Toll Road Infrastructure Development in Indonesia: A System Dynamics Perspective

Lukas B. Sihombing
lukas.b.sihombing@gmail.com

Abstract

The development of infrastructure, especially toll roads in Indonesia, is critical because if compared with toll roads in other countries like China or Malaysia, Indonesia toll road growth is much slower. This paper will examine the development of toll road infrastructure in Indonesia from 1995 to 2012, and then analyze it with a System Dynamics methodology. At the conceptualization stage of SD methodology, there is a significant gap between forecasts based on the current situation and forecasts based on an econometric data panel method. The results of this paper, based on a current investment process from the Government of Indonesia, is the total toll road construction, based on the government's plan is 2213 km; it will be finished in 2080. It means that toll road construction in Indonesia is very challenging. This paper recommends that to accelerate the construction of toll roads in Indonesia, it should be leveraged with something innovative.

Keywords: gap, econometric, system dynamics, toll road infrastructure

1. Introduction

According to the Masterplan Acceleration and Expansion of Economic Development (MP3EI, 2011), the infrastructure, including roads, ports, airports, power plants, water supplies, sewers, telecommunications, and other infrastructures are needed to strengthen the inter and intra connectivity of future center economic growth. However, the object of this paper is toll road infrastructure. According to Government Decree No.15, 2005, toll road organization intended to bring about equitable development and its results as well as a balance in regional development with regard to justice, which funds are derived from road users to build a road network. The aim is to improve the efficiency of distribution services and support economic growth, especially in areas that have high levels of development. A toll road is not only an alternative road that can be taken from an existing public road, but it is also an alternative road when there are no public roads in a particular region. Therefore, a toll road is necessary to develop a particular area.

According to Aschauer (1989), the decline of infrastructure investments in the United States from 1971 until 1985 reduced the productivity level to 0.8% annually for country-wide businesses. Related to measuring infrastructure investments, Sutherland, Araujo, Egert, and Kozluk (2009) said there are two kinds of measuring infrastructure investments. The first is an estimation of capital stock, which is often used for calculations in a national context. Meanwhile, the second is to measure physical infrastructure size. The measurement of toll road infrastructure investments which is used in this study is physical toll road infrastructures, such as toll road length in kilometers (km).

If toll road length is used as a measurement of investment, based on data, it can be shown that the growth of toll road infrastructure in Indonesia is insignificant. For instance, in 2000 the toll road length was 585.07 km, whereas in 2001 toll road growth only reached 0.95% or 590.62 km. At that time, there were 5 private investor funded toll roads or equal to 23% (BPJT, 2007). The participation of the private sector is low due to the impact of the financial crisis at the global level especially in Asia in mid-1997, and also the collapse of the domestic commercial bank sector (The World Bank, 1999).

According to Jasa Marga (2012), "Jagorawi (Jakarta Bogor Ciawi) is the first toll road which was operated by Jasa Marga in 1978. With a total length of 59 km, the toll road connects Jakarta, Cibubur, Citeureum, Bogor, and Ciawi. The operation of Jagorawi marks a milestone in the establishment of Jasa Marga (Persero) Tbk, as the company to develop and operate a toll road in Indonesia." Based on BPJT (2013), the total length of functional toll roads as of 2013 has reached 784.06 km (BPJT, 2013).

In fact, the Government of Indonesia through the Toll Road Authority Board (BPJT) engaged in accelerated efforts in Indonesia for toll road investments as was issued by the Toll Road Acceleration Program 2005-2009 for 1099.08 km length, consisting of 32 sections of Trans Java toll roads or equal to 763.24 km length; and 19 sections of non-toll roads for Trans Java or equal to 335.84 km length (BPJT, 2010). Nevertheless, the realization until 2010 was only 78.45 km length; so the average growth per year from 2006 to 2010 was 15.69 km or 2.3% per year.

On the other side, the acceleration of toll road programs was also carried out by other countries such as China and Malaysia, but the actual acceleration of toll road construction in China and Malaysia is better than Indonesia. It can be shown from the Toll Road Acceleration Program in China that the length of toll roads in 2007 reached 45,000 km (World Bank, 1999); in 2010 it reached 65,000 km (CIA, 2012) or an average growth of 30% annually from 1996 until 2010. By 2020, the expected length of toll roads in China is expected to reach 85,000 km (Peopledaily, 2007). Meanwhile, Malaysia toll road length in 1966 was 20 km (Wikipedia, 2009), and the length of toll roads in 2010 reached 2,671.28 km (Wikipedia, 2007) or an average growth of 9.24% annually from 1996 until 2010.

From the description above, the following question arises: How is the complexity of toll road infrastructure development dynamics depicted in Indonesia?

To answer the question, a relevant approach to analyze the complexity of toll road infrastructure development dynamics in Indonesia is the System Dynamics (SD) Approach, because according to Sterman (2001), "System dynamics draws on cognitive and social psychology, organization theory, economics, and other social sciences. To solve important real world problems, we must learn how to work effectively with groups of busy policymakers and how to catalyze change in organizations." So in a system, Indonesia toll road infrastructure development is very complex and dynamic. In the real world, for example, there are delays in land acquisition, a shortage of development funds both by the government and private parties, etc. Because of that, using a system dynamics method is relevant to analyze the development of the complexity of toll road infrastructure development dynamics in Indonesia.

