Tanjung Priok Port Development Policy Effect Analysis to DKI Jakarta Economic Growth with System Dynamic Approach

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***Abstract*— DKI Jakarta as the capital city of Indonesia has a role as the main gate to national and international trade through its Tanjung Priok Port. The New Priok Port project then rise its priority to be executed due to the natural important roles of Tanjung Priok Port for the country as well as the fact that the 2015 Tanjung Priok Port Capacity has reached its limit to handle the rapid flow of container. Port development theoretically would give a huge multiplier effect that are higher than the benefit perceived by the port itself. Port development effect is predicted to absorb employment and income. But in other hand, the logistic infrastructure conditions in DKI Jakarta is currently relatively bad, this also become much worse by the traffic jam condition. Access road condition to the main industrial district is also bad. These situations could lead to the diseconomies of DKI Jakarta. The result shows that the port related sector could absorb more employment over time. Another result that also discussed in this research is the effect of policy interventions made by port authorities and government: tariff progressive policy and access road development which has shown good contribution to increase the port and industrial competitiveness.**

***Index Terms*—system dynamic, GDRP, port, transportation, employment, policy analysis**

I. Introduction

DKI Jakarta as the capital city of Indonesia as well as its role as the main port city in the country should perceive the benefit of the port for its city. But, this condition also meets some dilemmas regarding maritime industry in Jakarta such as congested access to the main port, overload cargo, as well as the lack of supporting port facilities to handle the rapid growth of cargo (Rofiq, 2010). The main port of DKI Jakarta is Tanjung Priok Port that facing the problem mentioned before. Tanjung Priok Port problem became much crucial due to its major role in national level for international trading gate.

The rapid flow of container handled in Tanjung Priok Port has an increasing trend over years. The flow of container is noted in 5,83 million TEUs in 2012 and 5,89 million TEUs in 2013. In other hand, the handling capacity of Tanjung Priok Port until 2009-2011 lies in around five million TEUs per year. After the short-term action regards to the rapid flow of container with terminal reconfiguration, new equipment procurement, and operation management, the handling capacity of Tanjung Priok Port already became 7 million TEUs per year (Salim, 2016). This situation won't stay long due to the rapid growth of container cargo. This situation also became the key driver for government to make and accelerate the development of North Kalibaru Terminal or New Priok Container Terminal (NPCT). This terminal is projected to have the total capacity of 11,5 million TEUs per year in full operation.

There are a lot of research that show the economy advantages of port city as well as the region around that port city. It is noted that from 20 major cities in Indonesia, 13 of them is a port city. Fact also shows that these port cities has a greater value of gross domestic regional product (GDRP) than those that are not classified as port city (Kurnia, 2013). This situation also applied in DKI Jakarta.

Cluster development approach can be used as a reference to perform an analysis of effect from the existence and the development of Tanjung Priok Port along with its benefit to DKI Jakarta economic growth. This approach also explaining the multiplier effect phenomenon regarding policy implementation for a company to its surrounding environment (Porter,1990). Multiplier effect from a port also be said could absorb employment and revenues (P. Rodrigue & Schulman, 2017). Port development also has a strong impact for the regional condition in where the port is located at, as port will also create logistic regionalization at the area (Notteboom * & Rodrigue, 2005).

Policy analysis of port development policy will be conducted with system dynamic modelling method due to its function as a tool to understand complex interactions (Sterman, 2000). The usage of system dynamic in observing cluster effect already been performed by Buendía in 2005.

Output of this research is an evaluation of the development plan of Tanjung Priok Port and any factors that affect to it which hopefully can be an insight for the policy maker and authorities of Tanjung Priok Port and DKI Jakarta.

II. Theoritical Background

A. DKI Jakarta Profile

1) DKI Jakarta economy profile

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Foreign trade is an economic sector that can be a major driver for economic development in Indonesia including DKI Jakarta. DKI Jakarta development which is directed as services city placed trading sector as the major contributing sector in this region. The data gained in 2014 shows that trading sector is the most employment generation sector in DKI Jakarta with the contribution of 34,92%, followed by another service sector in 25,30%, and manufacturing industry in 14,44%. This huge employment also came as indicator to show how huge trading sector contribution for DKI Jakarta (Badan Pusat Statistik Provinsi DKI Jakarta, 2016a).

