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Cost Optimization for Logistics Services: A Simulation Approach to Delivery Alternatives

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ABSTRACT

An essential activity in the delivery of goods by logistics service companies is how to deliver goods to consumers according to the agreed time with minimal costs. A case study was conducted on one of the logistics service companies in Bandung, which has an exciting feature: promising goods to consumers within 24 hours. The interesting thing about this company is that it uses the rest of the luggage of travelers traveling to the destination city by plane. In existing conditions, problems often arise, namely, goods do not reach customers according to the agreed time. This causes losses to the company because it must pay a late penalty. Therefore, the author designed several alternatives to meet freight forwarding in less than 24 hours. This study aims to optimize the cost of shipping goods from various alternatives by considering the delivery time of less than 24 hours. This study uses an experimental method with a system model to conduct simulations. Parameters use primary data from the company and secondary data from websites. The author designed two alternatives to shipping goods if no match was found with the traveler. The first alternative is to use air cargo at Bandung Airport. The second alternative is that if it is predicted that the goods will not reach the customer within 24 hours through Bandung Airport, they will be sent to Soekarno Hatta Airport Jakarta using a truck. A match with the traveler at the airport will be sought. The second alternative is also considered if there is no match with the traveler, then the delivery of goods uses air cargo. The simulation results provide a total cost for alternatives 1 and 2 of IDR 69,779,084.40/month and IDR 107,025,296, respectively, for goods that do not meet the delivery of less than 24 hours for alternative 1, namely nine items/month or 1% of the total shipment and alternative 2, namely 19 goods or 2% of the total delivery. The simulation in this study resulted in choosing the first alternative as the best alternative with the lowest cost.

1. Introduction

Starting during the 2019 Covid pandemic, people's shopping behavior, especially in Indonesia, has shifted from initially meeting physically in person to online shopping behavior (Harahap & Amanah, 2018). This shopping behavior increases online business and e-commerce in Indonesia. Based on data from Bank Indonesia released on the BI website portal, it is informed that e-commerce transactions will increase in 2023 by 4.99% or equivalent to IDR 42.2 trillion in October 2023. In terms of volume, transactions increased by 32.04% annualy. The increase in the volume of shopping transactions through e-commerce affects in the development of freight forwarding services. Logistics service companies are trying to develop both in terms of the type of service and improving the quality of service that is useful to support the delivery of goods from sellers to consumers.

The flow of shipping goods using travelers' services begins with customers accessing the Company's application and providing information about the goods to be sent. The Traveler also accesses the Company's application, registers the flight schedule and sees if there are any items to be delivered according to the available baggage. Travelers should consider the size of the baggage and the size of the items to be sent. Company X provides convenience to travelers, namely, it does not have to pick up and check in the goods to be sent because the company carries out this activity. In addition, travelers will also receive incentives in the form of coupons, cash, or promos from Company X. After data from customers and travelers are inputted, then the feeder will take orders from customers. Then, the goods are given to the travelers with the same purpose of goods. The travelers carry goods and travel to the destination. After arriving at the destination, the travelers hand over the goods to the feeder in the destination city; after the goods are given, the travelers get a reward. Feeders in the destination city carry goods received from travelers and deliver them to the recipient.

The day-to-day service feature is a mainstay feature of Company X that guarantees that the goods will arrive in less than 24 hours. However, the system used by the Company creates a problem, namely the possibility of goods not reaching their destination in less than 24 hours. This happened due to limited flight schedules from Husein Sastranegara Airport (Bandung) to the destination areas. Some areas have only one flight from Bandung. Based on data from the company, delivery delays exceed 24 hours by 15% every month. As a result, the Company must incur late fees of more than 65 million every month. Companies must be able to determine the best alternative delivery of goods so that effective delivery operations are obtained and fulfill promises to consumers, namely goods arrive within 24 hours. Research on the delivery of goods with the same day service feature has been widely carried out, such as the delivery of goods using the six-sigma method research (Chen et al., 2023; Kumar Phanden et al., 2022), the delivery of same day service goods with varied locations, and the causes of same day service delivery to the environment (Banerjee et al., 2023).

