
Shifting Analysis of Grain Carriers Using System Dynamics Simulation

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DOI: <https://doi.org/10.21107/rekayasa.v17i1.20886>

Submitted June, 28th 2023; Accepted March, 21st 2024; Published April 15th, 2024

Abstrak

PT PFS merupakan salah satu anak perusahaan PT BJ yang khusus melayani jasa kepelabuhanan. PT PFS perlu melakukan pemindahan FSO Ardjuna Sakti dari dermaga 1.6-1.7 karena adanya peningkatan demand, pengembangan dermaga 3. Pelabuhan CDG, Berth Occupation Ratio (BOR) yang sudah melebihi 65% dan rencana ekspansi PT BJ serta perlu adanya fleksibilitas dari dermaga 1.5 sampai dengan 1.8. Oleh karena itu, perlu dilakukan perhitungan Net Present Value (NPV), Internal Rate of Return (IRR), dan Payback Periode guna menganalisa kelayakan yang terjadi dari investasi pemindahan tersebut. Perhitungan tersebut dilakukan baik secara matematis menggunakan Ms. Excel maupun dengan metode simulasi menggunakan software Powersim. Selanjutnya membandingkan pendapatan dan keuntungan FSO Ardjuna Sakti di dermaga 1.6-1.7 dengan FSO Ardjuna Sakti di dermaga baru (dermaga 4.5-4.6). Berdasarkan hasil penelitian didapatkan hasil bahwa Internal Rate of Return sebesar 14,73%, Payback Periode adalah 5 tahun dan nilai Net Present Value Rp15.369.374.455 serta Net Present Value simulasi sistem dinamik adalah sebesar Rp1.184.863.983.489, sehingga keputusan investasi layak untuk dilakukan. Nilai pendapatan dan keuntungan saat FSO Ardjuna Sakti di dermaga 1.6-1.7 berturut-turut adalah Rp2.834.292.880 dan Rp2.125.719.660 sedangkan nilai pendapatan dan keuntungan saat FSO Ardjuna Sakti di dermaga 4.5-4.6 berturut-turut adalah Rp9.015.993.344 dan Rp6.761.995.008 sehingga pemindahan FSO Ardjuna Sakti tepat untuk dilakukan.

Kata Kunci : internal rate of return, net present value, payback periode, simulasi sistem dinamik

Abstract

PT PFS is a subsidiary of PT BJ specially serving of port services. PT PFS need to shift FSO Ardjuna Sakti from jetty 1.6-1.7 to the new jetty (jetty 4.5-4.6) because PT PFS has some problems and activity plans. The problems are teh increased of commercial demand, the development jetty 3 of port CDG, the Berth Occupation Ratio (BOR) which already exceeds 65%, the expansion plan of PT BJ and the need for flexibility on the jetty 1.5-1.8. Therefore, it is necessary to do the analysis of shifting the FSO Ardjuna Sakti. The method use in this study is comparing the financial analysis using manual calculation and system dynamics simulation. The financial analysis uses in this study are Internal Rate of Return (IRR), Payback Period, Net Present Value (NPV) and comparing revenue and profit between FSO Ardjuna Sakti in jetty 1.6-1.7 and jetty 4.5-4.6. The result of the study showed that the IRR is 14,73%, it is exceed than the MARR of BI rate 6,5%, Payback Period is 5 years so investment will comeback at 5 next years, and the value of the NPV with manual and system dynamics simulation has both positive value or exceed than 0 (zero). The result of manual calculation of NPV is Rp.15.369.374.455 and the result of system dynamics simulation is Rp.1.184.863.983.489. Comparing manual calculation and system dynamics simulation of revenue and profit of FSO Ardjuna Sakti in jetty 1.6-1.7 respectively is Rp.2.384.292.880 and Rp.2.125719.660 whilst in jetty 4.5-4.6 respectively is Rp.9.015.993.344 and Rp.6.761.995.008. From those financial methods compared manually and by system dynamics simulation, we can conclude the investment decisions are feasible. And activity of shifting FSO Ardjuna Sakti from jetty 1.6-1.7 to the jetty 4.5-4.6 is appropriate to do.