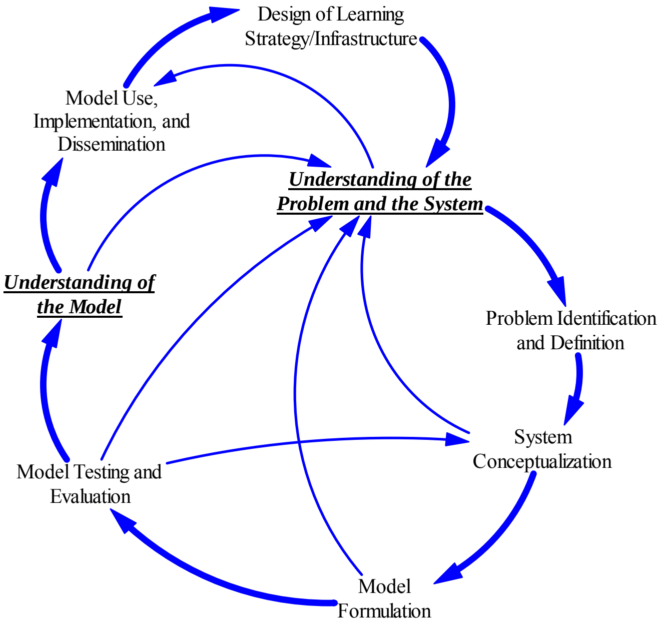
The purpose of this paper is to describe the dynamics of Indonesia toll road infrastructure development. The dynamic depiction of toll road development in Indonesia can be analyzed by using a System Dynamics Approach. This method can be used to assist us in comprehending the feedback system of toll road infrastructure development as being dynamic and complex. According to Sterman (2000), System Dynamics can be used as a method to improve understanding of complex systems in an interdisciplinary and fundamental way because SD is based on a nonlinear dynamics theory and feedback control developed through mathematics, physics, and engineering. SD draws on cognitive and social psychology, organization theory, economics, and other social sciences, solving problems in the real world, and as a bridge to a nonlinear system. According to Luan, Chen & Wang (2010), System

Dynamics (SD) can bridge a simulation system through an internal system structure simulation; it can particularly handle a multi-loop nonlinear system.

The structure of this paper is as follows: Section 2 is the methodology and data sources. The methodology used in this paper is a System Dynamics Approach, i.e. starting from a conceptual design until making a learning strategy/infrastructure design. Meanwhile, the source of data is that which supports the conceptual process of the SD method. Section 3 is a literature review of toll roads that outlines the literature which explains the correlation between the toll road lengths with the population and GDP. The literature outlines the econometric analysis of infrastructure and describes system dynamics. Section 4 describes SD conceptual methods to get a description of problems in toll road development and compare them with 21 countries. This section also describes the SD model formula for toll roads, starting from causal loops until stock and flow diagrams and then SD results. Finally, Section 5 is the conclusion.

2. Methodology

The methodology used in this paper is a System Dynamics Approach. The stages of a system dynamics modeling process according to Martinez-Mayano and Richardson (2013) are: 1) conceptualization – problem identification and definition, system conceptualization; 2) formulation – model formulation; 3) testing – model testing and evaluation; 4) implementation – model use, implementation, and dissemination; and 5) design of learning strategy/infrastructure. An overview of the system dynamics modeling approach can be seen in Figure 1.



Source: Martinez-Mayano and Richardson (2013)

Figure 1: Overview of the System Dynamics Modeling Approach

2.1 Source of Data

To identify the problems associated with physical gaps in toll road lengths in Indonesia, namely to get the length of a toll road which is appropriate with the current situation, historical data of Indonesia toll road lengths was used, starting from 1995 until 2012.

Meanwhile, to get desired toll road lengths, an econometric data panel method was used. Besides toll road length data, data from the population and GDP for 21 countries had to be collected, starting from 1995 until 2012. The data of the toll road lengths was collected from: BPJT, 2013; World Road Statistics, 1999-2004 (The IRF World Road Statistics 2006); 2001(The IRF World Road Statistics 2001); 2007 (The IRF World Road Statistics 2007); CIA Factbook, 2012; population data (data for 1995-2010 from Penn Tables (the Penn World Table, 2012); for 2011 from UNFPA 2011; for 2012 from UNFPA 2012, GDP data (The World Bank, 2012).

3. Literature Review of Toll Roads

In road infrastructure planning, Fuller and Morency (2013) used a population approach to reduce the exposure of motor vehicle traffic volumes for all road users, which may greatly reduce the total number of transportation fatalities. According to Ament, Clevenger, Yu, and Hardy (2008), as taken from the TRB/Transportation Research Board (2002), it stated that the national economy and population were expected to pose major new challenges for transportation and the environment. Yue, et al. (2003) used data population and road infrastructure as a scenario of spatial population distribution that could be developed as a basic forecast of population in China. Moller-Jensen and Knudsen (2008) used population data to gain a proximity index for locality; i.e. value was measured by network roads between one locality and other urban localities. Orenstein and Hamburg (2010) used population growth to measure land use/land cover, including roads in Israel.

Meanwhile, researchers who used GDP data as a factor that affects the increase of toll road development are as follows: Newel and Peng (2008) by citing OECD (2006) and the World Bank (2006) mentioned that developed countries allocated an average of 2.2% of the GDP to infrastructure, while developing countries invested 7% of the GDP to the new infrastructure (Newell, Peng, 2008, PG. 22). This statement was supported by Oronje, Rambo, and Odundo (2014) in citing Heggie (1995) and Brushett (2005), who mentioned that road transportation is very important for socio-economic development, because it is able to provide the necessities between center production and the market; it makes the mining, industrial, and agricultural sectors become more valuable. Road transportation also facilitates access to the workplace, as well as education, health, social and leisure facilities. As mentioned by Heggie (1994; 1995) and Brushett (2005), the quality of road networks can determine the ability of cost transportation to be affordable, commodity price basis, and the quality of life, especially for people who have low incomes. In this case, an efficient transportation system can minimize transportation costs, so that it can support economic growth by promoting production and trade (Oronje, Rambo, Odundo, 2014, p.75).

