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The Dynamics of the Freight Forwarder and Carrier Cooperation in Fulfillment of Load Capacity of Cargo Container Distribution

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Abstract: The increased needs of container ship capacities obtained positive responses from the shipping industry in terms of the construction and development of the naval facilities. Nevertheless, the uncertainty factors of the cargo generated problems for the ship owner (carrier) resulting in low utilization of the capacity therefore providing impact of losses suffered by the freight forwarder due to the business characteristics between the two. The insufficiency strategies of the capacity utilization applied by the carriers obligate the freight forwarders to develop suitable strategies in order to minimize losses. This research will discuss the development of strategies by conducting collaboration of the capacity reservations that are able to bring about the balance between advantages and disadvantages for both parties using the application method of the game theory and recognizing the consequences of the strategy implementations with the dynamic system methodology approaches. There are 4 scenarios generated from the applications of the game theory and are used as policy alternatives in the dynamic system methodology. As for the response variables that are the focus of the research are the carrier profit of the capacity, the freight forwarder profit of the capacity, the amount of vessels for the carrier investment, and the investment contract of the freight forwarder for the reservation intensity. The research results show that there are tradeoffs from the applications of each of the policy scenario alternatives toward the response variables. Therefore, in providing recommendation of capacity reservation policies to companies should be based on many considerations according to the research results.

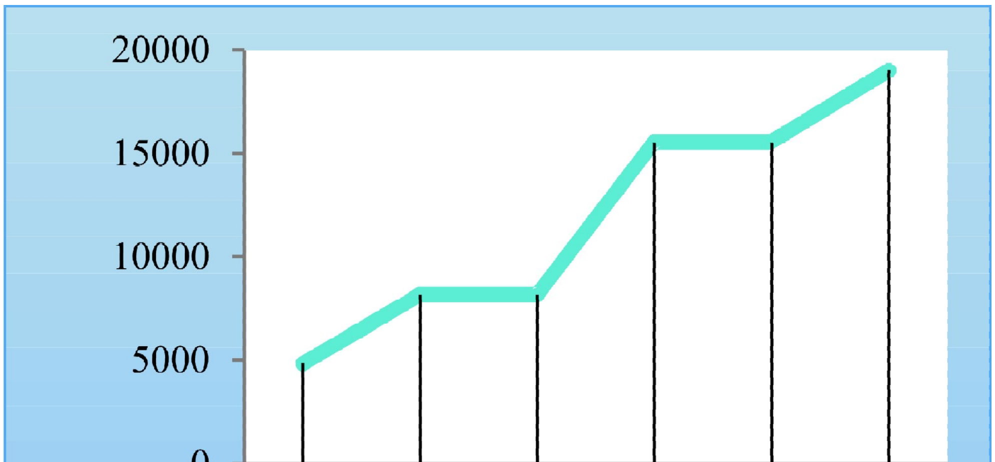
Keywords: Carrier, Freight Forwarder, Capacity Reservation, Dynamic System, and Game Theory.

1. INTRODUCTION

The sea transport modes are gaining popularities in the world of trades. There are as many as 80% of products that can be circulated to every corners of the world through the sea. Data released by the United

Nations Conference on Trade and Development in 2015, products distributions by sea reaches 10 billion tons, an increase of 4.8% every year [1]. This development is corroborated by the increased of the global gross domestic products from 2.2% in 2013 to 2.5% in 2015 along with the economic growth in developing countries and the global economic recovery.

Plans and actions taken in the construction and development on the naval facilities in various countries received positive responses from the shipping industry. In the year 2015, it was recorded that the number of the capacity reservation of ships carrying containers or freight vessels was of 190 million of dead weights. The rate of increase in capacity requirements of vessel containers is shown in Figure 1.



	1990	1995	2000	2005	2010	2015
Kapasitas	4818	8160	8160	15550	15550	19000

Figure 1: The Rate of Increase in Capacity Requirements of Vessel Containers

Source: OECD/ITF of Data Clarkson Reseach Service.