Key words : internal rate of return, net present value, payback periode, system dinamic simulation

INTRODUCTION

Port is a place consisting of land and/or waters with certain boundaries as a place for government activities and business activities used as a place for ships to dock, board passengers and/or load and unload goods, in the form of terminals and berths equipped with shipping safety and security facilities and port supporting activities as well as a place for intra and intermodal transportation (Indonesia, 2008). Port competition is increasing on the land side, so that port actors have the aim of increasing the role and improving the outbound transportation system as well as in-port logistics (Sdoukopoulos & Boile, 2021). Strategic planning is an important factor in achieving high competitiveness in the port context because ports face rapid and very competitive changes in competition in the business environment (Dang & Yeo, 2017). The port is very closely related as a place for ships to dock, dock, transport up and down passengers, and/or load and unload goods which are equipped with facilities so that they become an important means

of supporting the flow of domestic and foreign trade (Putra, Sitompul, Mardalena, & Romadani, 2022). The Port of Sines, which is located in the Continental Atlantic corridor, is declared a unique seaport and is able to accommodate ships of the "Postpanamax" type. With several connected transportation investments to accommodate the growth of goods in port (Prata & Arsenio, 2017), because it is so important information about the condition of a waters to reduce the negative impact in the future development of the area around the port (Sarita, Putra Suhana, & Wirayuhanto, 2023).

The Port of CDG serves as berths for ships from different continents carrying agricultural commodities. Grain cargo transportation must use the right strategy so that the grain commodity is not damaged in the packaging and can improve the quality of the origin of the supply chain of these agricultural products (Lirn, Bremer, Yeo, Shang, & Jiun, 2018). PFS (Port Financing Service) is a subsidiary of Bandar Jakarta (BJ) which specialized on port service for BJ as the holding company and/or for other party. PFS Ltd. has experienced a significant Ltd reuse in demand regarding port facility requirement in particular. For that matter, the flexibility of dock 1.5 to 1.8 is required. Moreover, there will be a development of CDG Port's dock 3 where dredging activity will take place which also covers the sea are in dock 1.6 and 1.7. The Berth Occupation Ratio (BOR) of PFS Ltd. in 2013 to 2015 has exceeded the ideal standard of 65%. Commonly, the BOR condition reaches a critical point when BOR level has exceeded the specified standard or beyond 50%. There is a plan of expensing BJ Ltd by constructing *Blast Furnace Complex* 1.2 MTPA which is planned to start in 2017. The problem that will be examined is the amount of Net Cash Flow that occurs each period after investing in the first period, namely investment for the construction of a new wharf, namely piers 4.5-4.6. After getting the Net Cash Flow value for each period, it will be followed by calculating the Net Present Value so that you know the feasibility of the investment to be made.

Port governance responsibilities are left to port authorities which are commercially driven autonomously. In the final stage, the structural configuration and strategic framework of potential frameworks that advance port competitiveness and have been identified in the port literature (Pallis & Syriopoulos, 2007). (Yun & Choi, 1999) proposes a container terminal system simulation model developed using an object-oriented approach and SIMPLE##, an object-oriented simulation software. This study considers a simple terminal which is the reduced model of the real CTS (Pusan east container terminal) and analyzes the system performance from the reduced model results. From the analysis it is known that many design parameters in CTS affect performance and if we want to get a reasonable CTS, by changing the design parameters, simulate and get the results iteratively with the simulation model. This paper (Petering, 2011) presents the results of nine independent studies that relate the long-term average dock crane rates of port container terminals to various strategic and tactical decisions made by terminal operating companies.

This research (Feng, Shaw, Peng, & Fang, 2020) is to verify the gap in company performance between the relationship levels between international freight forwarders and port logistics service providers. forwarders require operational cooperation with port logistics service providers, the high level of commitment between companies is related to the high level of company performance, the high level of communication between companies is based on customer performance gaps. The operational efficiency of seaports is an important issue for shipping companies and port authorities, due to moving ships in and out of seaports as efficiently as possible. Automatic identification system (AIS) data that records vessel movement trajectories allows us to assess operational efficiency as vessels move in and out of port, this study (Feng et al., 2020) proposes a time efficiency assessment framework that evaluates the amount of time each ship spends in different areas within the port (i.e. berths, harbors and fairways) based on the space-time trajectory of the ship's movements. Port performance can be used to determine the level of port service to port users (ships and goods) which depends on the service time of ships while in port based on Yard Occupancy Ratio (YOR) and Berth Occupancy Ratio (BOR) simultaneously which affect operational performance (Anggrahini, Karnawahadi, & Paniya, 2018), which simultaneously affect operational performance (Doris Ade Widyarti, Rinaldi, & Ferry Fatnanta, 2017).