According to Nùñez (2008), in the aggregated transportation demand forecast model, individual mobility and income are represented by traffic and gross domestic product (GDP). Mobility generates traffic and it is supposed that GDP growth also increases purchasing power ability. In economics, this relationship is represented by an elasticity of traffic with the leads on GDP usually greater than one (Nùñez, 2008, p.258).

For example, in India, as described by Lakhmani and Sikroria (2012), economic growth in India, especially in the previous three years, was robust in some matters. Economic growth has accelerated and now boasts an average growth of 8% annually. The economic growth is supported by investments in infrastructure such as road transportation, railways, air and water, power and telecommunications, and also water supply and irrigation. During the

Eleventh Plan (2007-2012), the GDP grew 4.6% to 7-8%, with nearly US $320 billion expenditures spent in the period of the Plan (Lakhmani, Sikroria, 2012).

Another example is in China. According to Wang (2011), it has most of the toll roads in the world. One of which is the longest in China, namely from 140,000 km in the world, 100,000 km is in China. He stated that toll roads greatly influence the economic development in China. Based on data, China's spending on logistic services amounted to 3.3 trillion RMB ($570 billion) in the first half of 2011 (Wang, 2011, p.1303).

To get a description of the ideal length of toll roads in Indonesia, namely compared with 21 countries in the times series and cross-country, a panel data econometric method is used. According to Gujarati (2004), econometrics means "economic measurement". Baltagi (2001) said that the term "panel data" refers to the pooling of observations on a cross-section of countries, households, firms, etc. over several time periods. This can be achieved by surveying a number of households or individuals and following them over time.

Various researchers have conducted studies related to the use of the econometric model in infrastructure; they are: Khanam (1996), who used the Cobb-Douglas and translog functional forms; Zhu and Tan (2000) who examined the causal relationship between the intensity of FDI inflow and the increase of technical efficiency; Globerman and Shapiro (2003) who analyzed the statistical importance of governance infrastructure; Tomljanovich (2004) who examined one possible source of growth and per capita output levels; Chien and Hsiau (2005) who researched an empirical analysis of factors that have influenced economic growth; Aristovnik (2006) who investigated the empirical link between the current account and the fiscal balance; Lall (2006) who examined the contribution of publicly supplied infrastructure; Henderson and Kumbhakar (2006) who estimated the returns to capital, employment, private and public capital in gross state product; Mohapatra and Giri (2009) who explored the relationship between economic development; Amdal, Bårdsen, Johansen, and Welde (2007) who studied the ease of planning new toll projects by a panel data; Márquez, Ramajo, and Hewings (2010) who investigated databases where the number of cross-sectional units is small for a typical panel of data; Gompert and Buerkle (2011) who developed a hierarchical Bayesian model to quantify the genome-wide population structure and identify candidate generic regions affected by selection; Sin-Yu (2011) who examined the causal relationship between financial development and poverty reduction; and Hämäläinen and Malinen (2011) who estimated the elasticity of private production with respect to public capital in a regional framework.

4. System Dynamics Modeling for Toll Road Development

As described in the methodology above, the first step to construct System Dynamics modeling is to identify and define problems and then create a System Conceptualization.

4.1 System Conceptualization

According to Lyneis and Ford (2007), a System Dynamics methodology is used as the form of a model conceptual structure and the approximate chronological order of development. The model structure was followed by some typical project behavior. Then by citing Roberts (1964, 1974), an understanding of management in the project conditions at the conceptual phase is the perception gaps – differences between perceived progress and real progress, and between perceived productivity and real productivity.

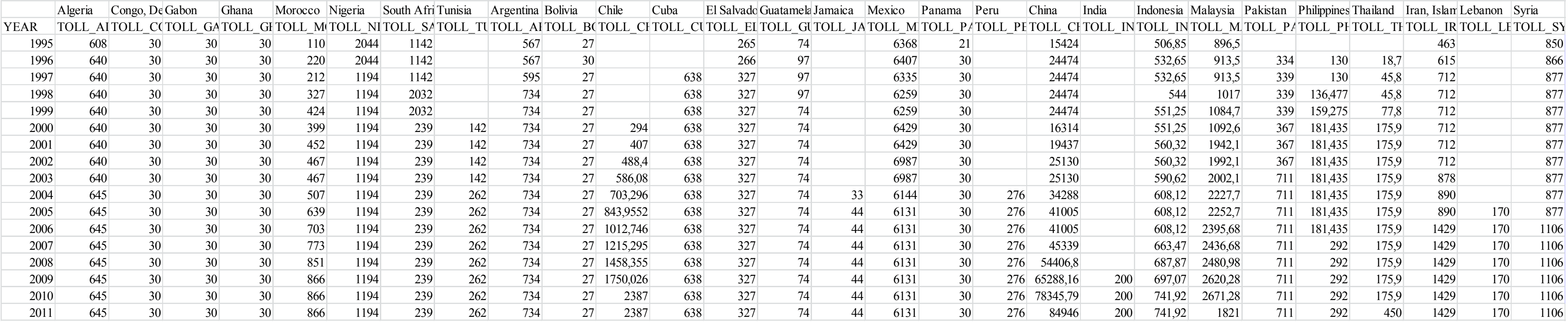
Thus, the perception gap is physical gaps in Indonesia toll road length, which explains toll road length forecasts by looking at possible toll road lengths and comparisons to 21 countries.