In existing conditions, deliveries using travelers at Bandung Airport often experience delays. The result of the delay is a loss to the company because it has to pay a penalty. Therefore, this study provides two alternative schemes for shipping goods so that goods can arrive according to the agreed time. The first alternative is if no match is found between the goods and the traveler, then the delivery of goods uses air cargo (Boysen et al., 2023; Horng & Lin, 2024; Kumar Kushwaha et al., 2024; Zheng et al., 2023). The second alternative is to collect goods that will be delivered within a certain period and brought to Jakarta to be sent through Soekarno Hatta International Airport. This is done because the airport provides many flight options and is more flexible. The alternatives are tested, and the best is determined. The objective function of this study is to minimize the total shipping cost for each alternative. The decision variables in the first alternative are cargo costs, traveler costs, feeder fees, and delay costs. The decision variables in the second alternative are the cost of trucks to Jakarta, cargo costs, traveler fees, feeder fees, and late penalty fees. Data obtained from the company or the website is used as a parameter for optimization. The most minimal total cost is selected from these two alternatives.

The contribution of this research is to design an alternative delivery of goods that can operate efficiently and fulfill the promise that goods will arrive within 24 hours by considering the dynamics of the time of demand from customers, the dynamics of the destination city of the demand, and the number of flights. The study was carried out using the simulation method to study the system. Simulation methods have often been used, such as scenarios on transportation problems with different social factors (N. Li et al., 2024; Zhou et al., 2024). Simulation methods have been used often, such as simulation scenarios on transportation problems with different social factors (Zhang et al., 2019). Transportation simulations on large-scale urban traffic can use this method (Osorio & Selvam, 2015; Straub et al., 2023) and transportation allocation (Girardet & Spinler, 2013; Levashev et al., 2022). This research is limited to Company X only by not considering the way the information system works, the type of vehicle used by the traveler is only an airplane, the delivery of goods by customers comes from Bandung, and the alternative delivery to Jakarta only uses trucks. This study assumes that it is an alternative delivery, and the model does not consider fluctuations in fuel costs or overtime costs.

2. Methods

Solving problems in this study uses experimental methods with system models. Experiments with real models cannot be used because they will interfere with PT X's operational activities; besides that, this method requires considerable costs and a long time. Therefore, this study uses an experimental model with a system model. Model experiments using system models are carried out using mathematical models. A mathematical model was chosen because the cost is cheap and can be done relatively quickly. Mathematical models are also easier to use when changing and manipulating the model to see how the model reacts. Mathematical models have two approaches to determining system solutions: analytical and numerical. In this study, numerical solutions are used because real systems are complex enough to make it quite difficult to determine the mathematical relationships of the system and evaluate the model analytically. Numerical models are used because the system is quite complex. Numerical solutions are obtained using simulations. Simulation has several advantages, namely, providing a way to see if the resulting decision is the best. However, simulation can also avoid trial and error in traditional expensive methods, which take a long time and interfere with real systems. The advantage of this simulation lies in the availability of formal and predictive analysis methods and being able to predict the system accurately (Shehadeh et al., 2021). There are dynamics such as customer request time, delivery destination city, and aircraft flight schedule (Benamou et al., 2014; Y. Li et al., 2022; Qu & Zhou, 2017; Zang et al., 2022). This study was carried out with several stages that were arranged systematically and structured.

This study was carried out in several stages, arranged systematically and structured. The research begins with a preliminary study that aims to discover the object of research to be researched and understand the problem under actual conditions. A formulation of the problem to be answered, research objectives, assumptions and limitations are prepared. The next stage is to conduct a literature study to understand theories related to simulation concepts and applications, then understand the system that functions to understand the research object clearly, especially in business processes. The problem element is displayed in Table 1 to help understand the problem. In this study, there are four stakeholders defined in this system, namely the system owner (who has the problem), the user system (who uses the solution), the consumer system (who is affected by the solution implementation), and the system analyst (who analyzes and finds the solution).

