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Analyzing the Impact of Industrial Areas Development on Investment Feasibility of Patimban Access Toll Road using a Dynamic System Method

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ABSTRACT:

The Government of Indonesia continues to build infrastructure through National Strategic Projects/*Proyek Strategies Nasional (PSN)*. One of those projects is the Patimban Access Toll Road which allows connectivity to one of the biggest ports in Indonesia. Ministry of Public Works and Public Housing of Republic of Indonesia offers business entities to participate in building the Patimban Access Toll Road with investment project data that still shows that the project is not considered feasible. In the development of the Patimban Access Toll Road, the government plans to build an industrial area around the project, which has the potential to increase travel demand, increasing the investment feasibility of the Patimban Access Toll Road. This study uses a travel demand forecasting approach with a dynamic system simulation model that can provide reliable estimation to compare the project's financial feasibility before and after involving industrial areas around the project. In this simulation model, scenarios is carried out to compare the financial feasibility with the possible tariffs. The output of this research is an analysis of financial feasibility after the existence of industrial areas and recommendations for the optimal tariff to produce an Internal Rate of Return (IRR) which shows that the project is feasible with high availability of payments.

Keywords: Toll Road; Patimban Access Toll Road; Dynamic System; Feasibility Study

INTRODUCTION

Towards the 100th anniversary of Indonesia, President Joko Widodo has tasked the Ministry of National Development Planning/*Bappenas* to draw up Indonesia's Vision 2045 to strengthen and accelerate the achievement of the goals of the life of the nation and state. Indonesia strives to be a developed country and one of the five world economic powers with excellent human qualities and mastery of science and technology, equitable distribution of justice in all fields of development, within the framework of the sovereign and democratic Unitary State of the Republic of Indonesia (Minister of National Development Planning, 2019). In achieving this vision, the government has issued National Medium Term Development *(RPJMN)* 2020-2024. In the *RPJMN* 2020-2024, there are five primary presidential directives: infrastructure development, human resource development, encouraging investment, reform in bureaucracy and the use of the state budget (Executive Summary of the 2020-2024 *RPJMN*). Infrastructure development is one of the president's 5 (five) primary directives as a strategy for implementing the mission and achieving Indonesia's 2045 vision.

The infrastructure development in Indonesia is directed through the National Strategic Projects *(PSN)*. Article 1 of Presidential Regulation No. 109 the year 2020 stipulates that *PSN* is a project or program implemented by the national government, local government, or business enterprises that have a strategic nature to increase growth and equitable development to improve community welfare and regional development. The regulation also establishes the Patimban Access Toll Road as one of the national strategic projects since it connects to one of Indonesia's

most prominent ports. Patimban access toll road has positive impacts, reducing transport time in the northern part of West Java, increasing export activities from industrial areas around Cikarang-Cibitung-Karawang-Cikampek, connecting the Cikampek-Cipali toll roads and connecting industrial activities with Patimban ports (Ministry of Public Works and Housing, 2020). Business enterprises are offered concessions of Patimban Access Toll Road with investment project data showing the Internal Rate of Return (IRR) is lower than the Weighted Average Cost of Capital (WACC). It indicates that the project is not financially feasible. The government also plans to develop industrial areas which have the potential to increase travel demand. Developing industrial areas is assumed to increase the area's selling value, as it is directly connected to the Patimban Port.

This study aims to obtain a dynamic system model that provides reliable travel demand estimates to compare the project's financial feasibility before and after the development of the industrial areas. The model can also be used to analyse the probability of tariff changes that causes changes in travel demand and investment feasibility.

LITERATURE REVIEW

The Patimban Access Toll Road Project Overview

The Patimban Access Toll Road supports the construction of the Patimban Port and the development of the surrounding area, with the Ministry of Public Works and Public Housing of Republic of Indonesia acting as the Responsible Party for the Collaborative Project *(PJPK)*. With a total length of 37.05 km, Patimban Access Toll Road connects the Cikopo Palimanan toll road at km.89+475 with Patimban Port. The toll road allows direct access to Patimban Port and provides an alternative route to Subang and its surrounding regions. The primary demand for the Patimban Access Toll Road comes from the shift of users from Tanjung Priok Port to Patimban Port by 33,9%.

Investment Feasibility

Investments are attractive if they benefit the investors. However, toll road investments always have uncertain risks (Pratiwi, 2016). Two components are used as the main variables in determining project feasibility: IRR and WACC. IRR is an indicator of an investment's efficiency, and WACC is a calculation of the company's cost of capital, proportional to its share of debt and equity. In a toll road concession project, IRR determines the project's feasibility. A project is feasible when IRR > WACC is not feasible if IRR < WACC (PT Jasa Marga, 2021).

The potential of Industrial Areas in the Investment Feasibility

According to the Minister of Finance (2021), Patimban Port's operation will improve West Java's infrastructure support. In developing the Patimban Access Toll Road, the government plans to build industrial areas at the port's initial access point. This improvement adds value to the industrial area as it is integrated with and directly connected to an international port. In addition to connectivity to Patimban port, the toll road is expected to positively impact the community, namely, cutting down logistic costs in the northern part of West Java. Reduced logistic cost is expected to improve Indonesia's industrial area's competitiveness in regional and international contexts. Furthermore, toll roads promote economic growth and equitable development and trigger regional development due to high accessibility and reduced cost of mobility (Sumaryoto, 2010).

