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Shipping Income Tariff Model Using System Dynamics Method

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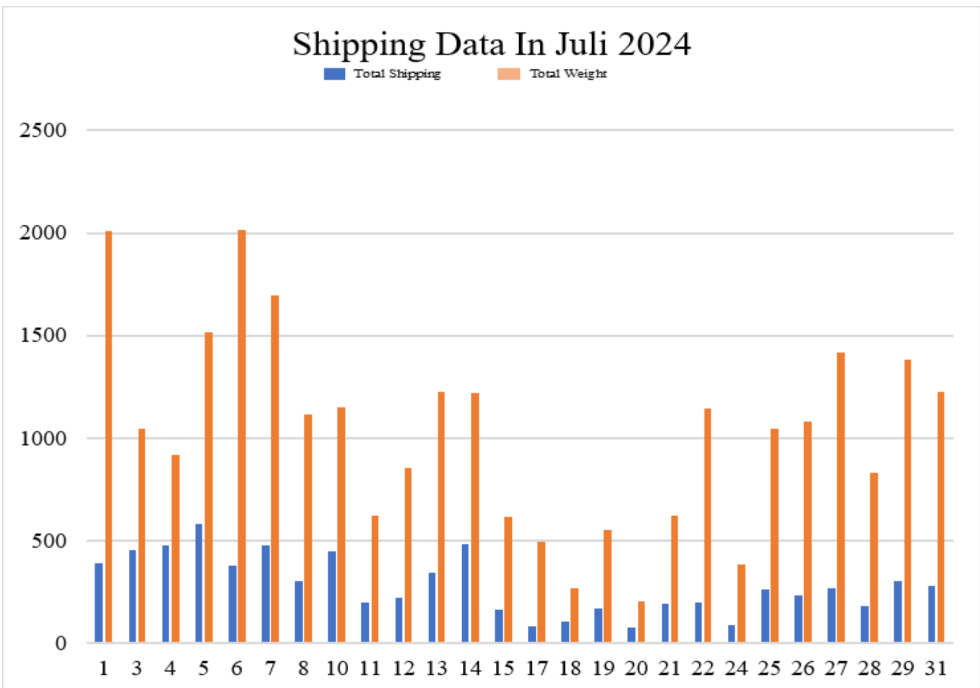
ABSTRACT: The Bandung City Hub Branch expedition service company is currently facing a decrease in the number of shipments and weight of goods sent for the Jakarta - Bandung shipping route, which automatically affects the income received. This decline phenomenon can undoubtedly impact the company's financial condition and profitability. This study aims to create and simulate tariff scenarios with a system dynamics model. The scenarios created are adjusted to existing conditions and scenarios based on consumer demand. The results of the existing scenario obtained an average amount of income in the ten iterations of the existing model output of Rp 293,789,065.095 with an average profit of Rp 77,397,734.026. In the scenario based on consumer demand, the average amount of income in the ten iterations of the first scenario model output was Rp 277,636,482.287, with an average profit of Rp 61,245,151.218. These results show that the existing model conditions are still better at providing income, so the company can still use them. This model allows companies to understand the interactions of various elements of the company's business because it models cause-and-effect relationships, and companies can analyze factors such as cash flow, costs, and revenues that influence each other and help companies make long-term decisions.