The carrying capacity of the port environment affects economic development and investment capacity to be made by ports, while technological innovation and industrial transformation are still less influential due to government policies on sustainable development (Li, Jiang, & Lin, 2018). This paper (Feng

et al., 2020) presents a conflict resolution model to resolve the demands of different stakeholders in the rebuilding of the Incheon Inner Port. The terminal operating company (TOC) supports the new terminal to maintain their business, while the Port Authority (PA) is concerned about the financial burden of making a replacement terminal, the model used to resolve the conflict is multi-criteria one of which is the ratio of BC (Benefit and Cost), Net Present Value and Internal Risk Return. Decision makers and practitioners need to assess their financial viability, an effort that can be greatly facilitated by relatively simple tools such as Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (Queiroz & Mladenovic, 2020). Based on the background of problem elaborated above, several problems were formulated as follow: (1) what is the Net Present Value using dynamic system simulation based on interest, coming vessel, and average cargo?; (2) what is the investment decision in consideration of the Net Present Value, Internal Rate of Return, and Payback Periods?; (3) what is the ratio of Income and profit of Ardjuna Sakti's FSO at dock 1.6 to 1.7 and dock 4.5 to 4.6?

The limitations of the research were proposed as follow: This research was conducted at the first dock in CDG Port 1 of PFS Ltd. Panamax was the type of cargo vessel used in this research. The data used in this research were obtained from the company data in in 2015. The loading and unloading process of the ship did not change during the research. Loading and unloading equipment did not experience any interruption or damage during the research. A year equals 365 days. The depreciation method used in this research was the straight-line method. The ship under study was only dry bulk vessel. BOR calculation was adjusted with the company. The time between ship arrivals was exponential. Technical perspective was not assessed.

RESEARCH METHOD

The primary data in this research was gained from intensive interview with the parties deemed capable of providing sufficient information related to Ardjuna Sakti's FSO data. While the secondary data was in the form of company activity data, Ardjuna Sakti's FSO data, company activates data, data FSO Ardjuna Sakti, historical data of the shipload, and BOR data. Problem solving plot is a general step in conducting the research. Problem solving plot is useful for providing information from the beginning of a research. Below is the problem solving plot as an overall description of the research conducted at PFS Ltd.:

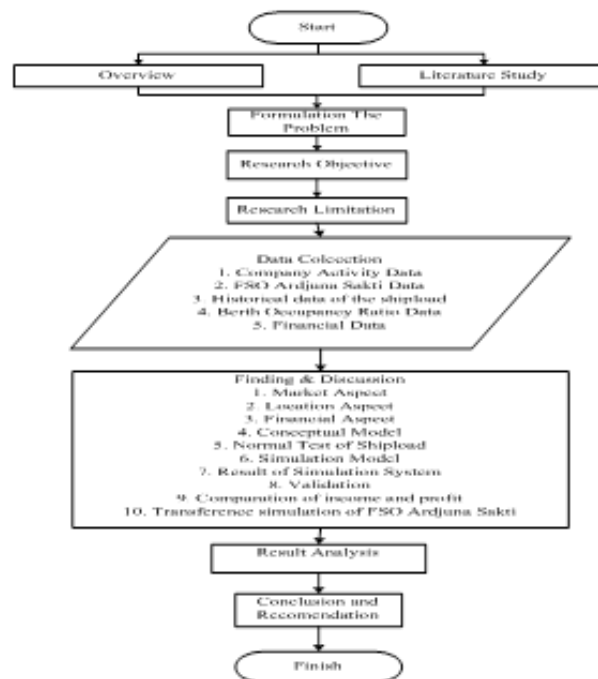


Figure 1. Research Flow Chart

Based on Figure 1, this research is included in a quantitative approach, which collects shipload data, BOR data, financial data, company activity data and FSO Ardjuna Sakti data as supporting data. These data are used to calculate the Net Present Value as the feasibility of investing in a new pier which ensures that

the activity of moving FSO Ardjuna Sakti to the new pier is more profitable than remaining at pier 1.6-1.7. Field observations were carried out directly at PT PFS, either by means of interviews with several related parties or by directly observing the condition of FSO Ardjuna Sakti at wharf 1.6-1.7. so researchers can determine. The limitation of the problem in this research is that the research was conducted at pier 1 of PT PFS CDG 1 port, the type of ship studied was panamax which is a dry bulk carrier.