Export and import activities in DKI Jakarta are highly depended in the existence of port. Tanjung Priok Port as the main activity for cargo loading and unloading plays an important role for export and import activities in DKI Jakarta and Indonesia. It is noted that more than 50% of international container flow of Indonesia is handled in Tanjung Priok Port (Badan Pusat Statistik Provinsi DKI Jakarta, 2016a). The role of Tanjung Priok Port is increasingly important due to Indonesia's strategic position in world trading route, moreover, currently the President of Indonesia, Joko Widodo initiate the vision to make Indonesia as global maritime axis.

2) Tanjung priok port

Nowadays, Tanjung Priok Port is servicing passenger, international cargo and domestic cargo vessels. The sufficient facilities in Tanjung Priok Port makes it possible to distribute cargo to all city in Indonesia. Its strategic location with hinterland, in which most dense activity of trade and industrial activity lies, makes Tanjung Priok Port as the main port in Java island (PT Pelabuhan Indonesia II, 2015).

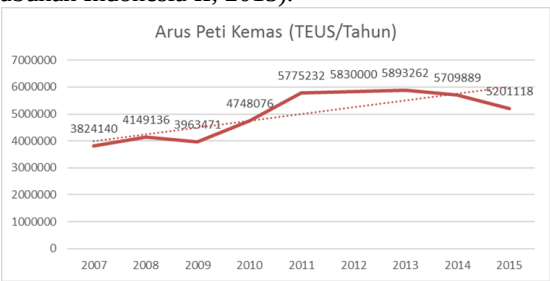


Figure 1 Container Flow Handled in Tanjung Priok Port
Source: processed from various sources

Loading and unloading traffic is growing every year in this port. Fig. 1 shows the container flow trends that passed through Tanjung Priok Port that indicate an increasing trend. This rapid loading and unloading activities are supported by sufficient facilities and equipment of Tanjung Priok Port. These modern technologies and facilities makes Tanjung Priok Port capable to handle vessels with capacity more than 4000 TEUs (PT Pelabuhan Indonesia II, 2015).

This rapid flow is responded by government and Tanjung Priok Port authorities with New Priok Port development or also be known as North Kalibaru Terminal since 2007 in three phases of development. North Kalibaru Terminal is targeted to be done in whole operation in 2030. Today, North Kalibaru Terminal phase one or New Priok Port Terminal 1 has been operating since August 2016 with annual capacity of 1,5 million TEUs. With the operation of North Kalibaru Terminal it is expected that, domestic terminals can be back to its main function as until April 2017 there are still some domestic terminals that handle international container cargo.

3) Logistic profile

Port road access development increasingly became one of the major concern for government due to high traffic density in DKI Jakarta which will affect to logistic cost. Nowadays, DKI Jakarta lies in 3th position of the most congested city in the world according to TomTom Traffic Index. Jakarta is in the level of traffic congestion in which causing extra 58% of travel time in average (TomTom Traffic Index, 2016). This is also exacerbated by the fact that in 2013, logistics costs in Indonesia reach 24.6% of the national GDP (World Bank, 2013).

4) Bonded zone

Bonded Zone in Indonesia is managed by PT Kawasan Berikat Nusantara (KBN) Tbk which is under Ministry of SOEs. According to Government Regulation No. 33 of 1996 concerning Bonded Hoarding Plants states that "Bonded Zone is a building, place or area with certain boundaries in which the business activities of the goods and materials processing industry, engineering activities, engineering, sorting, preliminary inspection Final inspection and packing of imported goods and materials or goods and materials from within other Indonesian Customs Area which result mainly for export purposes ". PT KBN has a business in the management of a bundled industrial zone (Export Processing Zone). Bonded Zone is a territory within the Indonesian customs area that has special incentives, namely the suspension of import duties and other state levies.

B. Port and Regional Development

1) Port cluster

Cluster theory was first raised by Porter (1990) which defines clusters as "a group of companies or associated institutions that are geographically linked to commonality and mutual need" (Porter, 1990). Cluster development by Porter (1990) is said to be an attempt for a country to compete with other countries. The competitiveness of a country depends on its industry's ability to innovate and develop. Industries certainly get this from the competition between domestic companies in the industry, the availability of good supply, and of course the demand. In addition, competitiveness at the national level can be defined as productivity. Productivity is the value of products produced by workers or capital.