Dynamic Systems

A dynamic system is a method to strengthen learning in a complex system. Dynamic systems are widely used in various issues, from government policies and corporate strategies to diseases. A dynamic system is used to form stimulator management, a computer simulation model to help understand a dynamic complexity more effectively (Sterman, 2000). A dynamic model is an abstraction and simplification of a complex system but strives to be able to represent the system well. Furthermore, based on the dynamic model obtained, a policy scenario simulation is carried out based on logically developed assumptions (Sterman, 2000). Dynamic thinking tools represent patterns of events from time to time and predict structures that create dynamics (Kim, 1995). System dynamics can describe, model, simulate, and analyse complex systems based on processes, information, organizational boundaries and strategies (Pruyt, 2013). Three types of dynamic thinking tools commonly used in dynamics systems are behaviour over time (BOT), causal loop diagram (CLD), and system archetypes (Kim, 1995). A causal loop diagram (CLD) is a conceptual model to picture the relationships in a dynamic system simulation model. A

flow diagram known as a Stock and Flow Diagram (SFD) is used to represent detailed structures so they can be developed in model formulation and simulated (Sterman, 2000).

Materials and Methods

Data Processing is done by developing a special computer program using the Powersim studio 10. There are three stages in conducting this research, namely:

1. Conceptualization and Model Formulation: Conceptualization and formulation is done by studying the various literature for the relationship in each variable to understand the theory. Furthermore, between variables is shown in a Causal loop diagram that shows behavior over time with a conceptual model with a system diagram.
2. Model Development: author collects data and identifies variables in making stock and flow diagrams. This model and simulations models using Powersim Studio 10 software
3. Analysis of result and conclusions: In the model, several scenarios in the form of sensitivity analysis will be applied. The simulation is carried out by comparing total trips, availability of payments and the Internal Rate of Return when there is an industrial area and with various possible tariffs. From this sensitivity analysis, conclusions are drawn in the form of an analysis of industrial areas development impact on the investment feasibility of Patimban access toll road. Also, the author concludes and formulates recommendations tariff that are best for Patimban toll road.

Mental data collection

1. Relationship between toll road demand and revenue
   This study aims to get a projected revenue based on the demand for the Patimban access toll road. Toll road revenues come from two main categories: rest areas and trip demand. The higher the number of private users and good shipments is, the higher the toll investment will be. There is a positive relationship between increased demand and increased toll road revenues. Therefore, a relationship between demand and toll roads is needed.
2. Relationship between industrial area and demand
   Toll roads have the potential to attract investments which have an impact on improving the industries in the area. The development of new areas at the Patimban access toll road starting point has the potential to increase demand due to its strategic location. This improvement adds to the demand for traffic flows in the areas. Moreover, toll roads also reduce travel distance, travel time and transportation costs. These reductions have an impact on increasing trip demand in the areas.

Diagram system

A dynamic system is needed to observe the behaviour of a complex system. Relationships in dynamic systems occur because of the reciprocal relationship between variables. Therefore, a systematic understanding of a system as a whole is needed as the basis for model development. This understanding is achieved by drawing a system diagram.

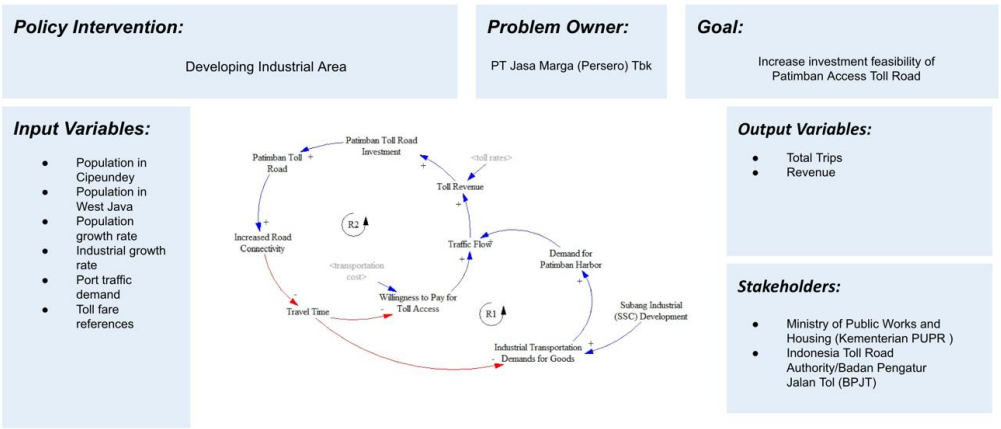

Figure 1. Diagram System

PT Jasa Marga (Persero) Tbk has the main objective to increase revenue for the Patimban access toll road. Developing industrial areas is one of their movements in order to fulfill this purpose. The development of industrial estates is expected to increase interactions which have an impact on increasing travel in order to meet the goal set by the problem owner.

Causal Loop Diagram

Models are mapped in Causal Loop Diagram to understand the system structure and the relationships between variables and feedback. Validation testing is carried out to ensure that the mental model is correct and represents actual conditions.