According to Vaishnavi and Kuechler (2008), a physical gap is a comparative description between ideal situations or desirable ones, so a "vision" needs to be created.

The physical gaps in toll road infrastructure in Indonesia are compared between toll road lengths based on current situations and ideal (desired) toll road lengths. These gaps are analyzed using data time series starting from 1995 until 2012 and then forecasted until the year 2040. To determine the potential gap (output gap), according to Chaudhry (2010), an econometric data panel is used with required data time series and cross-country. According to Gujarati (2003), the panel data regression model is a combination of features between time series data and cross-sections, because it provides "more informative data, more variability, less collinearity among the variables, more degrees of freedom, and more efficiency". The use of statistical and econometric data panel tools can be used for the length and distribution of a delay. The other reason is that the econometric technique is designed to spell out the time in most business and economic data being reported regularly, separating intervals such as quarterly, bi-annually, or annually. System Dynamics models are always developed for sustainable times. The second reason mentions that a regression equation for a lag has fixed lag weights, implying a fixed delay time. The structure of information and material delay used in system dynamics responds to changes in delay times (Sterman 2000, p.439).

Econometric panel data can be used in a system dynamics model. Then to get the desired results, it requires the determination of cross-country data that is taken based on countries that have the same income per capita or appropriate with Indonesia's position based on World Bank standards for lower income and upper income. As a result, there are 21 countries such as: Algeria, Morocco, Nigeria, South Africa, Tunisia, Argentina, Bolivia, Chile, El Salvador, Guatemala, Jamaica, Mexico, Panama, China, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, Iran, and Syria. In addition to toll road length data, data related to population and GDP should be collected in each country starting from 1995 to 2012. According to Sharma and Vohra (2009), toll road length, population, and GDP data among those countries can be used as a comparison of data, where GDP data is taken to describe the economy of a country, and the population data is taken to represent the number of people in a country. Furthermore, the toll road length time series data for 21 countries can be seen in Table 2.

To find the physical gaps above, an analysis of the current situation is carried out by using data about the length of a single Indonesia toll road. Meanwhile, to get an ideal or desired toll road using the panel data method, one should take into account 21countries as times series and cross-country. This method will result in a linear regression model and data panel model. So, this model will show that the development of toll roads in Indonesia will be significant. To determine the regression model with single data, time series data of toll road length in Indonesia can be used starting from 1995 until 2012 and then forecasted using ARIMA (Autorefressive Integrated Moving Average) model. Then the process to determine the best data panel is as follows: 1) collect data time series for 21countries as cross-country; 2) make a common structure model of each country considered the same and without any effect; 3) make a random structure model, which is indicated by each country as different individuals; and 4) make a random model, which is indicated by each country as a unique individual. It is further analyzed to obtain the ideal structure regression model. Then the hypothesis is tested to finally get the best model. The steps are shown in Figure 2.



	Algeria	Congo, De	Gabon	Ghana	Morocco	Nigeria	South Afri	Tunisia	Argentina	Bolivia	Chile	Cuba	El Salvado	Guatamela	Jamaica	Mexico	Panama	Peru	China	India	Indonesia	Malaysia	Pakistan	Philippines	Thailand	Iran, Islam	Lebanon	Syria
YEAR	TOLL_AI	TOLL_C	TOLL_GA	TOLL_GI	TOLL_M	TOLL_NI	TOLL_SA	TOLL_TU	TOLL_AI	TOLL_BC	TOLL_CI	TOLL_CU	TOLL_EI	TOLL_GU	TOLL_JA	TOLL_MI	TOLL_PA	TOLL_PE	TOLL_CI	TOLL_IN	TOLL_IN	TOLL_M.	TOLL_PA	TOLL_PI	TOLL_TI	TOLL_IR	TOLL_LE	TOLL_SY
1995	608	30	30	30	110	2044	1142		567	27			265	74		6368	21		15424		506,85	896,5				463		850
1996	640	30	30	30	220	2044	1142		567	30			266	97		6407	30		24474		532,65	913,5	334	130	18,7	615		866
1997	640	30	30	30	212	1194	1142		595	27		638	327	97		6335	30		24474		532,65	913,5	339	130	45,8	712		877
1998	640	30	30	30	327	1194	2032		734	27		638	327	97		6259	30		24474		544	1017	339	136,477	45,8	712		877
1999	640	30	30	30	424	1194	2032		734	27		638	327	74		6259	30		24474		551,25	1084,7	339	159,275	77,8	712		877
2000	640	30	30	30	399	1194	239	142	734	27	294	638	327	74		6429	30		16314		551,25	1092,6	367	181,435	175,9	712		877
2001	640	30	30	30	452	1194	239	142	734	27	407	638	327	74		6429	30		19437		560,32	1942,1	367	181,435	175,9	712		877
2002	640	30	30	30	467	1194	239	142	734	27	488,4	638	327	74		6987	30		25130		560,32	1992,1	367	181,435	175,9	712		877
2003	640	30	30	30	467	1194	239	142	734	27	586,08	638	327	74		6987	30		25130		590,62	2002,1	711	181,435	175,9	878		877
2004	645	30	30	30	507	1194	239	262	734	27	703,296	638	327	74	33	6144	30	276	34288		608,12	2227,7	711	181,435	175,9	890		877
2005	645	30	30	30	639	1194	239	262	734	27	843,9552	638	327	74	44	6131	30	276	41005		608,12	2252,7	711	181,435	175,9	890	170	877
2006	645	30	30	30	703	1194	239	262	734	27	1012,746	638	327	74	44	6131	30	276	41005		608,12	2395,68	711	181,435	175,9	1429	170	1106
2007	645	30	30	30	773	1194	239	262	734	27	1215,295	638	327	74	44	6131	30	276	45339		663,47	2436,68	711	292	175,9	1429	170	1106
2008	645	30	30	30	851	1194	239	262	734	27	1458,355	638	327	74	44	6131	30	276	54406,8		687,87	2480,98	711	292	175,9	1429	170	1106
2009	645	30	30	30	866	1194	239	262	734	27	1750,026	638	327	74	44	6131	30	276	65288,16	200	697,07	2620,28	711	292	175,9	1429	170	1106
2010	645	30	30	30	866	1194	239	262	734	27	2387	638	327	74	44	6131	30	276	78345,79	200	741,92	2671,28	711	292	175,9	1429	170	1106
2011	645	30	30	30	866	1194	239	262	734	27	2387	638	327	74	44	6131	30	276	84946	200	741,92	1821	711	292	450	1429	170	1106