Port Cluster theory has been popularized by de Langen and Haezendonck (2012), arguing that the value of a port can be analyzed through a cluster framework. It is based on four things. First, cluster perspectives can provide insights into port competitiveness. Secondly, in a transportation perspective, the competitiveness of ports is often seen from its throughput volume while when viewed from a cluster perspective, the focus will lie in the increase in the value of goods or may also be associated with costs. Third, the port is connected to various companies, where the performance of one company will

affect other companies and requires a broad level of coordination. Fourth, the transport node perspective does not provide a framework for analyzing the role of port authorities. Moreover, the role of port authorities in attracting and facilitating industrial activity will be more exposed in cluster perspectives (Langen & Haezendonck, 2012). Many factors determine success and performance in a port cluster. Based on the review conducted by Kocsis (2011) observing the performance of Port of Rotterdam clearly shows the main competitiveness factor of a port cluster is the geographic location, capacity, and port infrastructure (Kocsis, 2011).

2) Port-City

There are two different views on the relationship between port logistics activities and local economic growth. The traditional view holds that the port is an accelerator of regional economic growth. Another view confirms that ports simply respond to demand through physical transfers from the flow of goods that think ports can hinder local economic development (Jung, 2011).

The relationship between the port and the local economy has changed by various positive and negative state factors. The positive relationship between port and urban growth is analyzed by Jung (2011) with three things. First, the expansion of value-added activities from the logistics sector allows ports to create income and labor in related industries as well as the port itself. Expansion of port logistics functions as storage, distribution centers, and container stations. Moreover, it is also characterized by containerization that has revolutionized the world's logistics activities since its introduction in 1960. Second, the role of harbors in local and national economies is increasing with the advancement of transportation technologies that facilitate international trade. Third, economic globalization results in a rapid increase in the movement of goods which will also affect international trade and will promote export-oriented economic developments.

But this is also offset by the negative effects of the port's relationship with the city which is also investigated by Jung (2011). First, a change in transportation technology causes some ports cannot compete to serve large ships because some ports are inherited to geographical conditions which makes it impossible. Obviously, this will turn off activity on the port. Second, an increase in port activity may well affect world trade but if local industries are unable to compete, it will turn down local industrial activities.

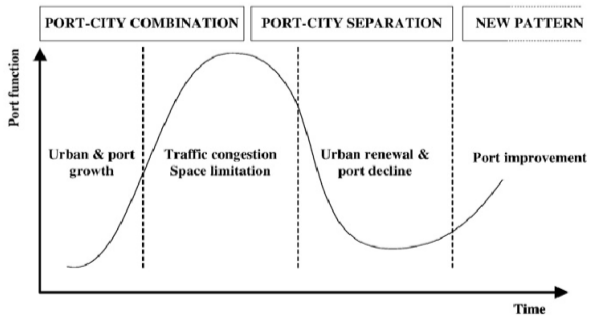


Figure 2 Spatial Relations Evolution and Port-City Functional Logic
Source: (Hoyle, 1989)

This can be seen also in relation to the evolution of port and city relations. Hoyle (1989) tries to explain a theory of the evolution of city and port relations as in Fig. 2 where it can be seen that a growth between the port and the city will experience a turning point when space availability and density occur resulting in a decrease in port function until the port improves.

Another framework that also explains the relationship between a city and a port is that the port will form a logistics region in the hinterland depicted in Fig. 3 (J.-P. Rodrigue & Notteboom, 2011). Increased concentration of port activity as a route evolves to a greater extent compared to other urban growth centres. The geographical system may change from a random pattern and have poor access to the port into a major network containing the corridor between the port gate and the hinterland centre. Empirical research suggests that some ports and access become increasingly spatially concentrated where others evolve into more distributed systems in a balanced way.

