPV_{project} = \sum_{i=0}^{n} \frac{NI_i}{(1+\delta)^i} - TPC_i, \quad i = 0, \dots, t \qquad (12)$$

where δ = discounted rate.

NPV for investment:

$$NPV_{investment} = \sum_{i=0}^{n} \frac{NI_i}{(1+\delta)^i} - TIC_i, \quad i = 0, \dots, t \qquad (13)$$

3.0 RESEARCH METHODOLOGY

In this paper, the methodology used is a System Dynamics (SD) approach, which was proposed by Forrester (1961) and has been applied in various research (including [16-19]) in different problem situations in developing financial and project management.

Sterman [16] introduced system dynamics modeling for a policy and strategy analysis, with a focus on business and public policy applications. "System dynamics is a perspective and set of conceptual tools that enables us to understand the structure and dynamics of a complex system. System dynamics is also a rigorous modeling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations. Together, these tools allow us to create management flight simulators – micro-worlds where space and time can be compressed and slowed so we can experience the long-term side effects of decisions, speed the learning and develop our understanding of a complex system, and design a structure and strategies for greater success."

4.0 PROJECT FINANCE MODELING USING SYSTEM DYNAMICS: A CASE STUDY OF A TOLL ROAD PROJECT

The case study is taken from a real-life toll road project that still construction. The 12.1 km project is undertaken by special purpose vehicle (SPV) with length of concession on the scheme being 50 years. The toll facility is designed to carry a maximum of 171,000 vehicles a day. Total project investment cost is estimated at Rp 3,504,497 million: total construction cost of Rp 2,552,795 million, land cost of Rp 650,000 million, and interest during construction Rp 301,522 million. The project is financed at a debt to equity ratio (DER) of about 71.02:28.98.

Based on (Eq. 1) until (Eq. 13), with an SD approach, the equation is divided in some sub-models, such as sub-models for Investment, Revenue, Operation & Maintenance, Debt Equity Ratio, and NPV. The instrument that is used is www.sysdea.com.

Sub Model: Investment

According to (Eq. 1), (Eq. 2), and (Eq. 3) with a case study of a toll road project in Section A, a sub-model investment can be drawn as in Figure 1.

Equation:

Construction Cost = "Road & Bridge Cost" + "Miscellaneous Building" + "Toll Facilities" + "Miscellaneous Road"

Total Project Cost = "DED Cost" + "Construction Cost" + "Supervision Cost" + "Toll Eqt. & Ops Toolkits" + "Project Overhead" + "Value Added Tax (VAT)"

Land Acquisition Cost =

0. 245754

1. 404246

Financial Fee = "Arrangement Fee" + "Underwriter Fee" + "Provision & Commission"

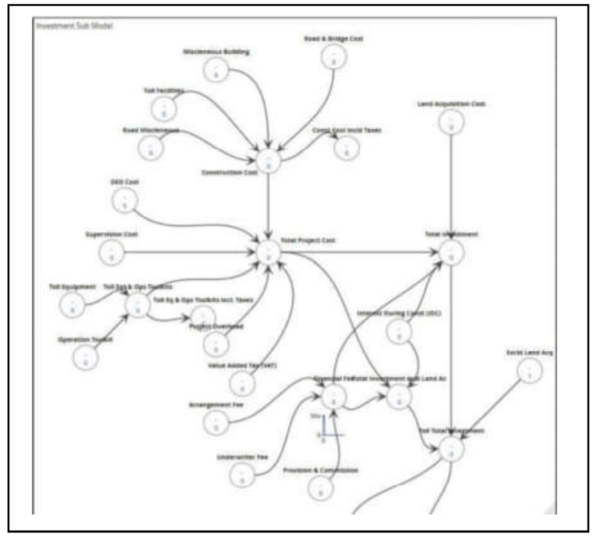

Fig. 1. Sub Model: Investment Cost

Sub Model: Debt Equity Ratio

Based on (Eq. 4) and (Eq. 5), and the case study of Toll Road Project Section A, the Equity is 0.2898 (28.29%) from the Total Project Cost, and the Debt is 100-28.29% = 71.71%. Furthermore, the sub-model of Debt Equity Ratio can be seen in Figure 2.