Figure 2. Location of FSO Ardjuna Sakti

Based on figure 2, FSO Ardjuna Sakti is a ship made of concrete. This ship was made in 1976 in Ohio, United States. This ship was previously operated by British Petroleum (BP), an oil & gas company from England, which got it from ARCO (an oil & gas company from the United States). In early 2006 the British Petroleum West Java (BP West Java) team conducted a feasibility study of the temporary mooring service for FSO Ardjuna Sakti at CDG Port. The results of the research were obtained by the BP West Java team, CDG Port was deemed suitable for FSO Ardjuna Sakti mooring services and at the same time the team conducted an assessment of all facilities owned by PT BJ (CDG Port) as well as supporting facilities. Beginning in March 2006, BP West Java confirmed that FSO Ardjuna Sakti would be moored at CDG Port. On April 21, 2006 FS Ardjuna Sakti moored at the pier in CDG 1 Port. The transfer of FSO Ardjuna Sakti due to an increase in demand related to the need for port facilities, an increase in demand requiring flexibility from pier 1.5 to 1.8, development of pier 3 at CDG port, PT PFS t Berth Occupation Ratio (BOR) which exceeds the ideal standard of 65%, and PT BJ's expansion in the form of construction of a Blast Furnace Complex.

RESULTS AND DISCUSSION

Cilegon city as the center of business and industrial activity, the service quality of the port in the area should have the requirement to meet the need of the market. It is important as a good facility in the port will guarantee the consumer’s satisfaction. PT PFS as a subsidiary of PT BJ which is engaged in port services in the Cilegon City area. PT PFS serves the Banten and DKI Jakarta Provinces, especially factories located in the Cilegon City area. The number of factories in the Banten area has the opportunity for the import market or loading and unloading through the port which is still quite large because there are approximately 1,600 companies engaged in the industrial sector.

Table 1. Unloading data PT PFS

Month	Number of Ship Arrivals (Ton/Vessel)	Vessel Payload Average (Vessel/month)
January	15	5998
February	12	8362
March	8	5040
April	14	6273
May	12	7069
June	9	5985
July	10	6337
August	10	6139
September	13	5768

Month	Number of Ship Arrivals (Ton/Vessel)	Vessel Payload Average (Vessel/month)
October	16	7730
November	13	7015
December	18	6575

From the observation of PFS Ltd employee, it was found that the company suffers many consumer opportunities lost (non-affiliate ship). It was caused by the consumer's un-satisfactions toward the port facility in PFS Ltd. such as dock. Fourteen docks were available in the company but ships queuing happened so often. It was caused by delays in ship arrival schedules, delays in loading and unloading activities or even lack of operational docks. For that matter, to decrease the opportunity lost, PFS Ltd need to relocate Ardjuna Sakti FSO from dock 1.6-1.7 which is an operational dock to the other dock that is not an operational one. Therefore, dock 1.6-1.7 can be used by other ship whether it is an affiliate or non-affiliate ship.

At this time the aim of constructing piers 4.5-4.6 is to berth FSO Ardjuna Sakti. The existing market potential for piers 4.5-4.6 include: Ardjuna Sakti Ship Berth, Package Handling (estimated 20% tonnage/year) of 237.25 tonnes (including Supervision, hopper and grab). PT PFS is developing port services by increasing the capacity of the pier to berth the FSO Ardjuna Sakti. The construction of piers 4.5-4.6 will make the terminal for the FSO Ardjuna Sakti ship berthing, enabling PT PFS to increase its loading and unloading capacity by using the wharf which is currently still used as the birth of FSO Ardjuna Sakti. The current location of FSO Ardjuna Sakti is still at docks 1.6-1.7. Piers 1.6-1.7 are in a position between pier 1.5 and pier 1.8 and facing pier 2 and pier 3. This will affect the flexibility of other ships that will carry out loading and unloading activities at these piers.