Table 1. Stakeholder System in logistics service companies

Stakeholder	Party
Problem Owner	Director of logistic company
Problem user	Operational Manager
Problem customer	Traveler and customer
Problem analyst	Author

After understanding the method and system, the next step is to collect and process the data used in the simulation. Then, a model was designed with several alternatives, and the model was validated and verified. Models that have been verified and validated are simulated using previously collected data, and then the simulation results are analyzed and compared to obtain the best solution. The final stage of the study is the drawing of conclusions. The conclusion is expected to answer the purpose of the research

3. Results and Discussion

This results in a possible delivery delay of more than 24 hours. The second is the feeder starts the journey from the head office and returns to the head office if it wants to pick up a new order. On each trip, feeders and travelers can only carry one order. The headquarters of the destination city are at their respective airports. The third is company cars and third-party cars for rent can fit 80 items. The fourth is that the number of feeders in each city is the same, every ten people, while the number of admins at each airport is 1 person, assuming they can handle goods and check-in.

3.1. Data processing

Data collection is obtained from historical data of companies and the internet. The data obtained is used as input in the simulation model. Before data is used as input, it is first processed to determine the data distribution. Data processing using software and testing data distribution with Kolmogorov-Smirnov Test. If the p-value is less than the significance level α=0.05 then the hypothesis is rejected, and the data cannot be used as simulated input. The parameters in the simulation are the time between the arrival of the order, the duration of the airplane flight, airport admin fees, feeder wages, feeder incentives, air cargo costs, delivery time by air cargo, shipping costs to Jakarta, the time needed for delivery to Jakarta, the time of handling goods, the check-in time of goods, the time it takes for the feeder to deliver to the airport, the time it takes the feeder to deliver to the consignee, time it takes feeder Back to the center (Akinyemi, 2023; Li et al., 2022).

This stage begins by describing the system that explains the existing business processes in the object of research, namely Company X. In the introduction, it is known that Company X has a problem. Some goods cannot be delivered within 24 hours. There are four assumptions used in the simulation model. The first study used four destination cities: Padang, Solo, Makassar, and Balikpapan. These four cities were chosen because based on Traveloka data in 2022 there is 1 flight from Bandung. This results in a possible delivery delay of more than 24 hours. The second is that feeder starts the journey from the head office and returns to the head office if it wants to pick up a new order. On each trip, feeders and travelers can only carry one order. The headquarters of the destination city are at their respective airports. The third is company cars and third-party cars for rent can fit 80 items. The fourth is that the number of feeders in each city is the same, every 10 people, while the number of admins at each airport is 1 person, assuming they can handle goods and check-in.

The resolution of this problem begins by describing the elements of the problem: the decision maker is the management of Company X, the goal is to design and choose the best alternative delivery of goods that can streamline operational costs and meet customer satisfaction guarantees, decision criteria are minimizing operational costs, alternative policies (air cargo used, number of vehicles needed and alternative delivery methods).

3.1.1. The time between order arrival (A)

Based on the company's historical data regarding order arrivals, the data distribution will be tested with the help of ARENA software. Using the Input Analyzer feature, the time distribution between order arrivals is obtained beta (β) value is 1.16 and alpha (α) is 1.21. The time between arrivals in the simulation model can be found with the formula.

$$A = 30.5 + 17 \times BETA(1.16, 1.21) \quad (1)$$

in minutes/orders.

Data distribution testing uses the following hypotheses:

H_0: the data follows the beta distribution

H_1: the data does not follow the beta distribution

Using the Chi-Square Goodness of fit test and obtained p-value of 0.397, the p value is greater than the alpha value ($\alpha = 0.05$). This means that there is not enough evidence to refute H_o, so the distribution of data corresponds to the distribution of Beta. Time data between arrivals can be used as input on simulation models.