Keywords: Expedition Service, Income, Simulation tariff, Profit, System Dynamics

INTRODUCTION

The current era of globalization requires companies to rearrange their business strategies and business plans to be more competitive in order to compete. Business people are now beginning to realize that providing cheap, quality products that reach consumers quickly will give birth to a new concept: supply chain management. This SCM concept certainly requires coordination when transferring raw materials, semi-finished goods, and finished goods to all locations from upstream to all downstream locations to minimize costs. (Arffien, Afferdhy, Iman Sudirman, 2024), (N. K. Dewi et al., 2024) Expedition services are part of SCM that is greatly needed by the community, both for individuals (consumers) and the business world, such as organizations and companies. Untimely delivery will cause delays in delivery. This will, of course, affect consumer satisfaction with the results of the delivery. (Widowati et al., 2023), Expedition services are goods delivery services that offer solutions for sending goods from one location to another quickly and efficiently. This service covers various activities, from picking, packaging, and inventory to delivering goods to the final destination. This service operates through various modes of transportation, including land, sea, and air, and has a wide reach, including intercity and international shipping Boye Benedict Ayantoyinbo (2018). Expedition services are part of the urban logistics system that distributes goods in the city and aims to reduce congestion and environmental impacts caused by logistics and transportation activities. The urban logistics system has many stakeholders who take action to influence others and is a fairly complex system (Andruetto et al., 2024) According to (Dwi et al., 2023), a logistics service company is a party appointed by the owner of the goods to transport and provide logistics services such as warehousing, document preparation, customs, packaging, labeling, shipping and others. The expedition service company is a liaison between the two parties who make a transaction: the seller and the buyer. An expedition service company is a business entity highly dependent on various factors to maintain its performance and profitability. One of the key factors in this business is factors related to the volume of shipments, including the weight of the goods and the income earned (Pada et al., 2019)(Mulyati & Alif, 2014)). As a shipping company, the Company strives to maintain growth and profitability by planning and managing these aspects carefully. However, in July 2024. The Bandung City Branch Hub experienced a decrease in the number of shipments and the weight of goods sent for the Jakarta - Bandung shipping route which automatically affected the income received. The decrease in the number of shipments and the weight of goods sent needs to be a concern for the company, especially since it is known that the rates offered by the company are no different from its competitors, when compared to regular rates for shipping goods on the Jakarta - Bandung route. For regular shipping services, the shipping destinations provided by the company consist of 46 destinations, most of which are major cities in Indonesia. For shipping goods on the Jakarta - Bandung route with regular services, the price set is IDR 11,000.

Figure 1 Shipping Data In Juli 2024

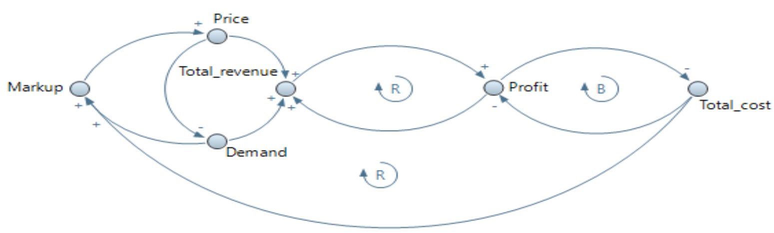


The phenomenon of a 15% - 20% decrease in net profit per month in 2024 could have an impact on the company's financial condition and profitability. Shipping rates in the logistics industry are an important component that includes shipping costs from one location to another. Tariffs are not only for the operational cost components of transportation, but other cost components such as handling costs and insurance. According to (Cahyadi et al., n.d.) Tariffs are the price level or costs paid by users of transportation services. The need to understand the tariff structure for companies is very important for companies in managing logistics expenses and ensuring efficiency in the company's operational costs Suliawati et al. (2021) The impact of tariffs on shipping on the company's profitability is that if there is an increase in shipping rates, there will be a significant impact on increasing product prices, shrinking profit margins and the stability of the company's supply chain. This study attempts to analyze the average income and profit of the company by evaluating the components of the company's expedition service tariffs and modeling them using a system dynamics model. This model is developed in a hybrid form to simulate the dynamics of the supply chain to increase the efficiency of the operational costs of the expedition service company through the analysis of factors that affect the company's income and profit (Ding et al., 2023). Through this approach, it is hoped that there will be a better understanding of the dynamics of the shipping service market and its ability to respond to consumer needs more effectively.

In the system dynamics model, to build a clear and accurate model, it is necessary to have an actual relationship in the Causal loop diagram; it is necessary to choose the relationship between the main activities of the system in order to obtain an effective model.(Gao et al., 2022) (Liu et al., 2023)).

The basic rate formation model can be seen below. The relationship contained in the company's operational system in generating profits for the company in general can be seen using the help of the Causal Loop Diagram (CLD) where the related variables affect each other.

Figure 2 Causal Loop Diagram Relationship Between Demand and Profit



Source: (Kar & Datta, 2024)

As can be seen in the image above, we can see the relationship between demand, profit and rates. There are three (4) loops that can explain the relationship between demand and price. (Kar & Datta, 2020)