Nevertheless, the uncertainty factors of cargo generated problems for the carrier. More than often ships are forced to depart with low capacity utilization when examined from the previous records, such as when demands in providing capacity from customers are needed promptly, however the regulation and requirement policy actioned sluggishly [2]. Another risen obstacle is the excess capacity of the industry due to the variation in demands and trade imbalances [3]. Thus when a recession happened, it caused a decrease in average capacity utilization of ships and cargo rates [4]. This causes ship owners to rethink the capacity utilization strategy. The closest affiliation to carriers is freight forwarders. If the carrier is the mode of transportation, the freight forwarder is the business entity that aims to provide services or maintenances of all activities necessary for the implementation of the delivery, transport and receipt of goods using multimode transports by the land, sea and air [5].

Business characteristics cause freight forwarders to be highly dependent toward carriers. The association between freight forwarders and carriers can be shown by the high demand of capacity on ship containers. Such dependence results carriers to easily choose a freight forwarder which then given a guaranteed of capacity availabilities. This causes harm to the freight forwarders. To minimize such losses, freight forwarders need to construct the proper strategy. Cooperation between competing parties will be able to diminish any shortfalls which may arise due to the competition [6].

Literatures which elevate the theme of vertical collaboration had done it with several methods, such as stochastic dynamic programming, QD pricing model and stackelberg game. However, literatures which discussing the strategy to win vertical competition in distribution and logistics by focusing attention to some parties and reviewing the relationship between freight forwarders and carriers as coopetition (cooperation and competition) for the optimization of profits are still a small amount. Proceeding from these conditions, the purpose of this research is to develop strategies that are able to generate a balance of advantages and disadvantages for both parties, namely freight forwarders and carriers by using the game theory application methods and the dynamic system methodology approaches to identify the consequences of the implemented strategies, in order to comprehend the recommended strategies which are able to be applied by companies in resolving dynamic problems of the collaboration of the capacity reservation. The benefits of this study are to investigate and provide evidences that the game theory methods will be able to use as a basis for decision making, contributing to the academic world regarding scientific articles on game theory applications in the pursuit of freight forwarder and carrier strategies, where the recommended strategy is capable to answer drawbacks of the capacity trade competition. The limitation of this research is the type of freight forwarders used is those who do not own vessels, the type of cargo used is a 20" container or 1 TEU, the type of vessel examined is a public vessel with scheduled route and timetable, the studied coordination are only between freight forwarders and carriers, and multiple discounts are not being conducted. The applied assumption is the shipper is not directly related to the carrier and monopoly is not valid and the capacity booking contract is done at the beginning of the period and is fixed.

2. BASIC METHODOLOGY

This study employed a four-stage process: variable identification and conceptual model, formulating strategies of each player, simulation model, analysis and withdrawal conclusion.

A. Variabel Identification and Conceptual Model

Variable Identification and Conceptual Model will conduct the identification of the used players which are freight forwarders and carriers with the aim of maximizing the profits of each player, the identification of variables which are conducted with literature studies and direct interviews with logistics companies, the model conceptualization which is the design of the conceptual model of the actual system in two ways namely the input-output diagram and the causal loop diagram, as well as data collection consisting of ship container capacity data, container sales tariff data from both parties, and data of container capacity leasing tariff by freight forwarder with Surabaya-Gorontalo route.

B. Formulating Strategies of Each Player

Formulating Strategies of Each Player will conduct the design processes of each player strategy in order to accomplish several strategy alternatives. Afterwards logical and mathematical verifications will be performed along with validations of the game theory models which represent obstacles thenceforth a matrix of payoff and a game structure with the game theory application will be constructed by means to achieve the optimal solutions.