3.1.2. Flight duration of the aircraft (t_{ij})

In this study, the destination area for shipping goods is limited to Padang, Makassar, Balikpapan and Solo. The percentage is assumed to be balanced i.e. each city is 25%. To determine the duration of the flight, this study used information from the Traveloka.com website. The number of flights from Bandung or Jakarta to the destination can be seen in Table 2.

Table 2. Number of flights in 2022 (source Traveloka.com)

Origin Flights	Purpose	Number of flights/days
Bandung	Field	1
	Makassar	1
	Balikpapan	1
	Solo	1
Jakarta	Field	11
	Padang (transit)	2
	Makassar	19
	Balikpapan	15
	Solo	3
	Solo (transit)	8

In this study, it is assumed that the duration of flights from Bandung is uniformly distributed with a time span according to information from Traveloka.com. Flights from Jakarta are also assumed to be uniformly distributed. This study also assumes that there is no flight delay so that the flight duration can be used. The density function of a continuous random variable at interval intervals $[a, b]$ is as follows:

$$f(x; a, b) = \{\frac{1}{b-a} \quad for \;\; a \leq x \leq b \; 0 \quad for \; others$$

where is the minimum value and b is the maximum value. Flight duration used in the simulation using Table 3.

Table 3. Flight Duration from the point of origin to another region

Origin Flights	Purpose	Flight Duration
Bandung	Field	Uniform (109, 121)
	Makassar	Uniform (181, 200)
	Balikpapan	Uniform (171, 189)
	Solo	Uniform (67, 74)
Jakarta	Field	Uniform (100, 110)
	Makassar	Uniform (190, 235)
	Balikpapan	Uniform (180, 195)
	Solo	Uniform (70, 90)

3.1.3. Airport admin fee (b_a)

The admin fee paid by the Company to officers at the airport using data from the Government Regulation on the minimum wage can be seen in Table 4. The task of the admin at the airport is to take care of the goods to be sent and the goods that arrive and check-in the goods to be sent.

Table 4. City minimum wage

City	UMK/month
Bandung	IDR 4,048,462
Jakarta	IDR 4,901,798
Field	IDR 2,811,489
Makassar	IDR 3,643,321
Balikpapan	IDR 3,324,273
Solo	IDR 2,174,169

3.1.4. Feeder (b_f) and traveler (b_r) fees

Feeders in this study are people who pick up and deliver goods both from customers to travelers and from travelers at the airport to the recipient of goods. Feeder is a driver on online motorcycle taxis that cooperates with the company. It is assumed that the feeder's wages are normally distributed with a fee paid IDR 15,000 to IDR 25,000 for each delivery of goods. The equation used in the simulation for feeder costs following the normal distribution is as follows.

$$b_f = uniform(15000, 25000) \tag{2}$$

in IDR/shipping units. In this study, it is assumed that the number of feeders is 10 people for all cities except Jakarta.

In addition to feeders, there are also travelers' fees, which are costs incurred by the Company to pay travelers who carry goods in the remaining aircraft baggage. Based on the Company's data, travelers are given incentives of IDR 25,000 to IDR 35,000 for each delivery. The distribution of traveler's costs in this study is assumed to be normally distributed with a lower limit of 25000 and an upper limit of 35000. The equation used in the simulation is as follows (in IDR / shipment)

$$b_r = uniform(25000, 35000) \tag{3}$$

The company's data also shows that the percentage of match and failure of goods with travelers is 75%: 25%.

3.1.5. Cost and time of air cargo delivery$(b_k)(t_k)$

Air cargo costs are used in first alternative, this fee is incurred if the goods are not found to match the travelers and do not meet the delivery within 24 hours. The cost of cargo used is the cost of Lion cargo with port-to-port service. This service of receiving goods presents faster, cheaper, and safer delivery. The calculation of shipping goods is at least 10 kg, meaning that if the item is under 10kg it will be rounded to 10 kg. This study assumes that the goods sent each time the shipment is 10 kg. Data on shipping rates from Soekarno Hatta Airport can be seen in Table 5. This rate applies to 10 kg of goods per shipment. Cargo shipping rates from Husein Sastranegara Airport (Bandung) are not found, therefore it is assumed to be more expensive IDR 5,000 than Jakarta shipping.