System dynamics models have significant advantages that stem from the ability to visualize and measure complex and dynamic systems by capturing the causal relationships between variables, risk factors, and their consequential behavior., (Ghadge et al., 2022). Some examples of research in the manufacturing industry explain that agricultural machinery manufacturing companies use system dynamics models to implement three procurement strategies based on line-side inventory supply, third-party logistics supply, and dynamic continuous supply. (He & Xiong, 2023). In the study, (Yu et al., 2022) provides an interpretation of the implications of the model results for future energy and climate policies in Taiwan. System dynamics is also adopted by (Laimon et al., 2020) to analyze the behavior of the energy sector in Australia. The above research illustrates that the system dynamics model is a tool used to understand the interaction of each part in the system. (N. K. Dewi et al., 2017), good for economic, social, and technical systems. This model has many advantages that make it very good for use in planning and decision making. (N. Dewi et al., 2015)

METHOD

The problem of declining revenue faced by the company, due to reduced frequency of deliveries by consumers, is also experienced by several other shipping companies that have the same regular rates. Several previous studies have solved this problem by recalculating using the (N. K. Dewi et al., 2022). Vehicle Operational Cost method (2021). Fluctuations in transportation rates are often a problem, highly dependent on the factors that form demand and supply. (Ervil & Rahman, 2020). Several previous studies have calculated in advance to find the variables that form the shipping service rate using the (Aulawi et al., n.d.). Hierarchy Process Analysis (AHP) method. Solving the problem of transportation service rates using the vehicle operating cost method. In forming the tariff, using cost-benefit analysis, which considers the value of the benefits or costs offered, the comparison of investment costs for benefits to environmental changes that occur. (Scotia et al., 2024). The approach uses the Willingness To Pay (WTP) and Ability to Pay (ATP) methods. (Alfariz et al., n.d.)(N. K. Dewi et al., 2022). The full costing method is used to form the expedition service tariff; this method aims to determine the costs incurred while calculating the desired profit. Modeling in transportation requires creating a unified model framework consisting of interacting sub-models (Guo et al., 2023). This previous study did not consider the behavior of each variable or component that forms it with this system dynamics approach. It is most effective in finding acceptable results to evaluate or validate it using statistical visualization to better understand the process when creating the model. (Khakifirooz et al., 2024) a system dynamics model in this study because it has dynamic and complex problems and contains components or variables with complicated and complex causal relationships produced in various feedback loops (Laimon et al., 2020). System dynamics explores the dynamic characteristics of the transportation tariff system and considers the factors that influence the operation of the transportation service (An et al., 2021). This dynamic system model is used to create a model that has a dynamic relationship to each influential variable. This simulation is used to identify how the variables that form the system model affect business performance and revenue receipts at the Bandung City Branch Hub Company on the Jakarta - Bandung route.

The research stage through the collection process is needed to support the creation of a dynamic simulation model. The data is divided into two (2) types, namely primary data and secondary data. Primary data was obtained from direct observations of research objects and direct and indirect interviews with staff at the Bandung Branch Hub company. Primary data is in the form of a tariff list for Regular Services, the number of vehicles, and several operational costs required such as vehicle prices, insurance costs, fuel costs, tire prices, oil prices, vehicle service costs, and vehicle crew salaries. At the same time, secondary data is obtained indirectly as support in the preparation of this study. This data can be obtained through a literature review by obtaining theories that can support research, historical data that the company usually provides, and data from reports provided by Bank Indonesia and BPS.

In making a dynamic system simulation model, several stages need to be carried out, starting from identifying the affected factors, making a rich picture diagram, making a causal loop diagram, making a stock-flow diagram, model verification process, model simulation process using Analogic software, result validation process, and scenario and policy design. When discussing the dynamic system model, one must consider the definition of a system. A system is defined as a collection of parts that operate together to achieve a goal. A system can include many people or physical objects (Bala et al., n.d.). Meanwhile, according to (Daellenbach and Mcnickle, n.d.), a system is a collection of things, entities, or people that are related to each other in a certain way, namely that they have been arranged and follow certain interaction rules. Collectively, a system has a specific purpose, such as having a goal to achieve or producing results that no part of it can do alone. A system can also be defined as a collection of components (elements or elements) that are interrelated so that they can influence (according to their respective functions) to produce an output.(Elyasi & Teimoury, 2023)