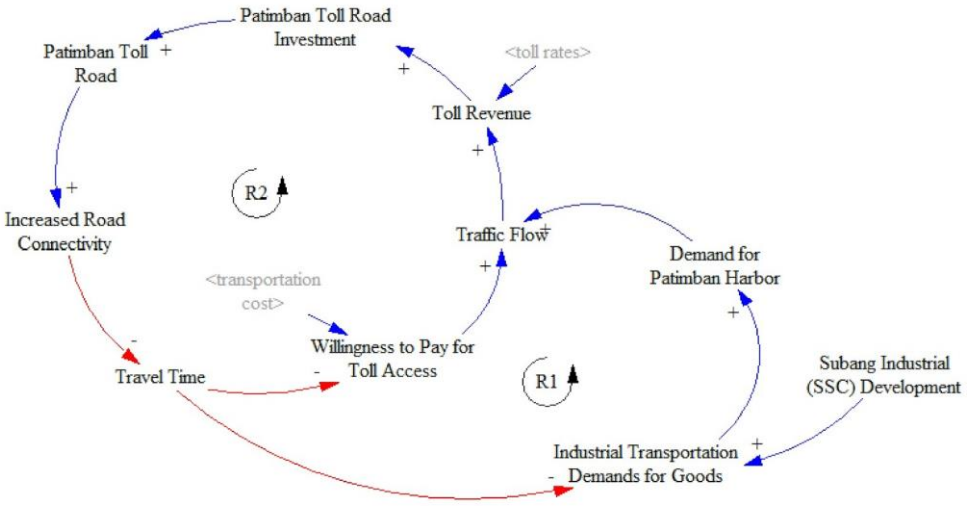

Figure 2. Causal Loop Diagram (CLD).

The author uses a Causal Loop Diagram to represent the mental model used as the basis for formulating the model, which is validated to ensure its ability to represent the actual system conditions. Two reinforcing loops describe the relationships between the variables and feedback that occur in the system within the scope of the system.

The reinforcing loop R1 illustrates the Patimban access toll road brings an increase in industrial transportation demand for goods due to the reduction in travel time generated by the toll road. With the increasing demand for industrial transportation, it will cause demand at the Patimban port.

The reinforcing loop R2 illustrates the relationship between increased trips to the Patimban access toll road. With the increasing demand for travel, it increases investment in the toll road itself. The Patimban access toll road is carried out for the continuity of infrastructure development in the road sector in order to improve connectivity between regions. High connectivity will make the travel time more efficient, affecting the willingness to pay for toll access.

RESULTS

Stock and Flow Diagrams

1. Toll Road Module

The toll road module in Figure 3 illustrates the toll revenue generated through total trips, fares, and toll road gate lengths. This module is divided into four sections and five groups according to the Patimban Access Toll Road plan. In this module, it is assumed that the toll road tariff increases every two years by 6%, and the annual trip growth is represented in the Trip Growth variable.

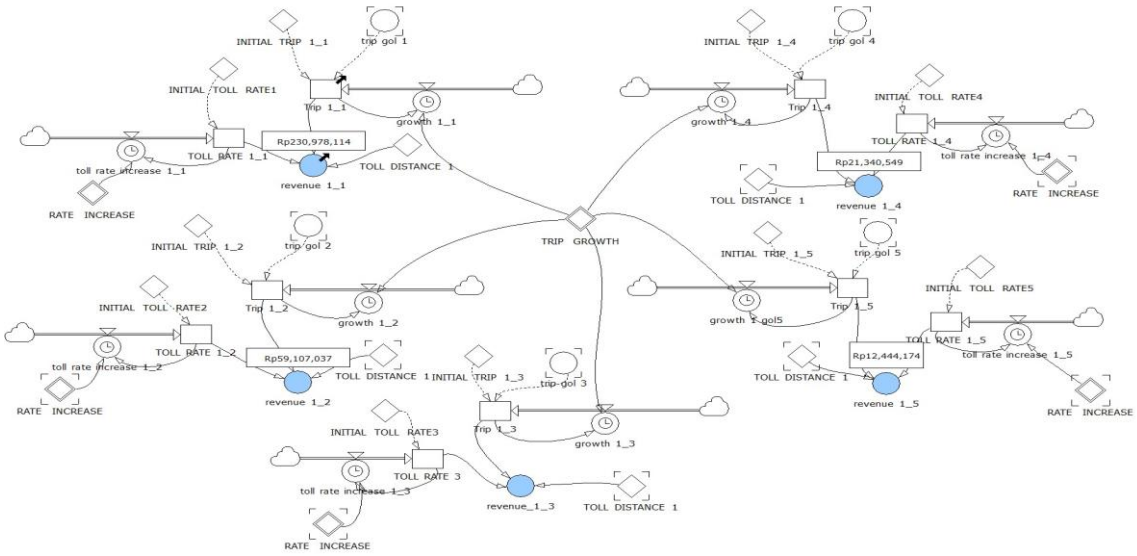

Figure 3. Toll Road Stock and Flow

This module shows the detail regarding estimating revenue based on total trips and toll road fares. Revenue is obtained from total trips, fares, and road lengths on the segment. Toll road tariffs changes by 6% every 2 years which have a major impact on increasing revenue on toll roads. The Patimban access toll road has four sections and five groups on each segment.