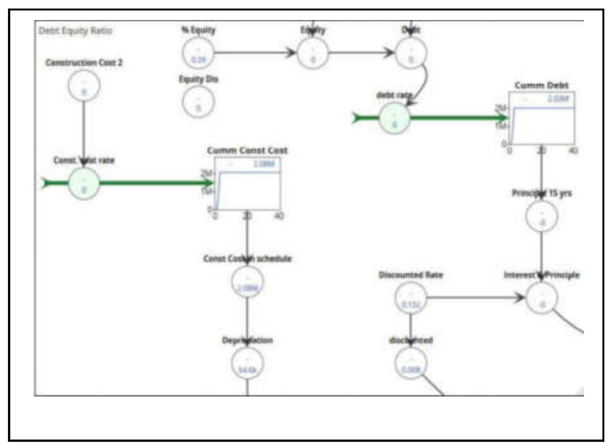

Fig. 2. Sub Model: Debt Equity Ratio

Sub Model: Revenue

Based on (Eq. 7), the toll road revenue comes from vehicle volume and vehicle tariffs per group. The Revenue sub-model is based on a case study of the toll road project Section A, which is depicted in Figure 3.

Assume the tariff growth per two years is 14% per two years.

Meanwhile, there are 5 groups of vehicles, such as: group 1 includes sedans, jeeps, pickups / small trucks, and buses; group 2 comprises trucks with 2 axles; group 3 is made up of trucks with 3 axles; group 4 contains trucks with 4 axles; and group 5 has trucks with 5 axles.

Rev Group 1 = "Traffic Group 1"*"Tariff Group 1"/10^6

Rev Group 2 = "Traffic Group 2"*"Tariff Group 2"/10^6

Rev Group 3 = "Traffic Group 3"*"Tariff Group 3"/10^6

Rev Group 4 = "Traffic Group 4"*"Tariff Group 4"/10^6

Rev Group 5 = "Traffic Group 5"*"Tariff Group 5"/10^6

Total Toll Revenue = ("Rev Group 1"+"Rev Group 2"+"Rev Group 3"+"Rev Group 4"+"Rev Group 5")*365

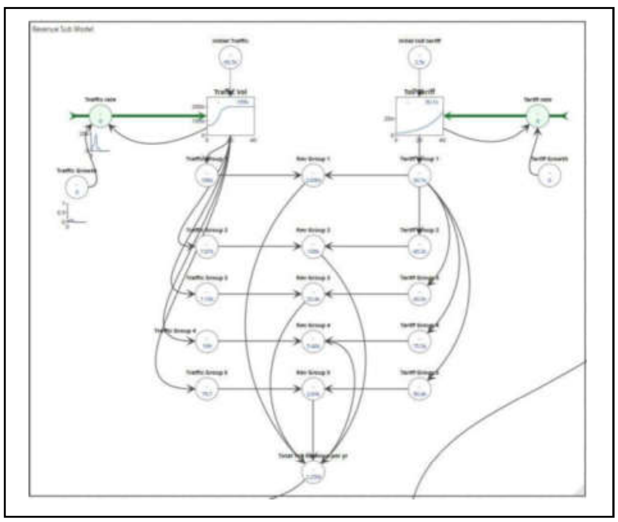

Fig. 3. Sub Model: Revenue

Sub Model: Operations & Maintenance

Based on (Eq. 8), operations & maintenance costs come from toll collection costs, toll service costs, general & administration, SPV office costs, and building and land tax costs. The Operations & Maintenance sub-model can be viewed in Figure 4.

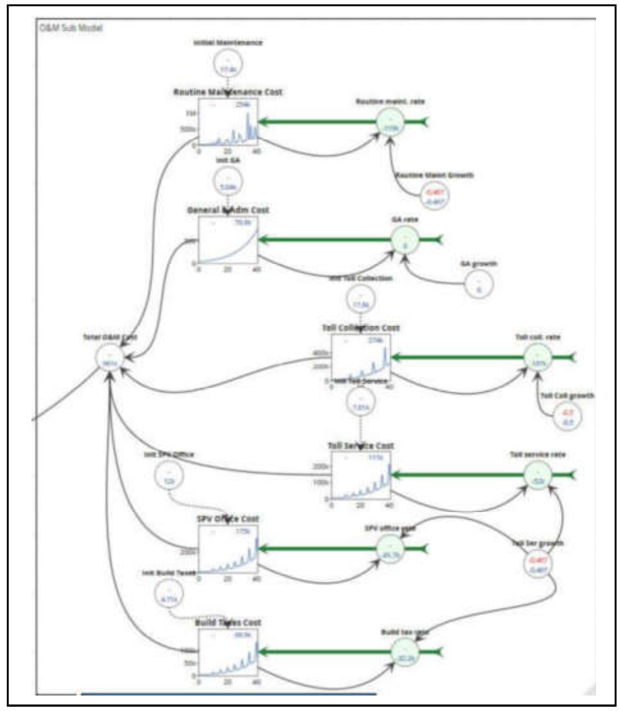

Fig. 4. Sub Model: Operations & Maintenance

Sub Model: NPV

Based on (Eq. 6), where EBITDA (Earnings Before Interest and Depreciation & Amortization) is Revenue minus Operations & Maintenance Cost, as seen at Figure 5.
Equation:
EBITDA = "Revenue"-"O&M"
Interest & Principle = "Principle 15 yrs"+("Principle 15 yrs"*"Discounted Rate")