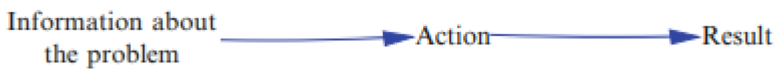
According to Senge (1996) in (Putri et al., n.d.), system thinking is a form of looking deeply enough at a problem and finding how to solve the problem from the right root cause so that a solution is obtained to overcome it. According to System thinking, systems thinking tries to solve problems by viewing a problem not as a single incident that occurs partially but as a whole as part of a system structure that is interconnected with each other. According to (Rahmasari et al., 2024), the purpose of systems thinking is to gain an understanding of the lever variables and understand the impact of alternative solutions. The system dynamics method created by Professor Jay W Forrester combines scientific theory and computer simulation; this method has been widely used to analyze the relationship between feedback structures, functions, and dynamic behavior of complex systems in various fields, including manufacturing, project management, supply chain management, inventory management, corporate strategy and others (Fuhao & Qiuhong, 2023). The system dynamics model is a model that understands the non-linear behavior of complex systems over time by modeling their feedback loops that apply to various complex social, managerial, economic, ecological, and supply chain distribution problems. Each model consists of stocks (rectangular shapes), variables (circular shapes), and connectors (arrow shapes) (Kazantsev et al., 2023). There are six important steps in building a system dynamics model. Starting from the identification and definition of the problem, followed by the conceptualization of a model, model formulation, model testing and evaluation, model use, implementation and dissemination, and learning/strategy/infrastructure design.

System dynamics itself is a methodology based on input systems brought from control theory, and it can easily overcome non-linearity time delays and complex multi-loop structures in system dynamics. According to (Rauf & Umer, 2024), the system dynamics model is a microsimulation model that connects several input variables that will change over time but are correlated through a causal loop diagram that will produce output decisions as needed.

A system is a collection of parts that work together to achieve a goal. The system can include many people or physical objects (Bala et al., n.d.). Meanwhile, according to (Nurlaela Kumala Dewi, Pradono, Miming Miharja, 2018), a system is a collection of objects, entities, or people that are interrelated with each other in a certain way, namely that they have been arranged and follow certain rules of interaction. Collectively, the system has a specific purpose, such as having a goal to be achieved or producing results that cannot be done by any part alone. The system can also be interpreted as a collection of interrelated components (elements or elements) so that they can influence each other (according to their respective functions) with a certain sequence/procedure in achieving a goal or producing an output.

A system can be classified into an open system and a feedback system. In an open system, the output responds to the input, but the output does not affect the input. And the input does not understand its performance. In an open system, past activities do not affect future activities. For example, a watch does not understand its inaccuracy and cannot correct itself. In an open system, problems will be perceived, and actions will be taken, but those actions do not affect the results (Bala et al., n.d.).

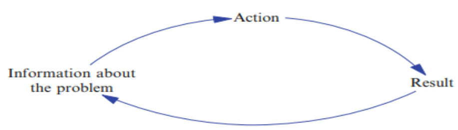
Figure 2 Open System Concept



Source: (Bala et al., n.d.)

Feedback systems can be called closed-loop systems, and inputs can change based on output results. Feedback systems have a closed-loop structure that gives back the results of past actions to control future actions. In a closed-loop system, a problem is received, and then an action is taken, and the results will influence further actions. Thus, what distinguishes a closed-loop system is the feedback path of information, decisions, and actions that connects output results to inputs. Feedback systems can be classified as positive feedback systems or negative feedback systems. Positive feedback systems result in growth, and negative feedback systems are goal-seeking.

Figure 3 Closed Loop System Concept



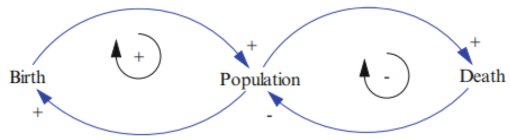
Source: (Bala et al., n.d.)

The feedback loop structure of a system simulates dynamic behavior, and all dynamics arise from the interaction between two types of feedback loops:

1. Positive feedback loop (reinforcing loop)

   Positive feedback loops produce growth, namely self-reinforcing and causal loops. Figure 2.3 below shows births, population, and deaths. Where the loops on births and populations are positive feedback loops, and this increases the population level if there is an increase in the birth rate. So, the positive feedback loop phenomenon can be identified if there is a condition where there is a change (small or large) that continues to affect an existing system, and this results in changes that have the same direction or value (+), this type of feedback produces growth or reinforcing or self-strengthening.

Figure 4 Causal Loop



Source: (Bala et al., n.d.)