Table 2: Toll Road Length Time Series Data for 21 Countries from 1995-2011

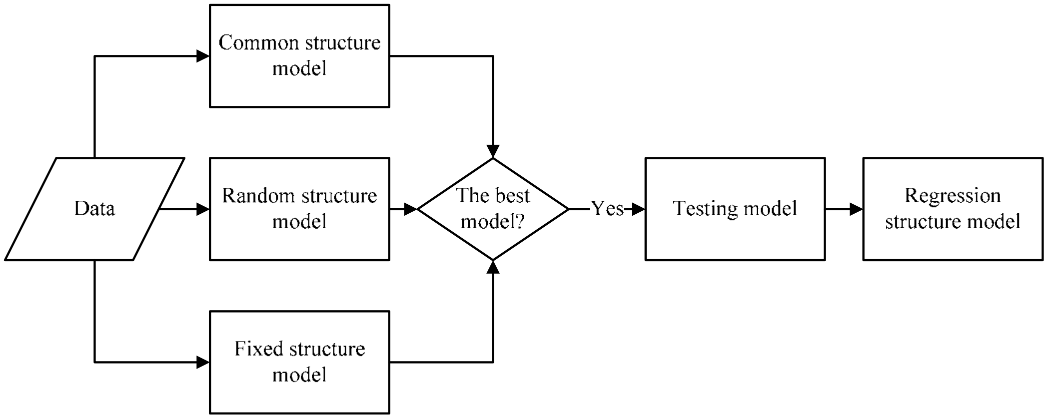


Figure 2: Steps of Panel Data

4.1.1 Single Regression Model

To obtain single data regression results, an ARIMA (Auto Regressive Integrated Moving Average) linear method is used. ARIMA models are, in theory, the most general class of models for forecasting a time series which can be stationary through differencing and transformations such as logging. In fact, the easiest way to think of ARIMA models is as fine-tuned versions of random-walk and random-trend models: the fine-tuning consists of adding *of the lags to be differenced series* and/or *lags of the forecast errors* to the prediction equation, as needed to remove any last traces of autocorrelation from the forecast errors (Introduction to ARIMA, 2014).

Forecasting with an ARIMA model example with the ARIMA model (0, 1, 1) (0, 1, 1) is outlined as follows:

$$(1-B)(1-B_{12})X_t = (1-\theta_1 B)\,(1-\Theta_1 B^{12})\, e_t \qquad (1)$$

But to use it in forecasting, it requires a translation of the regression equation to make it more general. The above model is in the following form:

$$X_t = X_{t-1} + X_{t-12} - X_{t-1} + e_t - \theta_1 e_{t-1} - \Theta 1 e_{t-12} + \theta_1 \Theta_1 e_{t-13} \qquad (2)$$

Using the Crystal Ball ® tool and data input of toll road length in 1995-2011, the best ARIMA equation (1, 1, 2) is obtained as follows:

TOLL_INA_As_Usual = 0.9767* TOLL_INA$_{t-1}$ + 1.39* YR$_{t-1}$-0.765 (3)

where:

TOLL_INA_As_Usual is toll road lengths in Indonesia, TOLL_INA$_{t-1}$ is toll road lengths from the previous year, while YR$_{t-1}$ is a dummy variable from the previous year.

4.1.2 Panel Data Model for Toll Roads

By combining the time series of a cross-section of toll road lengths, GDP, and population in 21 countries (Algeria, Morocco, Nigeria, South Africa, Tunisia, Argentina, Bolivia, Chile, El Salvador, Jamaica, Mexico, Guatemala, Panama, China, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, Iran, and Syria), we can use panel data. A simple dynamic panel data model with heterogeneous coefficients is presented as Gujarati (2004) has outlined:

$$Y_{it} = \beta_1 + \beta_2 X_{2it} + \beta_3 X_{3i} t + u_{it} \qquad (4)$$

This depicts where *i* stands for the *i*th cross-sectional units and *t* for the *t*th time period.