Table 5. Shipping rates with air cargo

Point of Origin	Point of Destination	Tariff/ Delivery
Jakarta	Field	IDR 10,500
	Makassar	IDR 16,500
	Balikpapan	IDR 16,850
	Solo	IDR 8,750
Bandung	Field	IDR 15,500
	Makassar	IDR 21,500
	Balikpapan	IDR 21,850
	Solo	IDR 13,750

The delivery time using air cargo is assumed to be normally distributed with a delivery time of no earlier than 240 minutes and no later than 1200 minutes. The uniform distribution equation used is as follows.

$$t_k = uniform(240, 1200) \tag{4}$$

in minutes/delivery.

3.1.6. Cost $(\boldsymbol{b_J})$ and delivery time $(\boldsymbol{t_J})$ to Jakarta

Shipping costs to Jakarta are costs needed to send goods that do not meet the 24-hour time or are not found to match the travelers in Bandung so they must be delivered to Soekarno Hatta International Airport. If needed, goods are delivered to Jakarta using one company truck and several third-party trucks. This fee is used on the second alternative. Delivery of goods using the Company's car (b_1) requires a rate of IDR 500,000 per shipment. These fees include driver salaries, tolls per trip and petrol costs. The cost of shipping goods by rental car.(b_2) is Rp.800,000. This fee includes car charter fees, driver fees, tolls, and fuel per trip.

The delivery time of goods to Jakarta takes 180 minutes to 300 minutes. The delivery time is assumed to be normally distributed with a lower limit of 180 and an upper limit of 300. The equation for delivery time to Jakarta is as follows.

$$t_J = uniform(180, 300) \tag{5}$$

in minutes/trip.

3.1.7. Goods handling time $(\boldsymbol{t_u})$ and check-in time at the airport$(\boldsymbol{t_c})$

Goods handling time is the time needed by the Company's admin at the airport when the goods will be delivered or when the goods arrive at the destination city. Based on existing data, the time needed by the admin in handling goods is around 10-15 minutes. The processing time of goods in this study is assumed to be normally distributed with a lower limit of 10 minutes and an upper limit of 15 minutes. The equation for goods management time in the simulation model is as follows.

$$t_u = uniform(10, 15) \tag{6}$$

in minutes/trip. Check-in times at airports are also calculated and assumed to be normally distributed. The upper limit and lower limit of check-in time are 10 minutes and 15 minutes respectively. The time equation required to check in at the airport is.

$$t_c = uniform(10, 15) \tag{7}$$

3.1.8. Delivery time of goods to the airport by the feeder $(\boldsymbol{t_{fb}})$

The time of delivery of goods to the airport by the feeder is the time needed by the feeder to deliver goods from the customer's location to Husein Sastranegara Airport Bandung. This time can be found by determining the distribution of distance from the central location to the customer plus the distribution of the distance of the customer's location to the airport divided by the distribution of vehicle speed using a motor. Central location distance data to customers and customer location distance data to airports are obtained from Google Maps using motorcycles. The distance used is the distance data with the fastest time. In addition to distance, motor speed information is also needed. Motor speed data is obtained by dividing the shortest distance on Google Maps divided by the estimated time needed to reach the destination location.