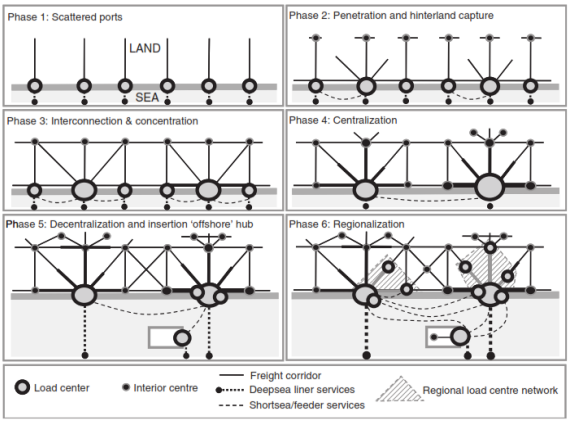


Figure 3 Spatial Port System Development
Source: (J.-P. Rodrigue & Notteboom, 2011)

C. System Dynamic

Figure 5 System dynamic Character
Source: (Sterman, 2000)

System dynamic is a method for improving learning in complex systems. Theories and applications can't be separated from non-linear dynamic theory and feedback controls developed in mathematics, physics, and engineering. System dynamic is fundamentally an interdisciplinary because the emphasized attention is the elation of a complex system. Many people think of the complexity in the number of components in the system or the number of combinations to be considered in making a

decision. Dynamic complexity can arise from a simple system with low complexity combinations. Dynamic complexity arises from interaction between agents within a given time period. The system dynamic model characterizes various complex system characters illustrated in Fig. 5.

System dynamic seeks to explore interventions or changes that can be made to change the structure and behavior of systems that are certainly to achieve an improvement. This usefulness is particularly relevant when applied in policy analysis and exploration. This is because, furthermore, if the structure of the system dynamic model can produce the desired behavior, then policy exploration can be done. The design of the policy is more than just a change of parameters in the model. Policy design involves the creation of new strategies, structures, and decision rules. This is quite possible illustrated using system dynamic modeling.

III. Research Methodology

A. Model Development Framework

Model development to understand the relationship between port development and urban development can be analyzed with various approach theories.

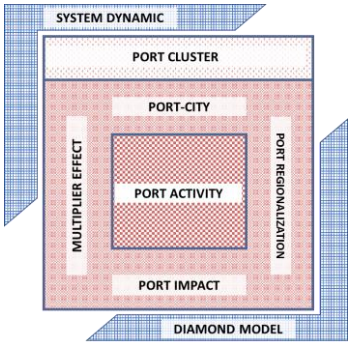


Figure 6 Research Theoretical Framework

Knowledge of port activity understanding can give an idea of the speed of port handling. Port-city theory illustrates a relationship of city and port formation and how ports can play a role for growth and city formation. Port impact theory provides an overview and classification of the types of impacts generated by port activity. Port regionalization theory provides an illustration of how a port can give effect to the pattern formation of logistics infrastructure in a city. The multiplier effect theory gives an overview of the general phenomenon that occurs when there is an investment of labor absorption and income. Cluster theory and port clusters provide a broader perspective on the actors and stakeholders involved when discussing a business's benefits to regional growth with an analysis tool of a diamond model. While in the object of this study strongly demonstrates its dynamic nature making it suitable for using dynamic system modeling. Fig. 6 illustrates the model development framework.

The model will be divided into five main modules: the Economic Module that will simulate the structure of the GDRP builder and the demand which is also derived from the GDRP value; Port Module which will simulate loading and unloading of import container, export container, and export container from EPZ; Logistics Module which will simulate the structure of container movement through road access; The EPZ module simulates production activities driven by investment; The logistics cost module will calculate the logistics costs charged to each 1 TEU container.

B. Reference Mode

The determination of reference modes in dynamic system modeling requires a projection of BOT (Behavior Over Time) or behavior against time from a trusted and credible source. The reference mode is useful for determining the behavior generated by system dynamic simulations and can be useful for the validity of the built model structure.