For an empirical illustration, Baltagi and Levin (1992) estimate a dynamic model of the demand for cigarettes based on panel data from 33 American states over the period of 1963-87. The estimated equation is (Baltagi, 2001):

$$\ln C_{it} = \alpha + \beta_1 \ln C_{i,\,t-1} + \beta_2 \ln P_{it} + \beta_3 \ln Y_{it} + \beta_3 \ln P_{nit} + u_{it} \qquad (5)$$

This depicts where the subscript i denotes the ith state ($i = 1, ..., 46$), and the subscript t denotes the tth year ($t = 1, ..., 26$). $C_{it}$is real per capita sales of cigarettes by persons of smoking age (14 years of age and older).

So, in the same way as the equation model (2), we can write the structure model for toll road length as follows:

$$\ln toll_{it} = \alpha + \beta_{1i1} \ln gdp_{it} + \beta_{i2} \ln pop_{it} + \varepsilon_{it} \qquad (6)$$

where:

$\ln_t toll$: toll road lengths (km), $\ln_t gdp$: GDP (millions of dollars), $\ln_t pop$: population (millions of people), α_1 = intercept, β_1 , β $until_n$= slope, ε_{it}= stochastic disturbance term and i =the number of individuals. Notice that α and β vary individually for all. This model indicates that the parameters for α and β are various.

So the data panel of the toll road length equation in Indonesia is:

LNTOLL_INA =-4.493-0.223 * LNYR + 0.246 * LNPOP_INA + 0.750 * LNGDP_INA (7)

or

TOLL_INA_Not As usual = EXP (-4.493)*YR_IND$^{-0.223}$* POP_ INA$^{0.246}$*GDP_ INA$^{0.750}$ (8)

where:

TOLL_INA_Not As usual is the toll road length in Indonesia by comparing it with 21 countries, POP_INA is the total population in Indonesia, GDP_INA is Indonesia's GDP, and YR_IND is a dummy variable of that year.

By combining Eq. (3) and (8) above, then a physical gap of toll road lengths in Indonesia until 2040 is forecasted as in Figure 3 below.

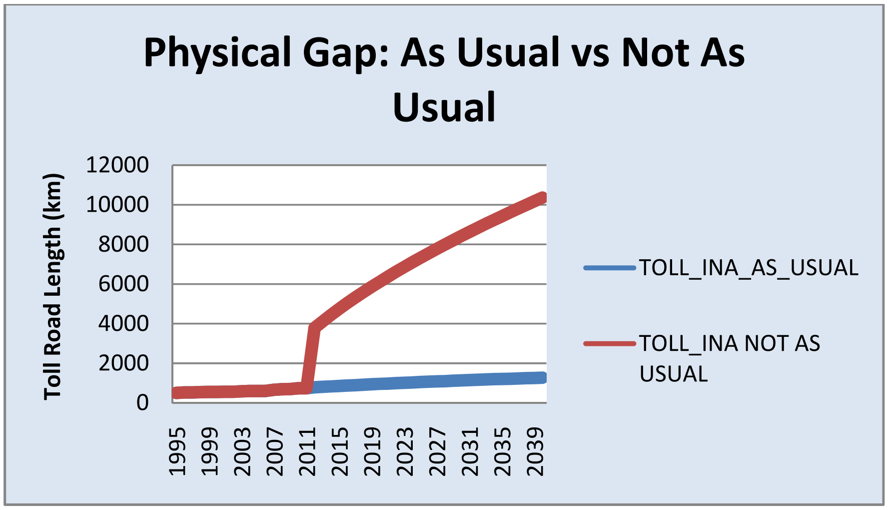


Figure 3: Physical Gap of Toll Roads between As Usual and Not as Usual

From Figure 3 above, it describes that forecasting as usual is based on Eq. (3) and not as usual based on Eq. (8). In Figure 3, it states that with not as usual, after calculating for the year 2012, Indonesia toll road length in 2040 should be 9,549 km, but with as usual Indonesia toll road length will achieve 1,269 km, so the physical gap in the year 2040 is 10,357 km.

From the results of the physical gap above, it can be explained that toll road development in Indonesia is required due to the needs of population and GDP. But in fact, the need for the toll road length in Indonesia as reported by the BPJT (2013) is 2,213.83 km length, where the toll roads operated are 784.06 km, establishment of toll roads is 874.79 km length, tender process is 159.77 km, and tender preparation is 395.21 km length. So, if compared with the results of Eq. (8), then a toll road length of 2,213.83 km should have been achieved in 2007. Unfortunately, this plan was never realized. So, the main problem of this study is that there is a gap between the current situation and the desired toll road length in Indonesia.

4.2 Formulation of System Dynamics Model for Toll Road Development

After knowing the problems of the development of toll roads in Indonesia with a physical gap analysis, a System Dynamics model is formulated.

4.2.1 Causal Loop Diagram

According to Sterman (2000, p.179), there is a need for new road construction because of congestion and delays. The construction of toll roads in Indonesia aims to streamline traffic in areas that have been developing, improve the distribution of goods and services to support economic growth, promote equitable development and justice outcomes, as well as ease the burden of government funding through the participation of road users (BPJT, 2013). So as the mental model of the outline of toll road development in Indonesia, it can be described in Figure 4.