2. Industrial Areas Module (Residential Travel Demand)

The SFD for the industrial area sub model simulates total demands for trips based on the population in the Cipeundey area. The population data is predicted using historical data of the area (Lang, 1998). The number of the population affects the movement of cars. The movement of cars is divided into five groups which are assumed to be demands for Patimban Access Toll Road.

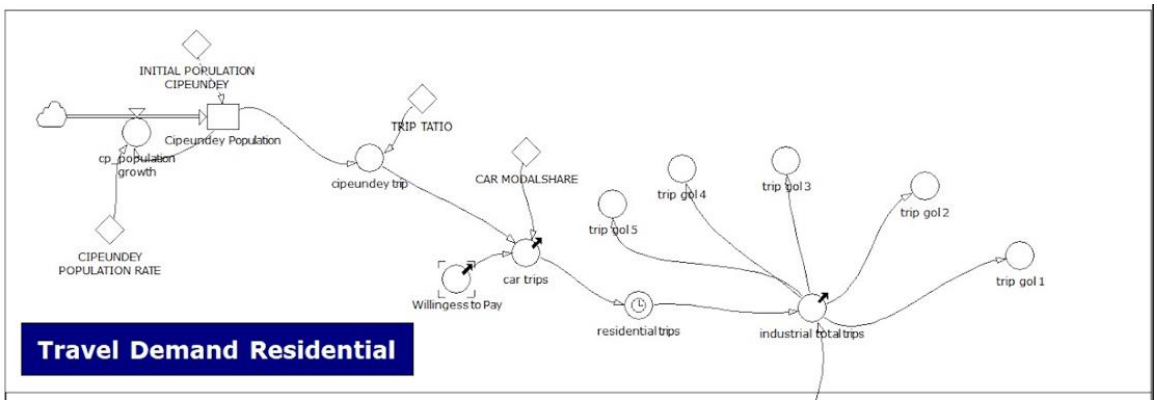

Figure 4. Travel Demand Residential Stock and Flow

This module shows calculation of travel requests based on residential trips. The calculation of this demand is influenced by the availability of payments and the mobility rate of the population. The calculation of the population is predicted with the available historical data.

3. Industrial Area Module (Industry Travel Demand)

The SFD for industrial area sub model for industrial travel simulates the travel demand based on the potential of the industrial areas to develop. The growth rate of infrastructure facilitates the processing and distribution of goods and services and the movement of people (Jungbecker and Alfen, 2010). The development of industrial areas is based on the development of industrial land and the effects caused by the Patimban Access Toll Road. The trip demand from industrial development is calculated by multiplying the growth of industrial land for each respective year by the industry vehicle trip rate in the area. The traffic demand caused by Patimban Access Toll Road is

calculated from the people's willingness to pay. The factors that determine the willingness to pay are the products offered, the quality and the quantity of the service, the utility or user's intention and the transportation costs incurred (Novita, 2016).

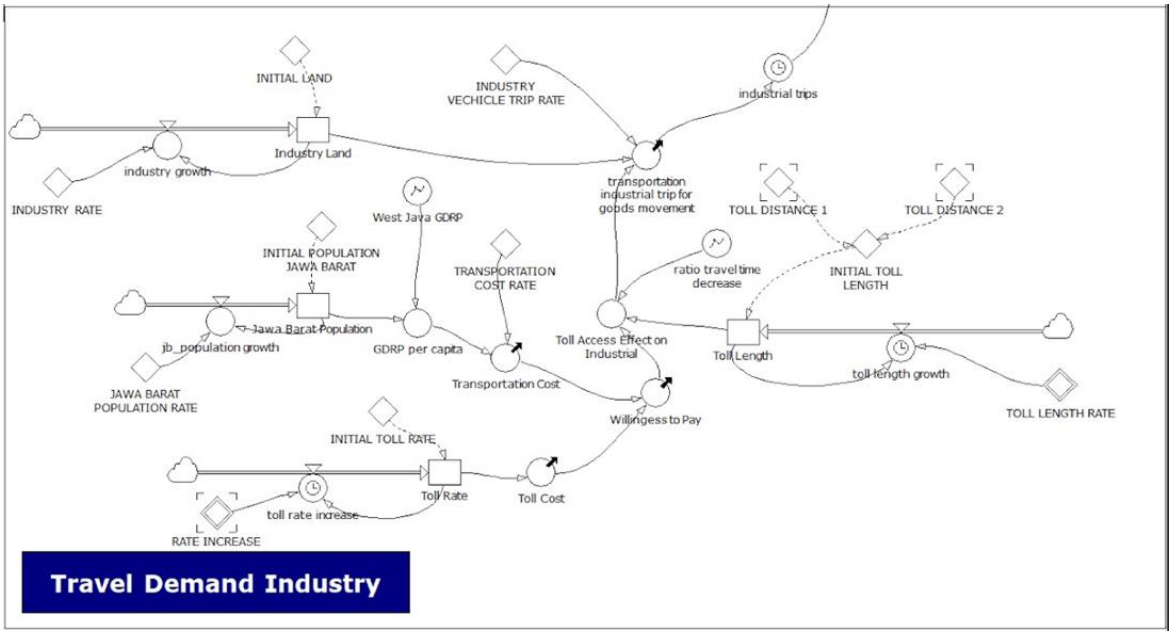

Figure 5. Industry Travel Demand Stock and Flow

This module shows calculation of travel demand based on the travel industry. The demand for industrial travel is generated from the potential of industrial. The growth rate of infrastructure facilitates the processing and distribution of goods and services as well as population movement that increases the demand for travel. The development of industrial estates is based on the development of industrial land and the effects of the construction of the Patimban access toll road. Travel demand from industrial development is calculated from the annual increase in industrial land multiplied by the industry vehicle trip rate in the area. Meanwhile, the calculation of traffic demand with the effect of the Patimban Access Toll Road is calculated based on the availability of public payments. Therefore, in the model to describe the availability of paying for industrial travel, namely the ratio of reduced travel time and the ability of the community to pay for toll roads based on transportation costs derived from PDB per Capita times the percentage of public spending on transportation compared to the toll rates issued.