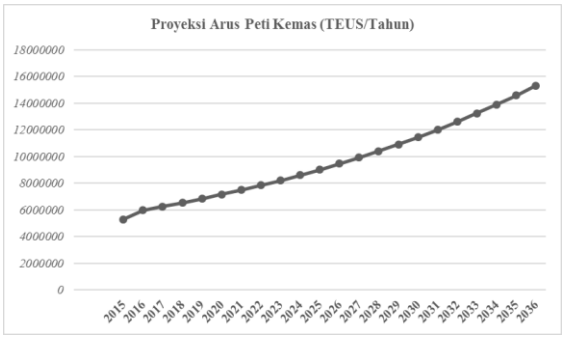


Figure 7 Container Flow Projection at Tanjung Priok Port

Source: (Ernst & Young Shin Nihon LLC, 2011)

The reference mode used is the projection of container loading and unloading volume at Tanjung Priok port over the next 20 years issued by PT. Pelindo II and Ernst and Young in the document of feasibility study of masterplan of Tanjung Priok port development. Fig. 7 shows the projection used in the document indicating that container flows are expected to grow by about 6% per year.

C. System Diagram

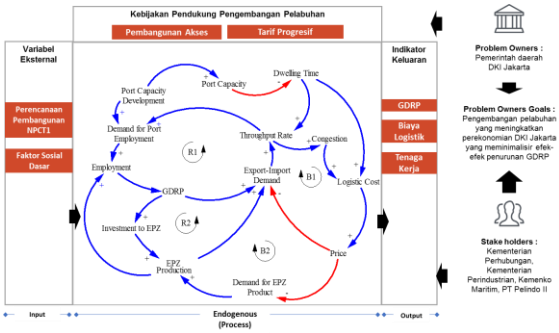


Figure 8 System Diagram of this Research

The interrelationships between variables and feedback provided between variables are crucial to be considered in system-based analysis model funding. System Diagram is a tool that can provide a picture of the relationship between variables with the context of the problems that occur. When the context of the problem is known, the output indicators as well as the various policies that can

be taken can be more precisely strayed to the observed problem. Fig. 8 illustrates the observed system diagram of this study.

IV. Results

A. Model Verification and Validation

Model verification is performed to see the logic conformity and the equations generated by the model. The sign of the verified model is the absence of undefined variables on the model display and during the simulation. This effort is certainly proven by software that runs the model.

The model built in this study can produce simulations for 20 years and shows no signs of unrecognized variables. The software used in the development of this model is PowerSim Studio 10.

The validation test model uses four tests:

1) Behavior comparison

The simulation results that have been run then compared the difference margin between business as usual with reference mode. The model is relatively valid if the margin does not exceed 25%. The simulation results in Fig. 9 show that the model has a margin of no more than 8.8%.

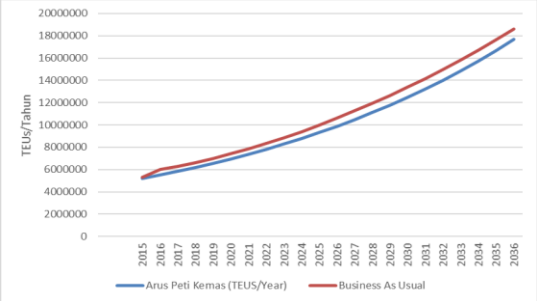


Figure 9 Simulation Result

2) Boudary adequacy

Through the design of boundary diagrams that have been formulated, the model has covered all boundaries, exogenous variables, endogenous, and which are not involved. Fulfillment of this requirement also makes the model can be said to be valid because the variable is already representative with the observed system.

3) Error in integration

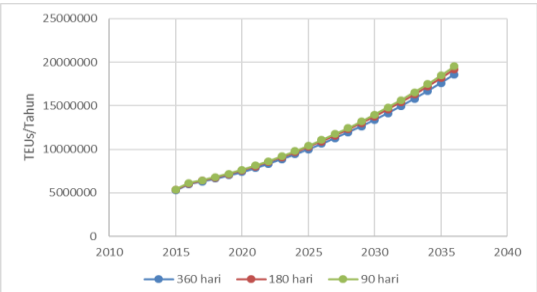


Figure 10 Error in Integration Test Result

The error validity test in integration attempts to see the model's sensitivity to the time-step change. The time-step used in the model is 1 year or 360 days, but the model must also run at 180 days and 90 days-time-step to know the integration of its value during simulation.

Based on the results shown in Fig. 10, it can be concluded that the model is validated in an error test in integration.

4) Structure assessment

The created model already has a structure that is relevant to the system and concept of the existing problem. This can be seen from the suitability between the simulation model created on the causal loop diagram with the System Diagram as the framework.