2. Negative feedback loop (balancing loop)

The negative feedback loop in the image above can be seen in the population and mortality, where the population is goal-seeking. The larger the population, the more deaths will occur, and each death will reduce the existing population. The negative feedback loop is the opposite of the positive feedback loop; this feedback can appear if there is a condition where a change in one (1) variable in the system can cause a continuous change so that it ultimately reduces or decreases a value or quantity in the same direction or value until the goal of the system model can be achieved. Therefore, a negative feedback loop can be used as a balancer for the positive feedback loop.

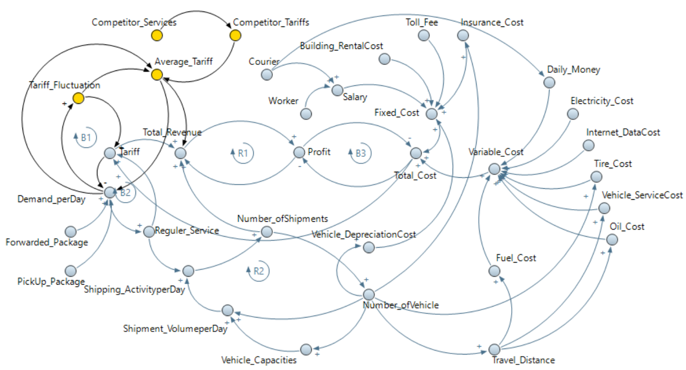
System thinking tries to solve problems by viewing them not as a single incident that occurs partially but as a whole as part of an interconnected system structure. According to (Putri et al., n.d.), the purpose of system thinking is to gain an understanding of the lever variables and the impact of alternative solutions.

Six important steps are involved in building a system dynamics model: identification and definition of the problem, conceptualization of a model, formulation, testing and evaluation, use, implementation and dissemination, and learning/strategy/infrastructure design.

RESULT AND DISCUSSION

Stock Flow Diagram (SFD) is generally a "translation," "continuation," or one form of "implementation" of the Causal Loop Diagram (CLD), which is already quantitative and in the form of a simulation model.

Figure 5 *Causal Loop Diagram Scenario Model*



The yellow variables show the addition of scenarios based on the image above. The variables added include Tariff Fluctuation, Competitor Services, Competitor Tariffs, and Average Tariffs. The first scenario shows the addition of the Tariff Fluctuation variable only, while the second scenario adds three (3) variables, namely Competitor Services, Competitor Tariffs, and Average Tariffs.

Analysis of Variables Forming the Dynamic System Model of Goods Delivery at the Bandung City Branch Hub

The Causal Loop Diagram in the image above shows the causal relationship between various variables. The causal relationship between these variables forms a dynamic system model for the operational model of goods delivery at the Bandung City Branch Hub. The model includes the goods delivery section, company revenue and profit, and operational costs. The variables in the goods delivery section shown in the Causal Loop Diagram in the image include the number of vehicles, number of deliveries, vehicle capacity, total vehicle capacity per day, deliveries per day, regular services, pickup packages, forwarding packages, service requests per day, markup, and rates. Meanwhile, the variables for the company's operational costs are divided into two variables, namely variable costs and fixed costs which are then influenced by other variables such as distance traveled, fuel costs, vehicle depreciation costs, oil costs, vehicle service costs, tire costs, quota costs, electricity costs, labor, salaries and wages, building rental costs, toll costs, insurance costs, and daily money as well as the variables of total income, profit, and total costs.

Analysis of Existing Model and Scenario Model on Goods Delivery at Branch Hub in Bandung City. The simulation of the dynamic system of the problem at Branch Hub in Bandung City uses the Stock Flow Diagram (SFD) model using Any Logic software. There are two (2) results or outputs, including:

1. Existing Scenario Model

Based on the data processing in the previous chapter, the Stock Flow Diagram (SFD) in the existing model has been validated to represent the real-world system behavior of Branch Hub in Bandung City. The output results of the first iteration of the existing model simulation can be seen in the image below.

The output results of the first iteration of the existing model simulation in the image show that the existing sub-model has four (4) outputs/results/outputs, consisting of the number of shipments, the amount of costs, and the amount of income and profit. The output result for the number of shipments is 26,573.58 kg.