Based on the research, it was concluded that the alternate dock could not accommodate Ardjuna Sakti FSO either from technical aspect (size of dock and the cruise line) and non-technical aspect (bigger cost). If Ardjuna Sakti FSO is relocated to land, it was found that the ship is made of cement (concrete), thus it is feared that the relocation may suffer deformation, the foundation of Ardjuna Sakti FSO has been overgrown with coral reefs, an even foundation is required while the area of dock 7.3 is coral reef.

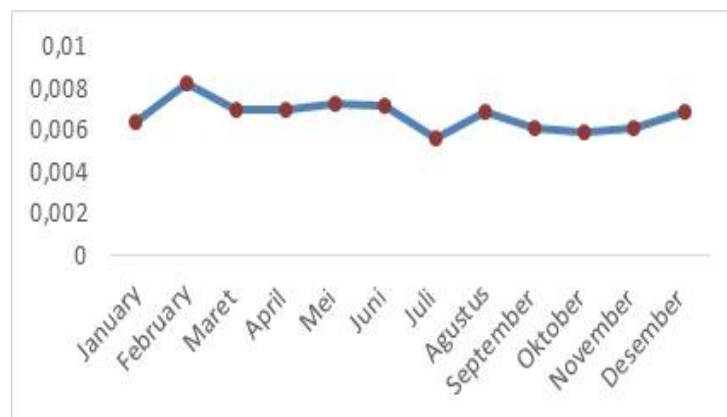


Figure 3. Berth Occupancy Ratio (BOR) Data

The Berth Occupancy Ratio in Figure 3 is an indicator of wharf utilization, the ratio between the amount of available wharf usage time and the total ready-to-operate time in each time period, expressed in units of percent (%). This variable is influenced by several factors, including the amount of mooring time used by ships, length of ships mooring and loading and unloading activities. Meanwhile, the length of the pier and the pier ropes as well as the working time available at the port. Therefore, the appropriate location to relocate is the new dock (dock 4.5-4.6) with consideration of draft requirement of Ardjuna Sakti FSO with minimum of 7,2 meters deep, calm current and not endangering the ship condition which has suffered a severe damage and the ease of the scale of the work so it doesn't require a long development process. Financial aspect is a key aspect of the feasibility study. Because even though the other aspects are qualified,

if the financial aspect is found unqualified, then the project proposal will be denied as it will not be beneficial to the economic.

Table 2. Financial calculation

$\text{Present Value} = \frac{\text{Net Cash Flow}}{(1+r)^n}$ $= \frac{\text{Rp1.427.096.026}}{(1+10\%)^1}$ $= \text{Rp1.297.360.023}$	$15\% \text{ of Present Value} = \frac{\text{Net Cash Flow}}{(1+r)^n}$ $= \frac{\text{Rp1.427.096.026}}{(1+15\%)^1}$ $= \text{Rp1.240.953.066}$
$\text{NPV} = \sum PV$ $= \text{Rp15.369.374.455}$	$\text{IRR} = i1 + \frac{PV(i2-i1)}{PV1+PV2}$ $= 10\% + \frac{\text{Rp1.297.360.023} (15\%-10\%)}{\text{Rp1.297.360.023}+\text{Rp1.240.953.066}} = 14.73\%$
$\text{Payback Period} = \frac{n}{1 \text{ tahun}} + n - \left(\frac{\text{NCF ke } n}{\text{NCF ke } n - \text{NCF ke } n-1} \right)$ $= \frac{10}{12} + 10 - \left(\frac{\text{Rp24.331.126.129}}{\text{Rp24.331.126.129} - \text{Rp22.779.004.782}} \right) = 5 \text{ year}$	

If NPV is more than 0, then the project is feasible. If the NPV is less than 0, than the project is not feasible. If the NPV equal 0, then it will not give any effect on the project. IRR was used to determine whether investment should be done. Investment is done if IRR is higher than Minimum attractive rate of return (MARR) (Rangkuti, 2001). With a positive NPV and the IRR that exceeds MARR which is 6,5%, then based on the real system calculation the investment is worth doing and the return on investment can be obtained within 5 years. Below is Causal Loop Diagram of Net Cash Flow at PFS Ltd.