This stage begins by collecting distance information from the center (Company X) to all sub-districts in Bandung City, namely 28 sub-districts. Then determine the distribution deployment by using the Arena application. The first step is first determined the distribution of distance from the head office to the customer's sub-district. The results of the input analysis in Arena show that the Company's office distance data to the customer's sub-district and the customer's sub-district distance data to the airport have a Triangular distribution with a minimum value of 0.999 km and a maximum value of 20 Km, a mode of 4.78 km. The probability distribution function of a triangular distribution where a is the minimum value, b is the maximum value, and c is the mode defined as follows (Vargas et al., 2023).

$$f(x;a,b,c) = \{ \begin{matrix} 0 & x<a \\ \frac{2(x-a)}{(b-a)(c-a)} & a \le x \le c \\ \frac{2(b-x)}{(b-a)(b-c)} & c \le x \le b \\ 0 & b \le x \end{matrix} \quad (8)$$

The equation used to determine the distance in the simulation model uses the following equation

$$distance_{kp} = triangular(a,b,c) \quad (9)$$

Hypothesis testing is performed on distance data to find out if it can be used as simulated input data. The hypothesis is as follows

H_0: the data follows the triangular distribution

H_1: the data does not follow the triangular distribution

Input analysis was carried out with the Kolmogorov-Smirnov test, obtained a p-value of 0.15. The p-value is greater than the value $\alpha = 0.05$. This indicates there is not enough evidence to refute H_o, hence the data corresponds to the Triangular distribution. This means that distance data from PT X's head office to the customer's sub-district is used as input in the simulation.

The second step is to determine the distribution of distance from the customer's sub-district to Husein Sastranegara airport (Bandung). The distribution is obtained using the input analyser feature in the Arena, obtained Weibull distributed distance data with values $k = 9.25$ and lambdas ($\lambda = 1.41$). The Weibull distribution with the parameters k and λ is given as follows.

$$f(x;k,\lambda) = \{ \begin{matrix} \frac{k}{\lambda}\left(\frac{x}{k}\right)^{k-1} e^{(-\left(\frac{x}{\lambda}\right)^{k})} & x \ge 0 \\ 0 & x < 0 \end{matrix} \quad (10)$$

The equation used to calculate the distance from the customer's sub-district to Husein Sastranegara Airport using the Weilbull distribution is.

$$distance_p = weibull\ (a,b,c) \quad (11)$$

Data distribution testing is performed to determine whether Weibull distributed data uses the following hypotheses:

H_0: the data follows the Weibull distribution

H_1: the data does not follow the Weibull distribution

Conducted analytical input with the Kolmogorov-Smirnov test, obtained $p - value > 0.15$. The p-value is greater than the value $\alpha = 0.05$. This indicates there is not enough evidence to refute H_o, hence the data correspond to the Weibull distribution. This means that distance data from the customer's sub-district location to Husein Sastranegara Airport can be used as input in the simulation.

Vehicle speed data (motor) is inputted using the input analyser feature and obtained data distribution is a normal distribution with an average (μ) of 20.3 km / h and a standard deviation (σ) of 3.11 km / h. The density of a random variable with mean (μ) and standard deviation (σ) is as follows:

$$n(x;\ \mu,\sigma) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{1}{2\sigma^2}(x-\mu)^2} \quad (12)$$

with.$\pi = 3.14 \ldots .dan\ e = 2.71 \ldots$

The equation used to calculate the speed of the vehicle that the feeder uses to deliver goods using the Normal Distribution is

$$kec_m = normal\ (\mu, \sigma) \tag{13}$$

Data distribution testing is performed to find out whether the data is normally distributed using the following hypotheses:

H_0: the data follows the normal distribution

H_1: the data does not follow the normal distribution

Conducted analytical input with the Kolmogorov-Smirnov test, obtained $p - value\ >\ 0.15$. The p-value is greater than the value $\alpha = 0.05$. This indicates there is not enough evidence to reject H_o, hence the data corresponds to the Normal distribution. This means that the vehicle speed data used by the feeder can be used as input in the simulation.