C. Simulation Model

The design and formulation of the model is done by using the STELLA© (*i*See System) software. The model is designed and formulated by utilizing a stock and flow diagram that is mathematically engineered against the variables that interact. The running output result of the initial simulation model can be verified and validated to ensure that the simulation model has represented the actual system. Alternative scenarios are generated through the process of applying the game theory. The criteria of a policy assessment are determined based on the variables that are the measurement of the success of the system objectives.

D. Analysis and Withdrawal Conclusion

In this section we will analyze the results of the previously obtained data processing, *i.e.* analysis of the output win-win solution from each player in the game theory application and analysis of the output simulation model from each scenario which compared to each other in order to learn the consequences from each scenario alternative that will be applied. The key points in drawing the conclusions refer to the purpose of the study. The suggestions related to this research are addressed to the relevant stakeholders and subsequent researches.

3. THE DESIGN OF SIMULATION MODEL AND GAME THEORY

A. The Causal Loop Diagram (CLD)

The causal loop diagram serves to describe the relationship between one variable with another. The causal relationship is marked by positive and negative signs located near the arrow's tip. Positive relationship exhibits a directly proportional bond between the variables while the negative relationship has the meaning of an inversely proportional connection between the variables.

B. The Applicattion Gamet Theory

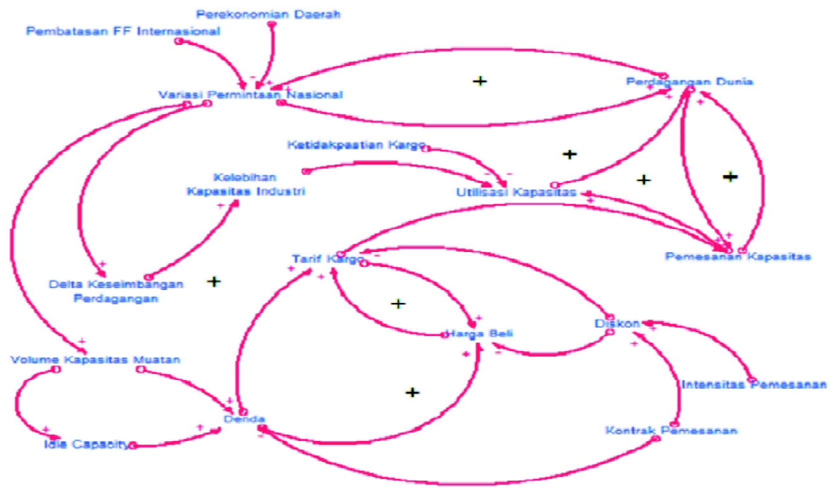
In this section we will identify some components of the game theory that are used, namely

1. *Games:* Cooperative Two-Person Non-Zero Sum Game,
2. *Players:* Player 1 (Carrier) and Player 2 (Freight Forwarder) where there are 3 criteria in the distribution of the freight forwarder, they are FF 1 with booking contracts < 1 year, FF 2 with booking contracts 1-2 year, and FF 3 with booking contracts > 2 year.
3. *Strategy:* The carrier has 4 strategies, namely the specification of discount, penalty, discount and penalty, as well as normal.

Meanwhile the freight forwarder has 3 strategies, namely booking with large payload capacity (350 TEU), normal (200 TEU), and small (100 TEU). The number of alternative scenarios for each strategy combination is 36 scenarios with 12 scenarios held by each freight forwarder. The formulation of the applied mathematical model [6], as follows:

1. *Discount:*

$$Max\,\Pi Fi = (R - (P_{(q)} - (P_{(q)} \times a_i))) \times Q_i \tag{1}$$



		Freight Forwarder		
		SA	SB	SC
Carrier	S1	(PC_{1A}, PFF_{1A})	(PC_{1B}, PFF_{1B})	(PC_{1C}, PFF_{1C})
	S2	(PC_{2A}, PFF_{2A})	(PC_{2B}, PFF_{2B})	(PC_{2C}, PFF_{2C})
	S3	(PC_{3A}, PFF_{3A})	(PC_{3B}, PFF_{3B})	(PC_{3C}, PFF_{3C})
	S4	(PC_{4A}, PFF_{4A})	(PC_{4B}, PFF_{4B})	(PC_{4C}, PFF_{4C})