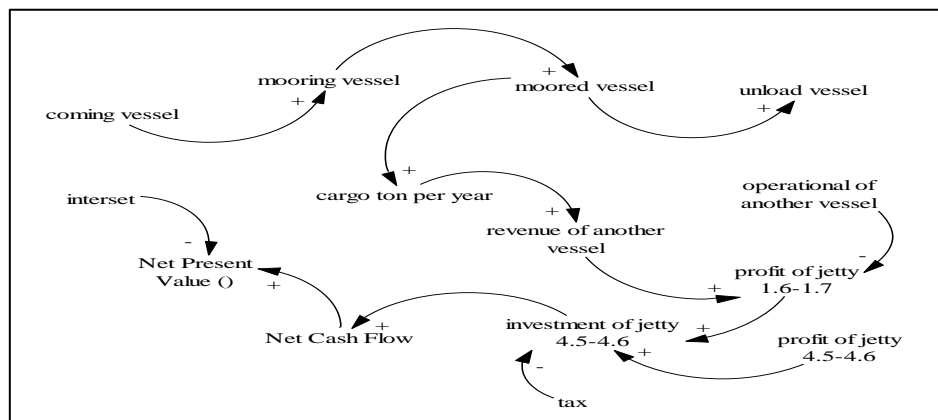


Figure 4. Causal Loop Diagram of Net Cash Flow at PFS Ltd

The Causal Loop Diagram above describes the relation between Net Cash Flow. Casual relations with the positive sign (+) indicate if the dependent variable increases then the independent variable will increase. On the other hand, the casual relations with the negative sign (-) indicate if dependent variable increases then the independent variable will decrease. Below is the Stock Flow Diagram of Net Cash Flow at PFS Ltd.

The results of the Causal Loop Diagram in Figure 3 are the development of the Stock Flow Diagram Net Cash Flow at PT PFS. The Stock Flow Diagram that has been made can explain the flow of obtaining the Net Cash Flow value. During the ship loading and unloading process in 2015 at PT PFS, ships came to the port with an average arrival rate of 13 ships/month. The incoming ship will dock and be demolished. The average load that is unloaded is 6524 tons/day. The load of this ship can affect the BOR value at the dock, the flow in calculating the Net Cash Flow value to get the Net Present Value. which is influenced by the amount of PT PFS investment. in the construction of a new wharf, namely piers 4.5-4.6. The dock profit value 4.5-4.6 determines the cost of moving FSO Ardjuna Sakti and the addition of a tax percentage, the amount of fix revenue and variable revenue. The total cost obtained is the cost incurred by PT PFS in carrying out ship loading and unloading activities and the transfer of FSO Ardjuna Sakti, while the total revenue is obtained from the sum of fix revenue and variable revenue.