In shipping goods, operational costs are needed to support the company's activities at the expedition company, especially in the cost structure of Branch Hub in Bandung City which is divided into two (2) fixed costs and variable costs. Fixed costs consist of toll fees, salaries and wages, insurance, vehicle depreciation, and building rental costs. While variable costs consist of electricity costs, quotas, vehicle services, tires, oil, daily allowances, and vehicle fuel. The results of the accumulated costs incurred by the Bandung City Branch Hub based on the simulation results for 26 working days are Rp. 213,893,927,069. The income/revenue received by the Bandung City Branch Hub is obtained based on the accumulation of goods deliveries (in kg) per day for 26 working days multiplied by the regular rate offered by the company to consumers, which is Rp. 11,000 per kg, so that the company's income from the delivery of 26,704 kg of goods is Rp. 213,894,128. Profit is the remaining income obtained by a company after being reduced by all existing operational costs, in the existing model, profit is calculated by finding the difference between accumulated income and the company's operational costs. So the company's profit based on the simulation results of the existing model output for 26 days is Rp 78,415,427,496. The table below compares historical data with ten iterations of the existing model output.

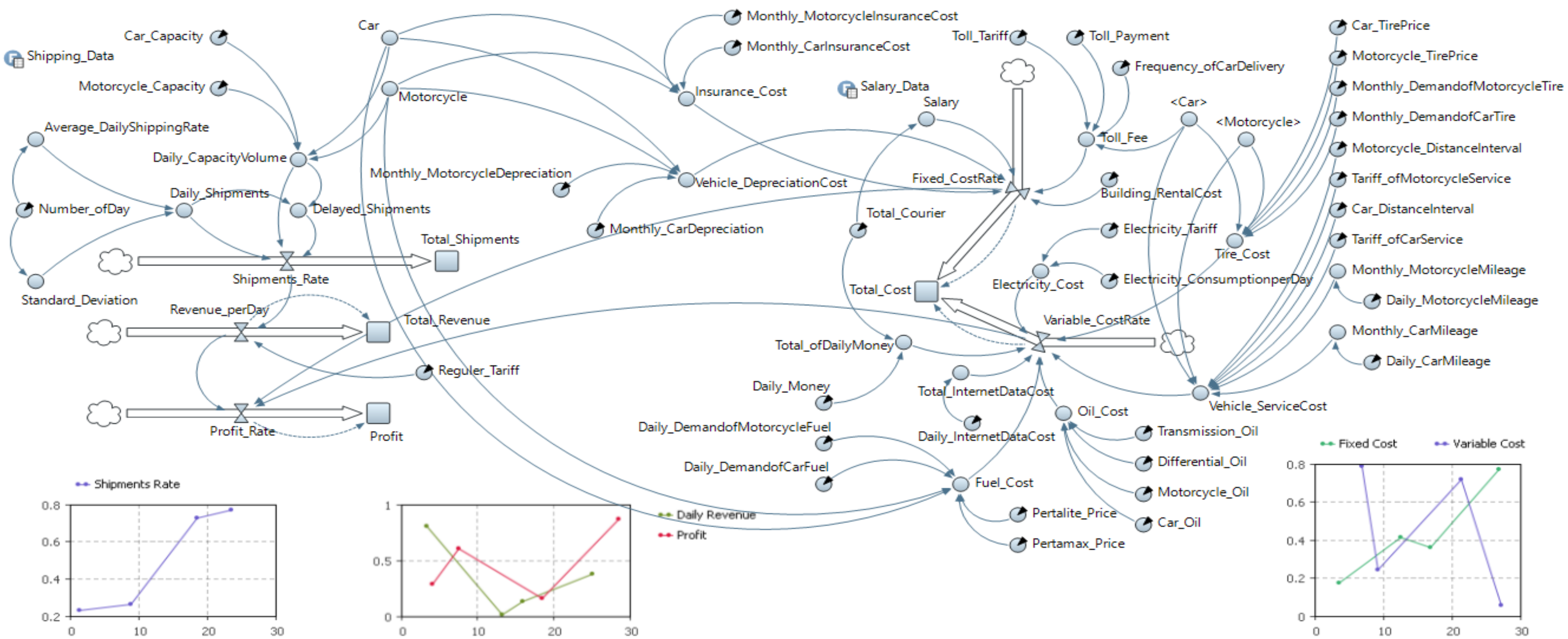
Table 1 Comparison of Historical Data with 10 Iterations of the Existing Model Output

Comparison of Existing Models		Total Income (Rp)	Profit (Rp)
Historical Data		293.414.000,000	77.022.668,931
Iteration	1	294.619.364,262	78.228.033,193
	2	294.007.327,955	77.615.996,886
	3	293.109.431,398	76.718.100,329
	4	294.288.577,705	77.897.246,636
	5	292.959.925,808	76.568.594,739
	6	293.900.267,216	77.508.936,147
	7	294.190.331,721	77.799.000,652
	8	293.226.675,758	76.835.344,689
	9	295.292.527,431	78.901.196,362
	10	292.296.221,700	75.904.890,631
Average		293.789.065,095	77.397.734,026

Based on table 1 above, it is known that the average amount of income in the ten iterations of the existing model output is IDR 293,789,065.095 with an average profit of IDR 77,397,734.026.