Model Validation

The validity of the dynamic model in this study is calculated by comparing the company's comparative data with the data generated by the model on variables that have essential roles in the validity of the dynamic system simulation model developed. The difference between the actual data and the model simulation results generates the Mean Absolute Percentage Error (MAPE), the average absolute error percentage against the company's comparison data. The smaller the MAPE value, the higher the validity of the tested model. This means that the predicted value is close to the actual data.

A comparison of behavioural reproduction is carried out with the company's comparison data for 2024-2028. The error percentage in the number of trips (Table 1) is below 10%; therefore, the model is considered valid. The second comparison of behavioural reproduction is carried out for the total toll road trips (Table 2). The error percentage in the toll revenues in the first year shows a high number since the toll road begin the operation in the middle of the year. At the same time, the simulation runs a full-year operation. The error percentage in 2025-2028 is below 10%; therefore, the model is considered valid (Lewis,1982).

Table 1: Total Trip Demands for Toll Road

Year	2024	2025	2026	2027	2028
Company comparison data	7460	7916	8458	9095	9879
Simulation	7460	7908	8390	8952	9632
Error	0.00%	0.11%	0.80%	1.57%	2.50%

Table 2: Total Revenue of Toll Road

Year	2024	2025	2026	2027	2028
Company comparison data	Rp. 12.887	Rp. 27.127	Rp. 29.860	Rp. 33.042	Rp. 36.972
Simulation	Rp. 24.961	Rp. 26.459	Rp. 28.073	Rp. 31.751	Rp. 34.164
Error	93.69%	2.46%	5.98%	3.91%	7.59%

DISCUSSION

Analysis of Alternative Tariff Scenarios

Analyzing the financial feasibility of a toll road investment project is inseparable from the risks that may occur. Some variables influence or determine a project's financial feasibility; inflation, change of fare, concession periods, tax and interest rates. Patimban Access Toll Road is currently in the tender process which goes through a negotiation process. The project most likely go to the company and its consortium because PT Jasa Marga (Persero) Tbk is the single bidder. The negotiation process determines the initial tariff for Group I in the concession of Patimban Access Toll Road. Table 3 shows the fare negotiated.

Table 3: Initial Patimban Access Toll Road Fare

Optimistic (Scenario A)	IDR 1700
Realistic (Scenario B)	IDR 2315
Pessimistic (Scenario C)	IDR 2930

*S*cenario Simulation Results

1. Scenario A

The simulation for Scenario A is run by setting the initial tariff of IDR 1,700 for group I. This scenario shows an increasing number of trips from the industrial area (Figure 6). The trips from the transportation industry generated from industrial areas at the fare of IDR 1,700 show an increase from the beginning of the concession of Patimban Access Toll Road, where the residential trips start to decrease in 2050 until it reaches a negative point in 2072. The industrial trips show a declining trend in 2072.

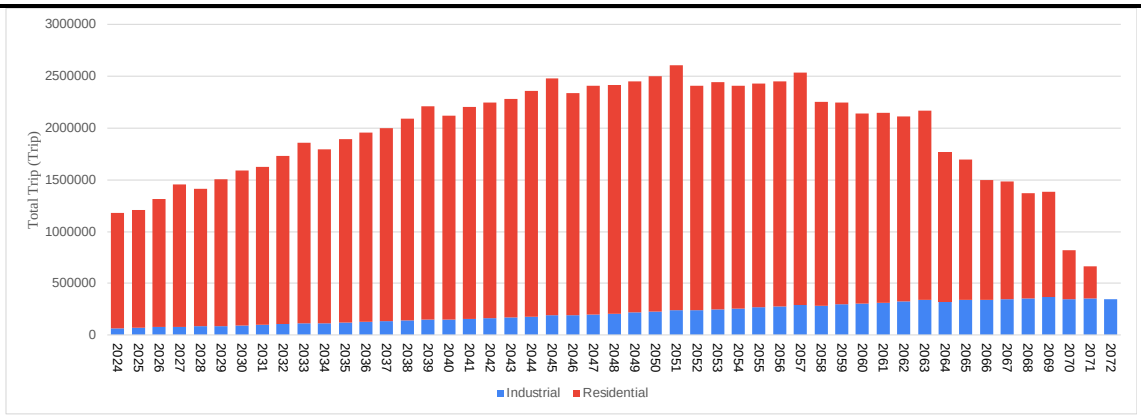

Figure 6: Trips from Industrial Areas in Scenario A

The negative number of trips from industrial areas is caused by the inability of the public to pay toll fares, resulting in a decrease in demand. The simulation result of toll road costs vs transportation costs with an initial fare of IDR 1,700 shows that after 2071, the costs or expenses for toll fares are higher than the transportation budget, as shown in Figure 7. It means that by 2072 people will no longer be able to pay the toll fares, resulting in a decrease in demand for industrial trips and no more demand for residential trips.