After Interest = "EBITDA"-"Interest & Principle"

Taxes = max(0,0.3*"After Interest")

After Tax = "After Interest"-"Taxes "

Depreciation = "Const Cost"/38

After Depreciation = "After Tax"-"Depreciation"

Dividends = max(0,"% Equity 2"*"After Depreciation")

NET INCOME = "After Depreciation"-"Dividends"

NPV = ("NET INCOME"*"discounted 3")-"Toll Total Investment 3"

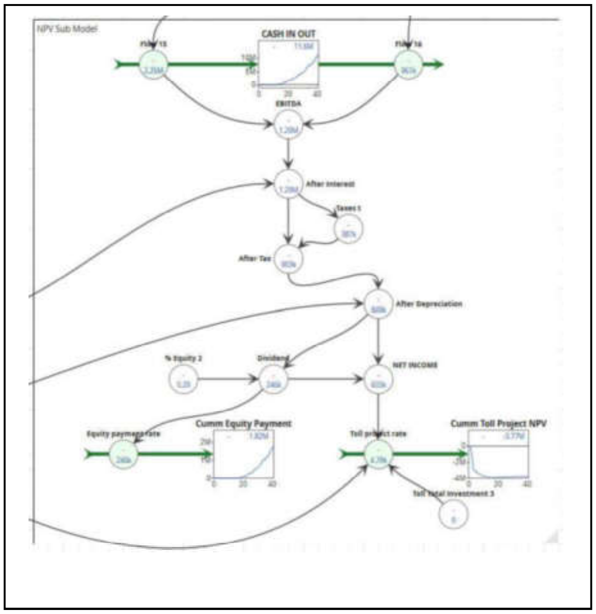

Fig. 5. Sub Model: NPV

5.0 DISCUSSION & CONCLUSION

Comparison cash flow modeling calculations between conventional (Excel) and System Dynamics are determined by the graph and its feedback, where Excel does not directly describe the graph. On the other side, with SD SysDea, the results can directly show the graph. As stated by Warren [19], SD SysDea is a strategic analysis to help in such a case. It must answer three basic dynamic questions, such as "Why has business performance followed the time path that it has?; Where is performance heading into the future under current policies?; and How can we act to alter that future for the better?".

Furthermore, at toll road project investment, the highest risk is land acquisition. Before finishing it, the construction cannot be started. Nowadays, land acquisition including funds and officers are handled by GoI through The Ministry of Public Works and Public Housing with Directorate of Bina Marga. On the other hand, if GoI postpones financing of land acquisition, then the SPV will wait it or SPV requests to shareholder to top-up equity or it can be a reserve funds which is funded by shareholders.

Meanwhile, at operation, the highest risk is traffic volume. If traffic forecast lower than business plan, then the revenue will be decline. It means that SPV can be loss or they cannot pay the debt, meanwhile they have to operate and maintenance toll road.

According to Wibowo and Kochendörfer [7], risky variables for toll road are initial toll base (rupiah/km), land acquisition time, error of land acquisition cost, error of 1st year traffic, error of later year's traffic, construction cost, and additional investment. These risky variables can be modeled at each sub models, for example, land acquisition funds is postponed by GoI, namely 2 years, means that the impact to toll land acquisition can be delayed, as well as construction will delay, as seen at Figure 6.

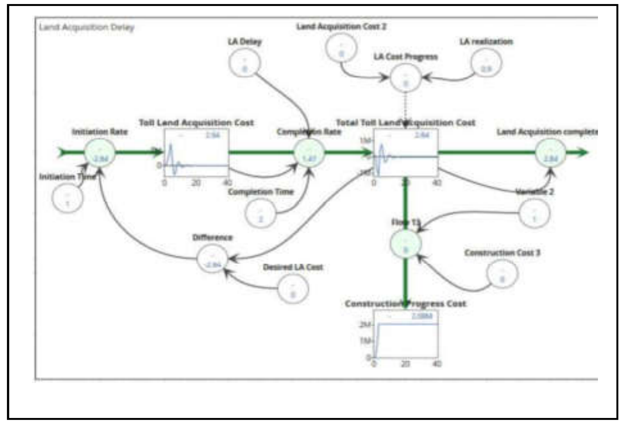

Fig. 6. Land Acquisition Delay

Therefore, this model can be used as an analytical strategy of a toll road projects not only in Indonesia but also it can be used in other countries.

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