B. Policy Analysis

1) Port module result analysis

The capacity of the Tanjung Priok Port field in 2030 reaches 20,500,000 TEUS per year. This capacity is the largest port capacity in Indonesia ever owned.

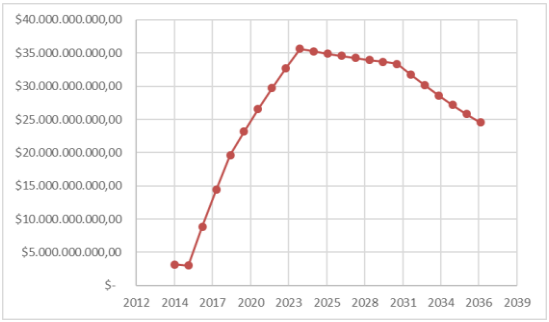


Figure 11 Port Capital Modal Formation

Capital formation due to the addition of capacity can also be seen in Fig. 11 until 2023, capital formation at port has increased rapidly, but along with the time of capital formation decreasing every year.

2) Logistic module result analysis

The logistics module simulates the direct impact of port development that increases import-export demand. The immediate impact is the increasing congestion in DKI Jakarta which is expressed in the road density unit.

The road density is represented by the Jakarta-Cikampek toll because this toll is passed by 70% more goods to and from Tanjung Priok Port which also connects with Cikarang and Jababeka industrial areas as the largest contributor to the export-import volume. In 2019 the Jakarta-Cikampek Elevated toll road will be built which will reduce congestion by 10% but the road density will continue to be severe considering the increase of vehicles on the road with the number of trucks increasingly rapidly.

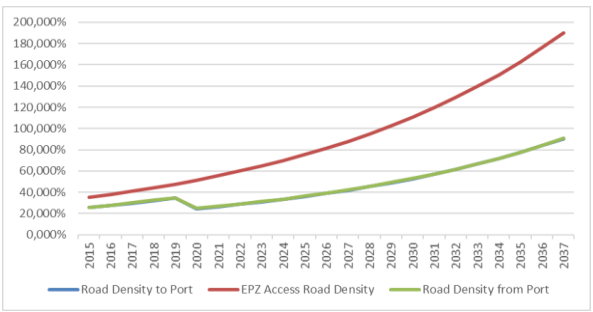


Figure 12 Road Density in 20 Years

3) EPZ module result analysis

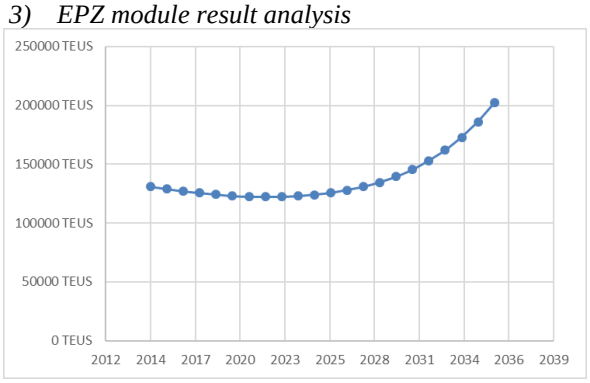


Figure 13 Export Cargo Volume from EPZ

Although the EPZ is impacted by over 180% of road density in the final years of the simulation, the EPZ can still demonstrate a fairly good export performance. Despite a decrease in volume in the middle of the simulation period, EPZ still rely on capital from government capital expenditure still shows improved performance at the end of the simulation period. This can be seen in Fig. 13.

4) Logistic cost module result analysis

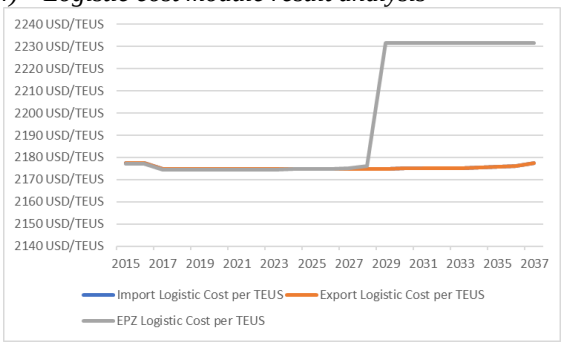


Figure 14 Logistic Cost per TEUs

Logistics costs for export and import products tend to show a flat trend every year. A drastic increase is shown in the EPZ logistics cost. The indication is that there is no growth in EPZ access road capacity. This trend can be seen in Fig. 14.