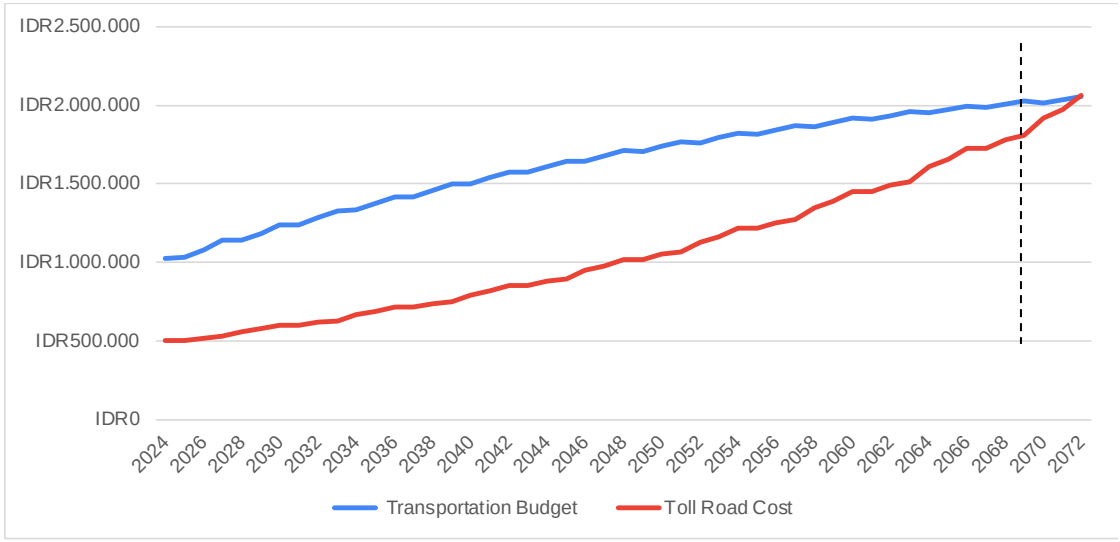

Figure 7: Transportation Budget Vis a Vis Toll Road Cost Scenario A

With the transportation industry trips (Figure 6) and transportation budget vis a vis toll road cost scenario A (Figure 7), the areas with Scenario A generate an income of up to 69.65% in 2072. This increase in income causes an increase in IRR to 12.81.

2. Scenario B

The simulation for Scenario B is run by setting the initial tariff of IDR 2,315 for group I. In this scenario, the industrial areas increase trips, as shown in Figure 8. The trips of transportation industry generated from the industrial area in the initial fare of IDR 2.315 are illustrated in which the behaviour of industry area trips shows an increase from the beginning of the concession of Patimban Access Toll Road to 2059, where the residential trips start to decline until they reach a negative point in 2060. Trips from industries start to decline in 2059.

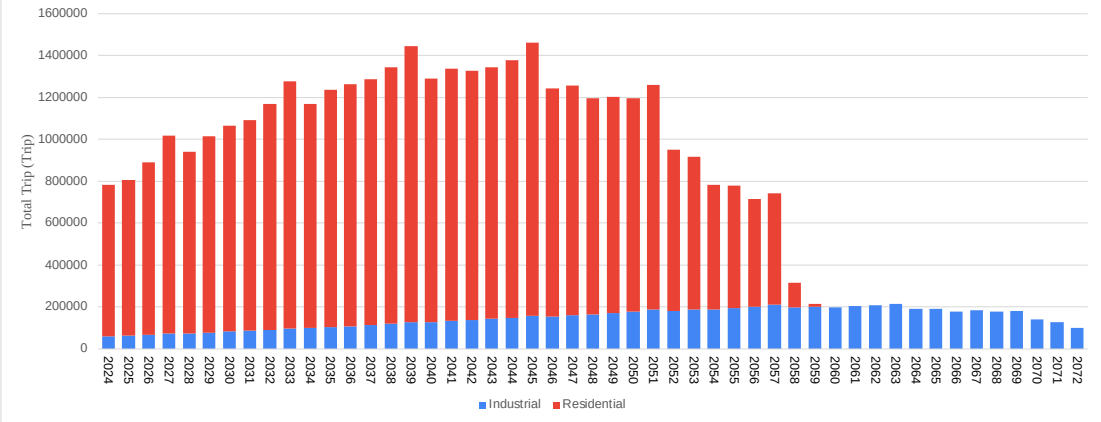

Figure 8. Trips from Industrial Area in Scenario B

The negative numbers of trips generated from industrial areas are caused by the inability of the people to pay for toll fares, which results in decreasing demand for trips. The simulation result for the initial tariff of IDR 2.315 shows that after 2059 the costs or expenses for toll fares are higher than the transportation budget, as shown in Figure 9. This means that in 2060 the people will no longer be able to pay for toll fares, which will decrease demand for industrial trips and result in no more demand for residential trips.