Figure 2: The Causal Loop Diagram and The Conceptual Model of the Game Theory

$$Max\ \Pi C = ((P_{(q)} - (P_{(q)} \times a_i)) - P_{(O)}) \times Q_i \tag{2}$$

2. *Penalty:*

$$Max\ \Pi Fi = (\mathrm{R} - (P_{(q)} + (P_{(q)} \times i_i \times b_i))) \times Q_i \tag{3}$$

$$Max\ \Pi C = ((P_{(q)} + (P_{(q)} \times i_i \times b_i)) - P_{(O)}) \times Q_i \tag{4}$$

3. *Discount and Penalty:*

$$Max\ \Pi Fi = (\mathrm{R} - (P_{(q)} + (P_{(q)} \times i_i \times b_i) - (P_{(q)} \times a_i))) \times Q_i \tag{5}$$

$$Max\ \Pi C = ((P_{(q)} + (P_{(q)} \times i_i \times b_i) - (P_{(q)} \times a_i)) - P_{(O)}) \times Q_i \tag{6}$$

4. *Normal:*

$$Max\ \Pi Fi = (\mathrm{R} - P_{(q)}) \times Q_i \tag{7}$$

$$Max\ \Pi C = (P_{(q)} - P_{(O)}) \times Q_i \tag{8}$$

Annotation

ΠFi = freight forwarder profit

R = capacity sales tariff from FF to shipper

$P_{(q)}$ = capacity rent/sell tariff from carrier to FF

Q_i = total amount of rented/bought capacity i

ΠC = carrier profit

$P_{(o)}$ = carrier vessel management tariff

a_i = discount on criteria i

b_i = penalty on criteria i

i_i = idle capacity

Specification of the percentage of discount and penalty shall be based on the criteria of the booking contract and the load capacity volume. FF 1 retains a discount value range of $0\% \leq a_i \leq 2\%$ and a penalty of $3\% \leq b_i \leq 5\%$, FF 2 retains a discount value range of $3\% \leq a_i \leq 5\%$ and a penalty of $2\% \leq b_i \leq 4\%$, and FF3 retains a discount value of $6\% \leq a_i \leq 10\%$ and a penalty of $1\% \leq b_i \leq 3\%$.

Specification of the idle capacity is closely related to the amount of penalties received by the concerned parties. The value is used by the model developer to form several policy strategy scenarios which based on the volume of load capacity, *i.e.* large capacity 15%, normal 12%, and small 1%.

Verification of the game theory model is done by checking the variables and the equation formulation. In the examination of the variables in the model; it indicates that the variables are in accordance with the concept and in the examination of the equation formulation; it is completed to ensure there is no syntax error in the equation. Validation is done by the Mean Absolute Percentage Error (MAPE) method that searches for error output from the actual system and model results. Validation test is performed on one model only that is the model where cooperation is executed between the carrier and FF 1 which solution exhibits MAPE value equal to 0.0374289 or 3.74% for carrier profit and 0.033172 or 3.32% for freight forwarder profit. The result of this test, the model is declared verified and validated.

The payoff matrix is structured by using a strategic game model to further achieve its equilibrium value. The value in the payoff matrix is lined based on the amount of profits gained from the running result of each scenario. The equilibrium value or optimal solution obtained for each player, namely between the carrier and FF 1 chose to apply a penalty strategy as well as a discount and penalty strategy with large load capacity, between the carrier and FF 2 chose to apply a penalty strategy and large load capacity, and between the carrier and FF 3 chose to apply a penalty strategy and large payload capacity as well.