5) Economic module result analysis

The economic module simulates the growth of GDP of DKI Jakarta which is also in the calculation of this model added with the contribution of sectors related to port and EPZ.

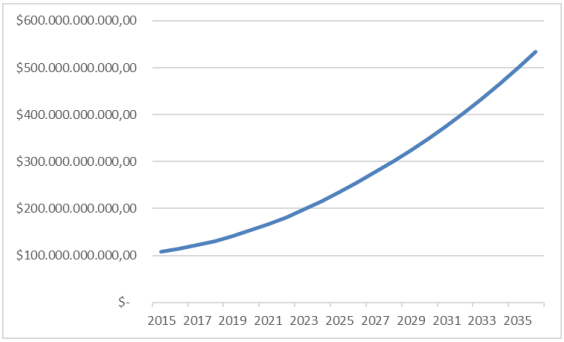
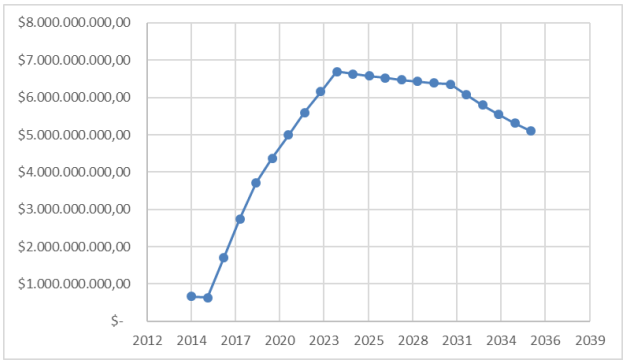


Figure 15 GDRP DKI Jakarta

The model results shown in Fig. 15 show that the GDRP of DKI Jakarta will continue to increase which, in comparison to its growth with the contribution of port and EPZ-related sectors, that the contribution is experiencing rapid growth especially during 2017 to 2024. Clearly this sector is greatly benefited North Kalibaru Terminal. Sector growth can be seen in Fig. 16.



Fugure 16 Port and EPZ Related Sector Contribution

C. Policy Testing

The policy test will compare the results when the implementation of progressive tariffs and the construction of access is revoked.

1) Progressive tariff

The progressive tariff regulation specified is that on the first day it will be applied free storage, for the 2nd day will be imposed 300% of the base rate of accumulation, on the 3rd day will be charged 600%, and on the 4th day and next charged 900%.

The revocation of this policy affects the average assumption of calling for five days as well as the mechanism of tariff imposition before the progressive tariff is applied. The tariff loading after revocation of the progressive tariff is free storage on the first day, which on the second day until the 10th day will be equal to 500% of the base tariff. Next on the 11th day will be imposed by 700%.

2) Access development

The road construction policy in the model is represented by the Jakarta-Cikampek Elevated II development project. This project is planned to be completed in 2019 and will have a length of 36 KM. The Jakarta-Cikampek toll road until 2016 is till up to 602,000 vehicles per day. The construction started from KM 46 in West Karawang regency.

The assumptions that are built in the model are all export and import containers have a transport delay on the Jakarta-Cikampek toll road. This assumption is built on the fact that 70% of container truck flows in DKI Jakarta are almost ascertained through this route.

D. Policy Testing Result Analysis

1) Analysis of the impact of progressive rate policy revocation

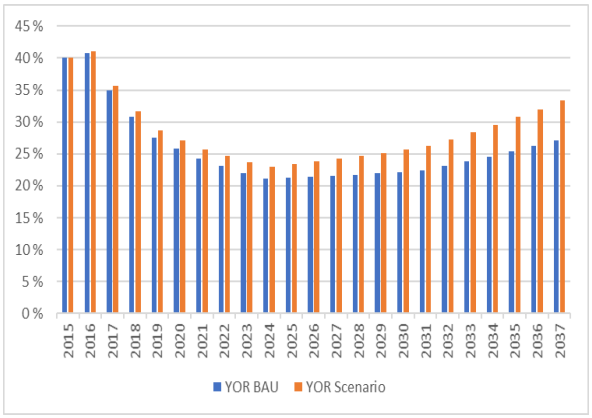


Figure 17 YOR and BAU Comparison with Scenario

The test of the policy performed shows significant results to the number of containers handled in each year. This is because the long calling of containers by the owner or the cargo shipper is considered longer for about five days. More duration of container callings will also lead to the use of a more used piling field. This can be seen through the ratio of YOR or yard occupancy ratio or the ratio of the use of the container-packing field in Fig. 17.