Based on the distance distribution of each equation (9) and equation (11) and the distribution of vehicle speed in equation (13), the equation used in the simulation to calculate the time it takes for the feeder to deliver goods to the airport is as follows.

$$t_{fb} = \frac{triangular(a, b, c) + weibull\ (a, b, c)}{normal\ (\mu, \sigma)} \tag{14}$$

The time it takes for the feeder to deliver the goods to the recipient is assumed to have the same distribution as the time it takes for the feeder to deliver the goods to the airport. The time it takes for the feeder to return to headquarters from the airport follows the following equation:

$$t_{fbk} = \frac{6.3}{norm(\mu, \sigma)} \tag{15}$$

3.2. Alternative Simulation Model 1

Alternative simulation 1 is an alternative to shipping goods using cargo (Kováčiková et al., 2023), this is done if the goods are identified as not being able to arrive in less than 24 hours and goods that do not have a match with the travelers. The stages in the simulation in first alternative are:

a. Order Arrival Process

This stage begins with creating a process of arrival of customers who will deliver goods through the application. The simulation is done by generating customer orders with the time between customer arrivals defined in equation (1). Then determine the destination of the order with each percentage of selected destination cities is 25%. Furthermore, it provides attributes for each entity so that it facilitates the distribution of goods according to the destination city.

b. Luggage delivery to Husein airport

Airport delivery of goods can be done after the order is received from the customer. Interstitial of goods is carried out by feeders using motorcycles. The number of feeders that can do this job is 10 people with a length of pick-up time using equation (14). After the goods arrive at the airport, the feeder Go back to the head office to pick up the new order. Time taken feeder Return to headquarters using equation (15). After the feeder delivers the order and returns to the head office to pick up the new order, the feeder is charged according to equation (2) with the unit of Rupiah / delivery. The total feeder wage is the number of shipments multiplied by the feeder wage in equation (2).

c. Flight schedule determination

After the goods arrive at the airport, several processes occur, namely determining the destination city of each, determining whether the goods can arrive in less than 24 hours, and so on. Items that have been identified as acceptable in less than 24 hours will be matched with travelers. If there is a match, the goods will be sent with the traveler but if not, the goods will be sent by air cargo. Travelers who bring goods will be compensated following equation (3). However, non-eligible items will be shipped with air cargo and freight forwarding costs using Table 5.

d. Delivery of goods by feeders from the destination airport to the receiving sub-district

This stage is carried out if the goods have arrived at the destination airport with the delivery time needed by the feeder from the airport to the receiving sub-district using equation (14) assuming the head office is at the airport. After the feeder delivers the order and returns to the head office to pick up the new order, the feeder is charged according to equation (2) with the unit of Rupiah / delivery. The total feeder wage is the number of shipments multiplied by the feeder wage in equation (2).

3.3. Alternative Simulation Model 2

The model in second alternative is used if the goods to be sent do not meet the 24-hour time and do not find a match with the traveler, the goods will be collected and sent to Soekarno Hatta International Airport. This is done because the airport has many choices of flight schedules to airports in related cities. The stages in alternative simulation model 2 are as follows:

a. Determine delivery time

Items that have been identified and do not meet the requirements will be sent to Soekarno Hatta International Airport at 12.00 WIB and 24.00 WIB. If the goods come after 12.00 then it will be sent at 24.00 WIB.

b. Determine the number of vehicles used

Once the delivery time is determined, the items to be sent are collected and counted. It is assumed that one vehicle can carry 80 items, so if the goods are more than 80 then 2 vehicles are needed. For example, if there are 100 items to be sent, 1 Company vehicle and 1 third party vehicle are needed to be rented. The amount of costs incurred to send goods to Jakarta using a company car is IDR 500.000 while using 1 rental car costs IDR 800.000

c. The process of shipping goods to the destination city

After the goods arrive at Soekarno Hatta Airport, the goods will be separated according to the destination city of the final recipient. The time needed by the airport admin for handling goods uses equation (6) and check-in time uses equation (7). The next stage is to determine the flight schedule. Items that have been determined by the flight schedule will follow the process as in first alternative. If the goods are predicted to arrive in less than 24 hours and there is a match with the traveler, the goods will be brought by the traveler. But if not, the goods will be transferred back to follow the next flight schedule.