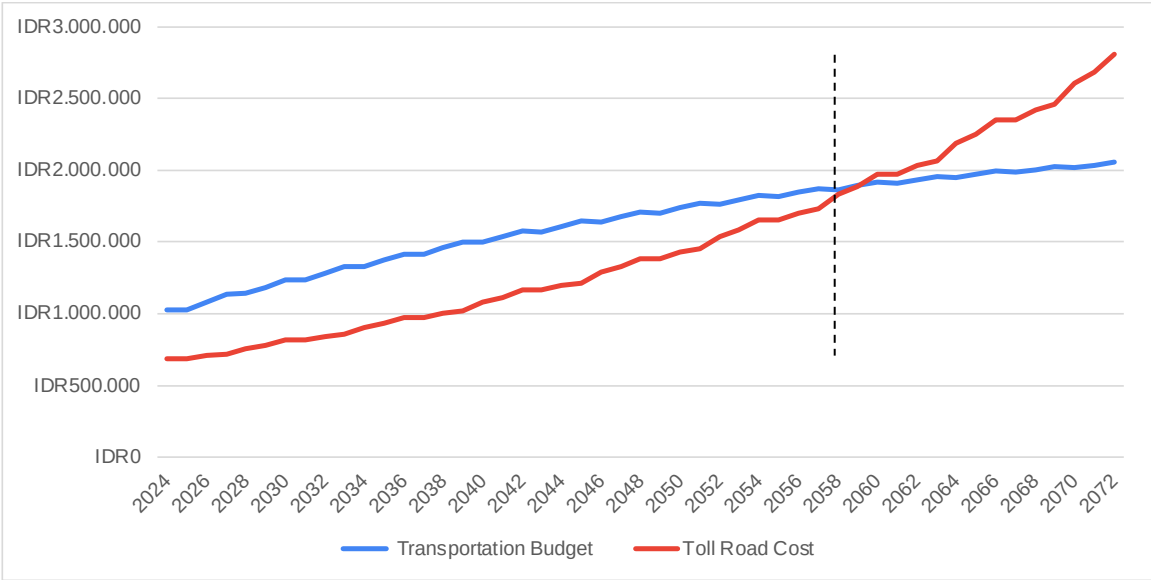

Figure 9. Transportation Budget Vis a Vis Toll Road Cost Scenario B

With the transportation industry trips in Figure 8 and transportation budget Vis a Vis toll road cost scenario B in Figure 9, areas with Scenario B generates an increase in income up to 112% in 2072. This will result in an increase in IRR to 14.55.

3. Scenario C

The simulation for Scenario C is run by setting the initial tariff of IDR 2,930 for Gol I. In this scenario, the industrial areas increase the number of trips, as shown in Figure 10. The trips from the transportation industry generated from industrial areas with the initial tariff of IDR 2,930 show the behaviour in which industrial trips are increasing from the beginning of the concession to 2045, where the residential trips start to decline until they reach negative points in 2047. The industry trips show a declining trend in 2048 and reach negative points by 2068.

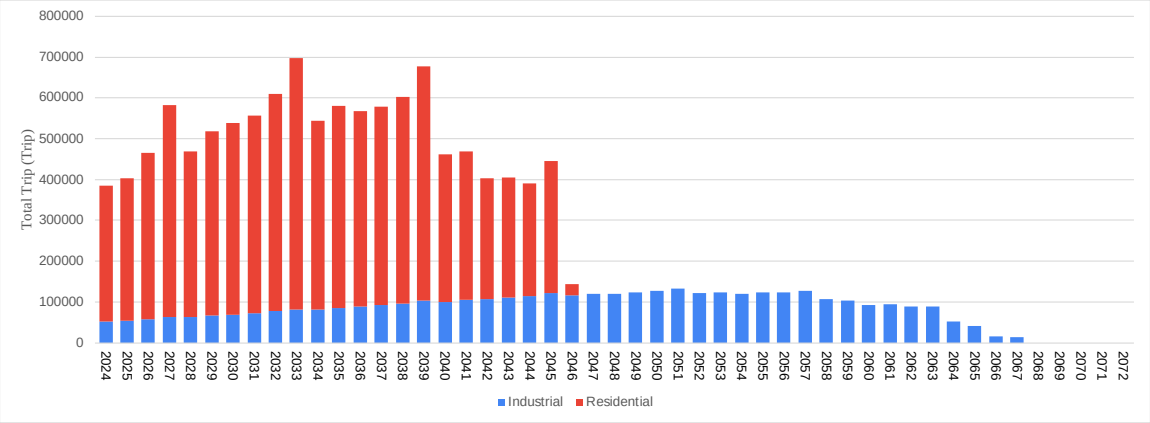

Figure 11. Trips from Industrial Areas in Scenario C

The negative numbers of trips generated from industrial areas are caused by the inability of the people to pay for the toll fares, which results in the decline in trip demands. The simulation with the initial tariff of IDR 2,930 shows that after 2047 the costs or expenses for toll fare are higher than the transportation budget, as seen in Figure 11. It means that by 2048, the people can no longer afford the toll fares, resulting in a decline in trip demands from industries and no more demand for residential trips.