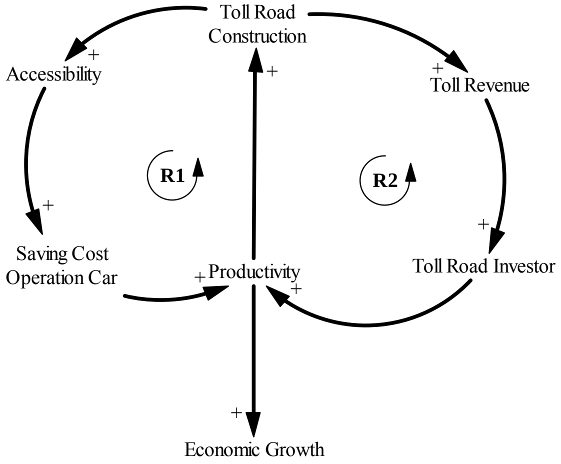
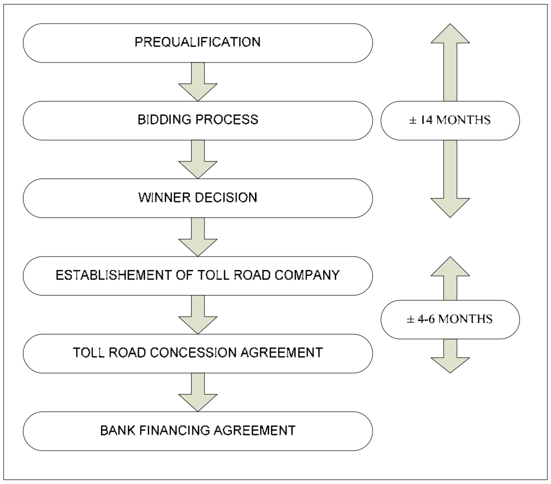


Figure 4: Conceptual Mental Causal Effect Diagram of Toll Road Investment Development in Indonesia

From Figure 4 above, there are two reinforcing loops: loop R1 and R2. Loop R1 explains that with toll road construction in Indonesia it is expected to facilitate accessibility and traffic in developing areas, increasing the effectiveness and distribution of goods and services, so that the toll road users will benefit from vehicle operating costs. This will increase productivity and finally support economic growth. Loop R2 explains that with the construction of toll roads in Indonesia, it will get toll revenues, so that with toll revenues the corporations will get investment returns, depending on the certainty of traffic volume and toll rates, which will finally support Indonesia's economic growth.

4.2.2 Stock and Flow Diagram

According to Martinez-Moyano and Richardson (2013, p.115) to make a model formulation, it uses two approaches. It starts small, adds complexity as necessary, and uses realistic operational thinking. Thus, in this paper the process is focused on the realities of the toll road investment process in Indonesia and the process of toll road construction, according to BPJT (2013). The toll road investment process can be illustrated as shown in Figure 5.



Source: BPJT, 2013

Figure 5: Indonesia Toll Road Investment Procedures

Based on Figure 5 above and the process of toll road construction in Indonesia, it can be described in the Stock and Flow Diagram as illustrated in Figure 6.

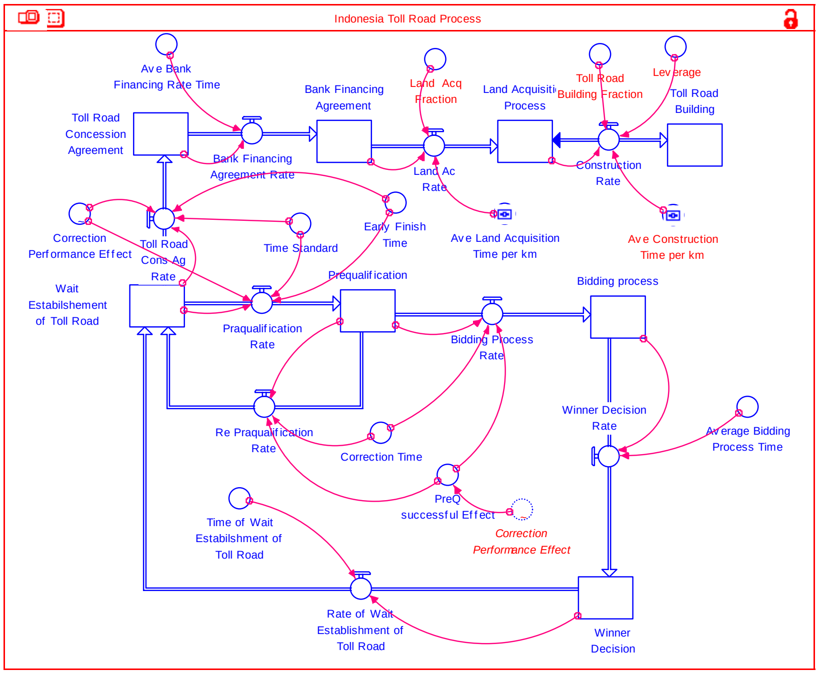
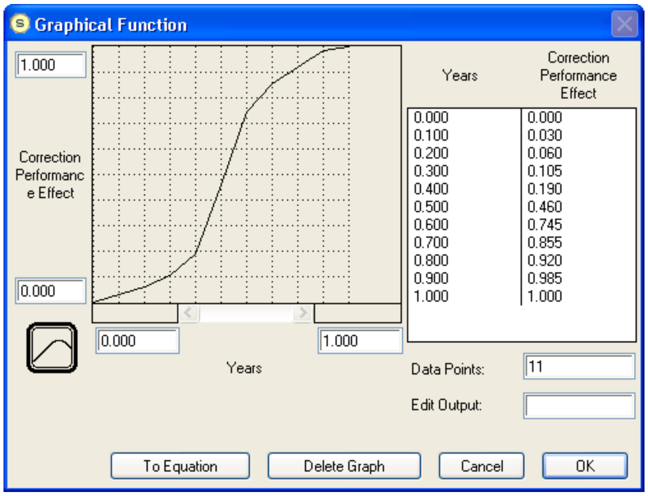


Figure 6: Stock and Flow Diagram of Indonesia Toll Roads

From Figure 6 above, the process of the wait establishment of the toll road company requires pre-qualifications, a bidding process, and a winner decision; then there is a toll road concession agreement between the Indonesia Toll Road Authority and the company. Then, the equation of the prequalification rate is as follows:

MIN (Wait _ Establishment_of_Toll_Road_Company * Correction _ Performance_Effect/Time_Standard, Early_Finish _ Time * Correction _ Performance_Effect) (9)

Meanwhile, the Correction Performance Effect is an effect that is obtained based on the Correction Performance that affects the Prequalification Rate and Re-Prequalification Rate and Bidding Process Rate, as seen at Figure 7.