This also affected the fewer containers handled at Tanjung Priok port due to higher YOR. The lower handling flow will certainly reduce the competitive factor of Tanjung Priok port because there is an opportunity lost due to the length of container calling due to the low tariff burden given.

2) Analysis of the impact of development policy revocation

The level of road density occurring as a result of the revocation of Jakarta-Cikampek Elevated II toll road development policy can be seen in Fig. 18.

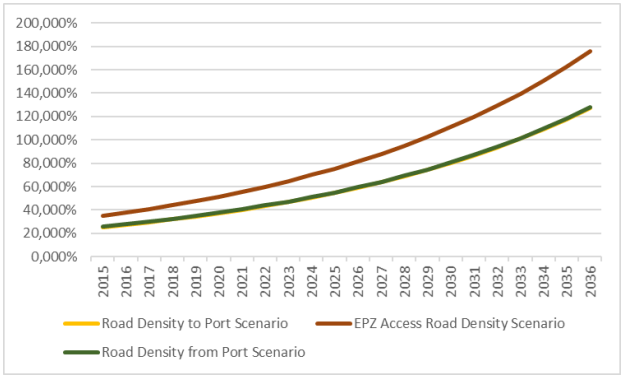


Figure 18 Road Density in Scenario

When compared to the road density of BAU, in 2019 there will be a decrease in road density in the access routes through which containers of export and general import due to additional road capacity. In the simulation scenario of road density will continue to increase due to the absence of government intervention, but it is also exacerbated by the growth of other vehicles that increasingly over years.

3) Analysis of combined impact

The combined impacts resulting from the removal of the two policies in the scenario can be seen through the logistics costs per TEUs. Progressive tariff revocation will make schema changes in the calculation of the stacking costs. The scheme that occurs is that the loading will only be 500% of the base rate of accumulation starting on the 2nd day until the 10th day of the accumulation and then the loading will increase to 700% from the base rate on the 11th day onwards. Another impact that occurs on logistics costs is due to transportation costs due to the imposition of transport costs using time variables while transport time in scenario is prolonged due to increased road density.

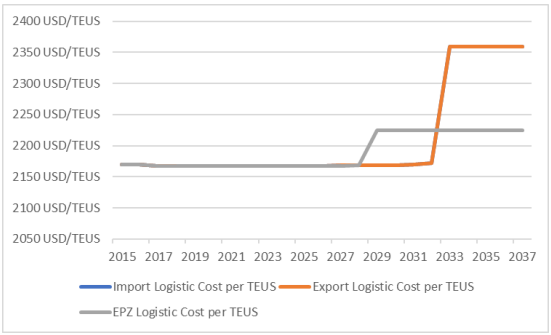


Figure 19 Logistic Cost per TEUs in Scenario

This can be seen in Fig. 19 logistic cost graphs per TEUs in scenarios of progressive tariff policy revocation and access building. There appears to be a change in logistics costs on export and import containers in general which is not the case in business as usual simulations.

V. Conclusion

After doing this research, there are several conclusions that can be taken:

- The built model is a valid model.
- The development of Tanjung Priok port has a positive effect on economic growth in Jakarta through sector contribution and employment.
- The port serves as an enabler for regional industry productivity through its role in lowering national logistics costs.
- The enactment of progressive tariff policies and the development of good port access has been one of the crucial interventions in improving the port and industry competitive factors.
- The development of Tanjung Priok port is hampered by congestion which, if not responded properly.
- The concept of port-regionalization or the establishment of adequate infrastructure in DKI Jakarta in response to trade growth did not occur.

VI. Future Research

After conducting this research, there are several useful suggestions for further research, which are to involve policy interventions that are useful for maximizing the economic growth of DKI Jakarta and involving

environmental aspects to apply the concept of sustainability.

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