Stock Flow Diagram (SFD) is generally a "translation", "translation", "continuation", or one form of "implementation" of Causal Loop Diagram (CLD) which is already quantitative and in the form of a simulation model written in a specific software application package format (Prahasta, 2018). The image below shows the Stock Flow Diagram (SFD) using Any Logic software on the existing model at Branch Hub Bandung City which has been developed from the existing Causal Loop Diagram (CLD) model

Figure 7 ***Stock Flow Diagram Model Existing***



2. Model Scenario 1

The first scenario, as explained in the data processing section, is a condition where if the demand for goods delivery services is at its peak, the rates applied will be high. If the demand for goods delivery services is at its lowest, the rates offered to consumers will also be lowered so that they can look attractive in the eyes of consumers. The results of the first iteration simulation output on the application of scenario 1.

The profit obtained by the company after applying the first scenario showed a decrease compared to the output of the existing model of the first iteration. The decrease was IDR 16,539,391.56, or 21.14%, compared to the results of the output of the existing model simulation of the first iteration. For more details, see Figure 1 below, a graph comparing the profit from the existing model output with the output from the first scenario model.

Based on the figure above, it can be seen that the profit generated in the first scenario model (first iteration) is IDR 61,688,641.633, which produces lower output when compared to the existing model. Therefore, the application of the first scenario with dynamic rates that depend on fluctuations in service demand produces negative output for the company.

The table below compares historical data with the ten iterations of the first scenario model output.

Table 2. Comparison of Historical Data with 10 Iterations of Scenario 1 Model Output

Comparison of Scenario 1		Total Income (Rp)	Profit (Rp)
Data Histories		293.414.000,000	77.022.668,931
Iterations	1	278.079.972,702	61.688.641,633
	2	277.569.117,638	61.177.786,569
	3	277.111.533,253	60.720.202,184
	4	277.617.620,893	61.226.289,824
	5	276.707.523,145	60.316.192,076
	6	276.616.687,817	60.225.356,748
	7	277.315.454,129	60.924.123,060
	8	279.010.391,400	62.619.060,331
	9	276.966.092,410	60.574.761,341
	10	279.370.429,482	62.979.098,413
Average		277.636.482,287	61.245.151,218

Based on the table above, it is known that the average amount of income in the ten iterations of the first scenario model output is IDR 277,636,482.287 with an average profit of IDR 61,245,151.218.

CONCLUSION

The variables forming the dynamic system model of goods delivery in increasing revenue at the Bandung City Branch Hub for the Jakarta - Bandung route are found in the Causal Loop Diagram of the existing model, namely the demand for goods delivery per day, regular service rates, vehicles and their delivery capacity, and company operational costs consisting of fixed costs (salaries and wages, building rental costs, toll fees, insurance costs, and vehicle depreciation costs) and variable costs (daily money, electricity costs, quota costs, tire costs, vehicle service costs, oil costs, and fuel costs). Based on the CLD, it can be seen that the components of vehicle operational costs consist of costs used in operating the vehicle, these cost components do not include salaries for non-courier workers, building rental costs, electricity costs, quota costs.

The dynamic system model of the Bandung City Branch Hub begins with a request for goods delivery services in Jakarta and Bandung which are then sent to consumers. For the simulation results for 26 working days at the company that have been carried out based on the first iteration, the amount of revenue obtained is IDR 293,789,065,095 and the company's operational costs are IDR 213,893,927,069 while the company's profit is IDR 79,895,138 in the existing model.

Further research can propose new scenarios such as the use of shipping rate data for the Jakarta - Bandung route offered by competitors and then looking for the average value which is then used as the rate offered by the company. The advantage of using a system dynamics model is in the context of strategic planning with several advantages in using this model, such as understanding complex interactions, visualizing long-term impacts, being able to manage risks better, making investment decision simulations, being able to manage complexity, and increasing the quality of decisions because this model provides accurate information.

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