Years	Correction Performance Effect
0.000	0.000
0.100	0.030
0.200	0.060
0.300	0.105
0.400	0.190
0.500	0.460
0.600	0.745
0.700	0.855
0.800	0.920
0.900	0.985
1.000	1.000

Data Points: 11

Figure 7: Correction Performance Effect

Next, to run the toll road concessioner, the company must show their 'bankable' financials to BPJT, and then the company performs land acquisitions and toll road construction.

4.3 System Dynamics Model Result

The system dynamics model results are as described in Figure 6 above with the stock. It is started with the toll road length in 2013 at 784.06 km (BPJT, 2013), Ave Land Acquisition Time per km= 5/30 year and Ave Construction Time per km = 2/25 years, with the Toll Road Building Fraction = 0.0456. Then the toll road length in the year 2040 is 1,488.04 km. Meanwhile, land acquisitions will be executed starting in 2014 with 2213.83-784.06 = 957.843 km, so that in 2014 the remainder is 948.41 km.

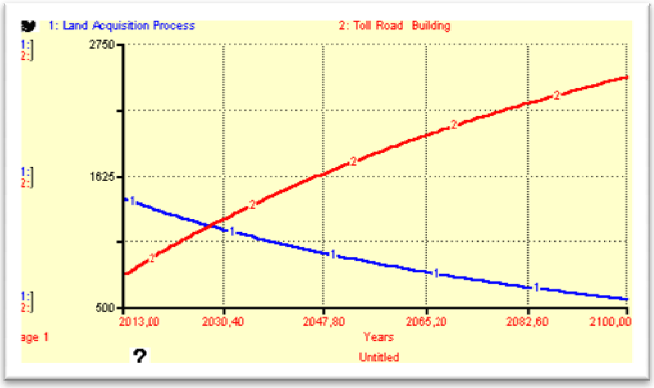


Figure 8: Indonesia Toll Road Infrastructure System Dynamics Model Results

If followed, land acquisition will be completed in the year 2067, but the toll road plan which is planned by the government for 2213.83 km will be reached in the year 2080.

Meanwhile, as can be seen in Figure 9, with the same input data above but using a leverage option, for example if the leverage is 2 times, land acquisition will be completed in the year 2032, but the toll road plan which is planned by the government for 2213.83 km will be reached in the year 2054. If leverage is 3 times, land acquisition will be completed in the year 2024, and the toll road plan which is planned by the government for 2213.83 km will be reached in the year 2043.

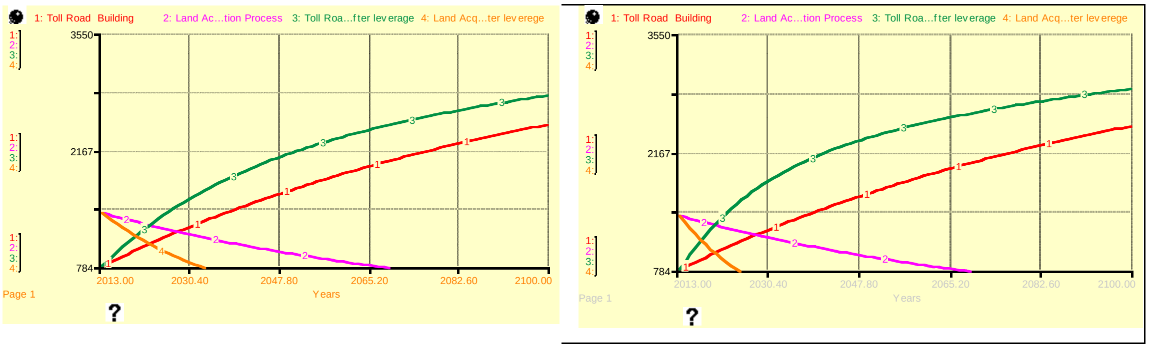


Figure 9: Indonesia Toll Road Infrastructure System Dynamics Model Results after Leverage

5. Conclusion

The problems of toll road conditions in Indonesia by using a physical gap analysis between the existing toll road length and estimated econometric panel data foretell a large difference in 2040, as long as 10,357.580 km. It proves that the construction of toll roads in Indonesia still needs to be accelerated by up to 8 times, because toll road development is based on population and GDP by comparing it with 21 countries.

If simulated by using real toll road construction in Indonesia, with Ave Land Acquisition Time per km = 5/30 year and Ave Construction Time per km = 2/25 years, with the Toll Road Building Fraction = 0.0456, then the toll road length in 2040 is 1,488.04 km. Meanwhile, the land acquisitions that will be executed starting in 2014 are 2213.83-784.06 =

957.843 km; so in 2014 the remainder is 948.41 km. Therefore, to accelerate toll road development in Indonesia, there must be leverage.

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