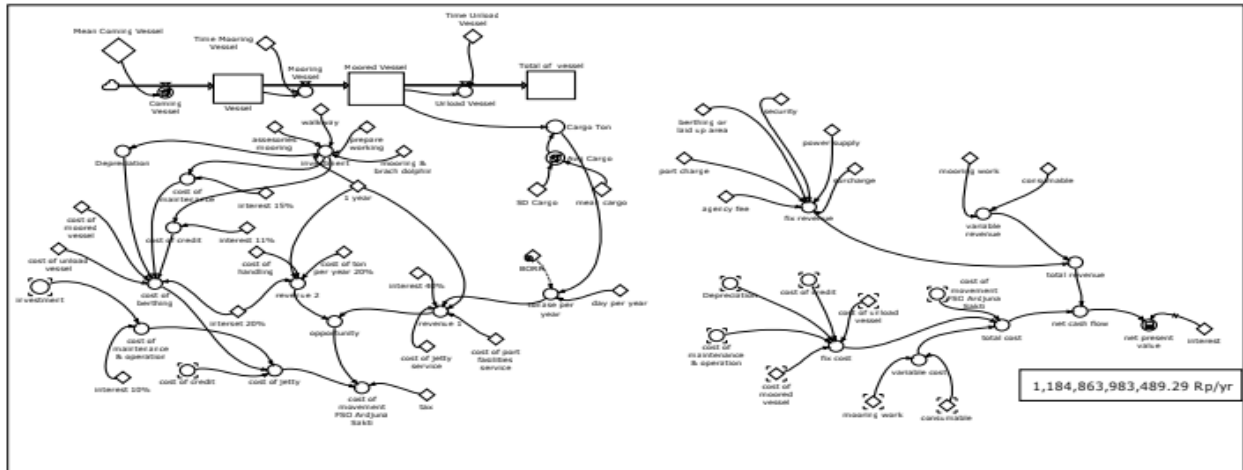


Figure 5. Stock Flow Diagram of Net Cash Flow at PFS

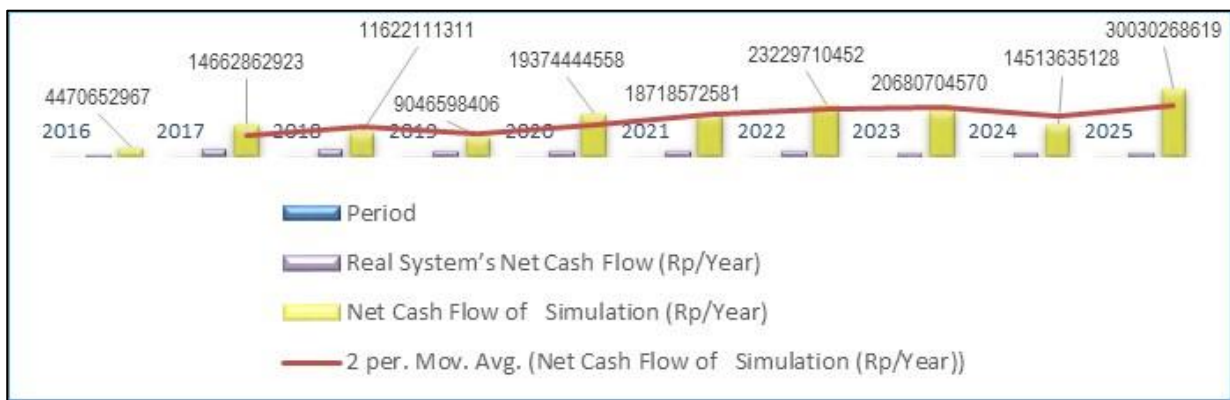


Figure 6. Result Corporation between Real System's Net Cash Flow with Simulation result

Based on the two sample t-test by using Ms. Excel software, it was found that statistical t value is -1,41. The number is less than t-critical two-tail which is 2,26. Thus, t value calculation is less than t table. t Stat value is -1,41 which still categorized into t-critical two-tail area that has an interval of -2,26 until 2,26. Other than that, the p value is of 0,189 which is more than the significance value of α (0,05). Considering those three finding, it can be stated that the alternate hypothesis (H1) was denied. Therefore, it was concluded that there was no significant difference between Net Cash Flow of the real system and the Net Cash Flow of the simulation. Thus, The Net Cash Flow of simulation can represent the real system's Net Cash Flow, so the NPV results obtained from the simulation can also represent the real system NPV which is equally positive. Therefore, investment decisions of new dock which influences the relocation of Ardjuna Sakti FSO is feasible. Based on the comparison of income and profit, it was known that the income of PFS Ltd. from Ardjuna Sakti FSO at dock 1.6-1.7 was of Rp 2.834.292.880 while the income of dock 4.5-4.6 was of Rp 9.015.993.344. With 25% of taxes, then it was known that the profit gained by the company from Ardjuna Sakti FSO at dock 1.6-1.7 was of Rp 6.761.995.008. According to that, it was known that PFS Ltd. obtained more income and profit when Ardjuna Sakti FSO was at the dock 4.5-4.6 than while it was at the dock 1.6-1.7. It shows that relocating Ardjuna Sakti FSO to the new dock (dock 4.5-4.6) is the right decision.

CONCLUSIONS

Based on this research, it can be concluded that with dynamic system simulation based on the interest, coming vessel and average cargo, it was known that the Net Present Value is of Rp 1.184.863.983.489, it was known that the Net Present Value, Internal Rate of Return, and Payback Periods with mathematical calculations are respectively Rp 15.369.374.455, 14,73%, and 5 years so the investment decision is feasible, the income and profit when Ardjuna Sakti FSO was at the dock 1.6-1.7 are respectively

Rp2.834.292.880 and Rp2.125.719.660 while the income and profit when the FSO was at the dock 4.5-4.6 are respectively Rp9.015.993.344 and Rp 6.761.995.008.

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