C. The Stock and Flow Diagram

This section will begins with the construction of a stock and flow diagram which is the embodiment of a model system through a simulation model to discover the relationships between variables that have previously been formulated on the causal loop diagram using the STELLA© 44 (iSee System) software.

The main model of this system aims to describe the amount of profits to be gained by the carriers and freight forwarders. The profits from both parties are influenced by each of the sales results or the demands of cargo capacities. The amount of sales or capacity requirement will be multiplied by the selling price of each capacity and will be reduced by variables cost and fixed cost of each party. The obtained profits will be accumulated for 1 year in order to identify the cost that must be retained by the carrier to buy a ship with the equivalent capacity and recognize the cost that must be preserved by the freight forwarder to be able to perform a booking contract with the identical capacity in the future.

Figure 3: The Research System Main Model

Verification of the simulation model is conducted to examine the logic and to equate the model information that has been designed on the model conceptualization into the programming system correctly in two ways, *i.e.* Check Units on the Run menu and Verify/Repair Model on the Run menu or by utilizing the Model Diagnostic Options menu by pressing SHIFT on the keyboard when opening the simulation model file on the STELLA© 44 (iSee System) software. Validation is performed by 5 mechanisms, namely the structure test, the parameter test, the limit sufficiency test, the extreme condition test and the behavioral or replication test [7].

Based on the mentioned verification and validation tests, the model that has been designed is able to be ascertained credible towards the actual system.

Table 1
The Description of the Validation Test

No.	*Validation Test*	*Mechanism*
1.	Structure Model	Viewing the system model through white-box with hypothetical approaches through logical thinking, journals, report, from companies' information, FGD, and historical approach through companies' historical data.
2.	Limit Sufficiency	Testing the variables in the system to recognize the significant variables which are affecting the system.
3.	Parameter Model	Assessing the input variables by comparing the simulated logical outputs with CLD to identify the consistency of relationships between variables.
4.	Extreme Condition	Examining the functionality of the model in extreme conditions by inserting extreme top values (500 TEU) and lower extremity (200 TEU) on variable load capacity requirements.
5.	Behavioral or Replication Model	Observing the system model through black-box by finding the average error between simulation results and actual system.

4. ANALYSIS

A. The Equilibrium Point

This section will perform on the running results of the game theory model to achieve a win-win solution for the carrier and freight forwarder which can be conducted after the formulation of the payoff matrix is completed by utilizing the Gambit software.

The running result of the Gambit software for the cooperation between the carrier and FF 1 convenes in the penalty strategy as well as the discount and penalty strategy by the carrier and the large load capacity by the FF 1 with the value of the game endured by the carrier of Rp 578,875,000 and the FF 1 of Rp 193,943,750. The cooperation between the carrier and FF 2 convenes in the penalty strategy by the carrier and the large load capacity by the FF 2 with the value of the game endured by the carrier of Rp 573,100,000 and the FF 2 of Rp 193,655,000. The cooperation between the carrier and FF 3 convenes in the penalty strategy by the carrier and the large load capacity by the FF 3 with the value of the game endured by the carrier of Rp 567,325,000 and the FF 2 of Rp 193,366,250.

B. The Simulation of the Scenario Model

Simulation is performed in units of months with a period of 8 years, *i.e.* 2012-2019. The research system is divided into 4 scenarios based on the strategy of the application of the game theory, consisting of:

1. Scenario 1, when the FF 1 with criteria of booking contracts less than 1 year implements a large load capacity strategy and the carrier applies a 0%-2% discount strategy and a 3%-5% penalty strategy.

   In this scenario the carrier earned profits have an inversely proportional relationship to the specification of the amount of discounts and the earned profits by the FF 1 as well as a directly proportional relationship to the specification of the amount of penalties. The implementation of the scenario causes the number of carrier vessels modified from 2 ships to 3 ships and the FF 1 contract investments of the load capacity reservation risen from 4 times to 5-6 times of bookings per each month. The carrier average profits from 2016-2019 had an increase of Rp 510,474,316,339 and the FF 1 of Rp 201,000,854,484.