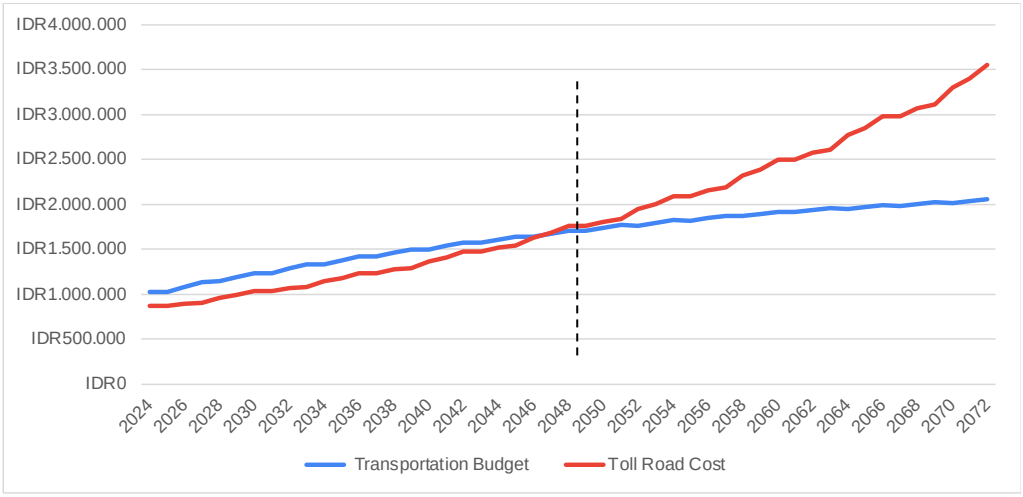

Figure 11. Transportation Budget Vis a Vis Toll Road Cost Scenario C

With the transportation industry trips in Figure 10 and transportation budget visa vis toll road cost scenario C in Figure 11, areas with Scenario C generate an increase of revenue up to 144% by 2072. The increase in revenue increases the IRR to 15, 73.

Comparison of Simulation Results

After simulating three scenarios and Business as Usual (BAU) conditions where there are no industrial areas, the results from the simulations are compared to see the impact of the industrial area in each scenario that has been carried out. The results of each scenario against the four evaluation criteria indicators can be seen in Table 4.

Table 4: Results Comparison of Evaluation Indicators for each Scenario

Variable	BAU	Industrial Areas + Effect of Patimban Toll (Scenario A)	Industrial Areas + Effect of Patimban Toll (Scenario B)	Industrial Areas + Effect of Patimban Toll (Scenario C)
Tarif	IDR 2315	IDR 1700	IDR 2315	IDR 2930
Industry trips	-	346.149 (2072)	99.216 (2072)	**Negative** (2069)
Residential trips	-	**Negative** (2072)	**Negative** (2060)	**Negative** (2047)
Total trips (2072)	107.423.124	205.703.583	179.210.514	163.136.020
Willingness to pay	-	2071	2059	2047
IRR	11,60	12,81	14,55	15,73

Fare and people's income will affect trip demand (Arihta, 2019). The results show that each scenario generates different total trip demands. It indicates that the difference in fare will affect the number of total trips. The total demand for industrial areas comes from industrial and residential trips (Xu, 2019). The results show that industrial trips tend to be higher than residential trips. The difference between these two types of trips is due to the factors influencing them. In residential trips, the determining factor is the willingness to pay. One of the considerations in using toll roads is the quality offered (Alasad, 2014). In industry trips, the determining factors are willingness to pay and the reduction of travel time since toll roads are expected to reduce the required time to travel.

Based on the primary evaluation criteria, namely IRR, Scenario C results in the highest IRR. However, Scenario C also shows that the willingness to pay in the regions surrounding the industrial areas only remains until 2047. Therefore, the industrial and surrounding areas will not be able to pay for the toll fares, resulting in opposing demands from industrial and residential toll road users in 2047 and 2048, respectively. According to the Ministry of Transportation, the higher the fare, the lower the probabilities of toll road utilization. It leads to the lowest total trips in Scenario C, among other scenarios. With the realistic tariff, PT Jasa Marga used in the initial tariff tender, IDR 2,315 or Scenario B, the industrial areas increases the IRR to 14.55. However, the willingness to pay in the areas only remain until 2059, resulting in negative demand for residential trips and a declining trend of industrial trips from 2060 onwards.

Article 48 Law No 38 the year 2004 regarding Roads stipulates that toll tariffs are calculated based on the road users' ability to pay, the profit from vehicle operating costs and investment feasibility. Based on Figure 4, therefore, Scenario A is favourable, where the industrial areas makes the investment of Patimban Access Toll Road feasible and the willingness to pay remains until the end of the concession period.

CONCLUSIONS

This study has developed a system model which illustrates the interaction between industrial areas and toll roads. Based on the analysis of the model, the following can be concluded:

1. The simulations prove that developing industrial areas around the toll roads increases the number of total trips on the toll roads.

2. Toll road concession undergoes a negotiation process to determine the tariff to be implemented, affecting the investment feasibility and the attractiveness of the toll roads. There are three alternative scenarios: an initial tariff of IDR 1,700, IDR 2,315 and IDR 2,930.
3. The increase in total trips generated by the industrial areas is optimal when the tariff is IDR1, 700. This tariff generates the highest trip increase and shows a high willingness to pay in industrial areas and the surrounding regions.

Data Availability

The authors affirm that the data supporting the study's conclusions are included in the publication. Raw data supporting the conclusions of this investigation are accessible upon reasonable request from the corresponding author.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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