2. Scenario 2, when the FF 1 with criteria of booking contracts less than 1 year implements a large load capacity strategy and the carrier applies a 3%-5% penalty strategy.

   This scenario aims to comprehend whether applying only a penalty strategy alone will generate a significant impact for some response variables of scenario 1. The running results demonstrate that the number of vessels of the response variables remains unchanged, however the contract investments are adjusted to 5 times of bookings per each month with an increase in the carrier average profits and a decline in the FF 1 average profits of Rp 40,255,865,849.

3. Scenario 3, when the FF 2 with a 1-2 year criteria of booking contracts implements a large load capacity strategy and the carrier applies a 2%-4% penalty strategy.

   This scenario aims to comprehend whether changing the value of the penalty range will generate a significant impact for some response variables which directly will affect the stakeholders involved in scenario 2. The running results demonstrate the response variables of the number of vessels and contract investments remain unchanged. Meanwhile, there is a decrease in the carrier average profits and an increased in the FF 2 average profits of Rp 3,767,870,808.

4. Scenario 4, when the FF 3 with criteria of booking contracts of more than 2 years implements a large load capacity strategy and the carrier applies a 1%-3% penalty strategy.

   This scenario exhibits that the change in penalty range does not significantly affect the response variables for the number of vessels and contract investments. However, it does impact the response variables of profits for both parties. The lower the specified penalty range will distress the carrier profits while the FF profits will increase.

C. The Comparison of the 4 Policy Scenarios Simuation Output

The running results of the simulation model from the 4 policy scenario alternatives that have been designed have their respective advantages and disadvantages on some response variables. Below is the table of comparison of the outputs.

Table 2
The Comparison of the Simulated Outputs

No.	*Focused Response Variables*	*Recommended Scenario*
1.	Carrier capacity profits	Scenario 2 with profits of Rp 540,526,719,294 in the year 2019.
2.	Freight forwarder capacity profits	Scenario 1 with profits of Rp 194,749,404,039 in the year 2019.
3.	Number of vessels which can be invested by carrier	The entire scenario implementations do not generate significant impacts toward the number of vessels because in 2019 it remains unchanged respectively 3 ships.
4.	Contract investments of cargo capacity reservation by freight forwarder	Scenario 1 with contract investments increasing to 6 bookings per each month in 2019.

5. CONCLUSION/SUMMARY

The conclusions that can be drawn from this research are:

1. There are 4 scenarios that can be achieved from the application of the game theory, respectively:
   (a) The first scenario, the FF 1 implements a large load capacity strategy and the carrier implements a 0%-2% discount strategy and a 3%-5% penalty strategy.
   (b) The second scenario, the FF 1 implements a large load capacity strategy and the carrier implements a 3%-5% penalty strategy.
   (c) The third scenario, the FF 2 implements a large load capacity strategy and the carrier implements a 2%-4% penalty strategy.
   (d) The fourth scenario, the FF 3 implements a large load capacity strategy and the carrier implements a 1%-3% penalty strategy.
2. The 4 scenarios which designed in this study, each has impacts on the specified response variables. The specified response variables are the profits of capacity earned by the carrier, the profits of capacity earned by the freight forwarder, the number of vessels that can be invested by the carrier, and contract investments that can be performed by the freight forwarder toward the reservation intensity in the booking contracts per each month.
3. Each policy scenario alternative has advantages and disadvantages on each response variables in the system. If the company is an establishment that owns ships (a carrier company) and generating profits is a priority, therefore the policy scenario 2 is suitable for consideration as well as if the company compels to prioritize the number of vessels that can be invested hence the 4 scenarios are proper to be considered. Conversely, if the company is a freight forwarder establishment and designating profits and contract investments which exhibit reservation intensity per each month as a priority thenceforward the policy scenario 1 is to be considered.

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