3.4. Analysis of Simulation Results

The analysis was performed on alternative simulation 1 and alternative simulation 2. The total cost in first alternative is IDR 69,779,084.40 / month consisting of cargo costs of IDR 9,782,355, travelers' costs of IDR 10,276,010, airport admin salaries of IDR 20,903,512, total feeder costs of 21,444,728 and penalty costs due to delays in goods of IDR 1,101,426. The cost graph in first alternative is presented in Fig. 1. From the picture the biggest cost is the feeder fee followed by the airport admin fee. The smallest cost is the total penalty paid by the Company to customers amounting to Rp 1,101,426 / month. The penalty fee is quite small because not too many items reach the recipient in less than 24 hours. Based on the results of the simulation, data was obtained that out of 468 items sent in 1 month, there were 9 items that were late or delayed by 1%. This is quite good considering the data from the Company delay that currently occurs reaches 15%. However, in this study the delivery of goods uses uniform distribution with a time limit of 4 to 20 hours, in actual conditions it could be that the time needed is greater. In addition, this study still ignores the time to queue for goods because the number of feeders is limited.

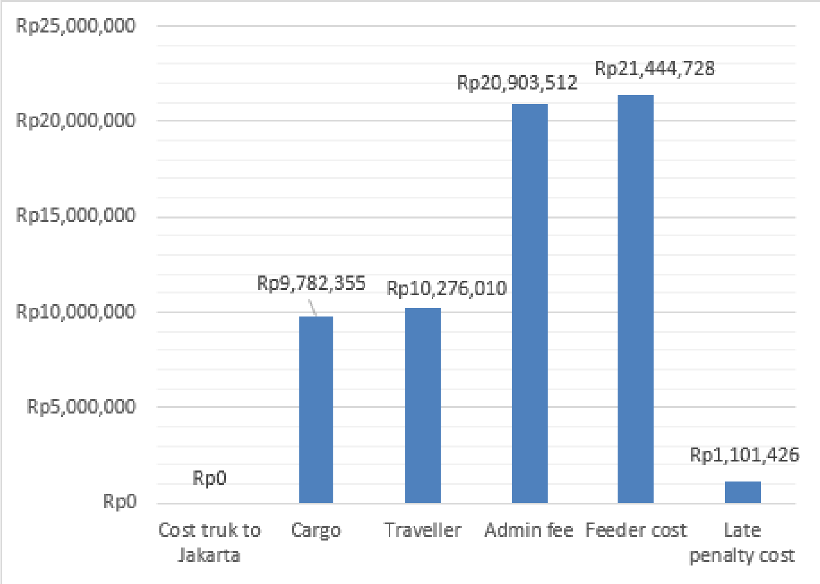

Fig. 1. Total cost on First alternative (/month)

The cost in second alternative is also calculated and obtained a total of IDR 107,025,296. This fee consists of the cost of intermediating goods to Soekarno Hatta Airport by car of IDR 38,119,900, cargo costs of IDR 229,832, travelers' fees of IDR 17,574,624, airport admin salaries of IDR 27,174,566, feeder costs of IDR 21,454,832 and the total penalty that must be paid by the Company to customers due to late delivery is IDR 2,473,543. All these costs can be seen in Fig. 2. From the chart the highest cost is the cost of shipping goods to Jakarta using the Company's car or a rented third-party car. The simulation results also show that the lowest cost is cargo costs of IDR 227,832. The cost of cargo is quite small because most of the goods that do not meet the criteria are successfully carried by travelers in Jakarta. However, the results of this simulation may change depending on the results of checking goods in Jakarta. The simulation results showed that the goods were successfully sent more than 24 hours using second alternative, which amounted to 19 items per month from 467 items sent. This means that there are 2% of goods that experience delays in delivery. When compared to actual conditions, this alternative is quite good considering that in actual conditions the delay reaches 15%.

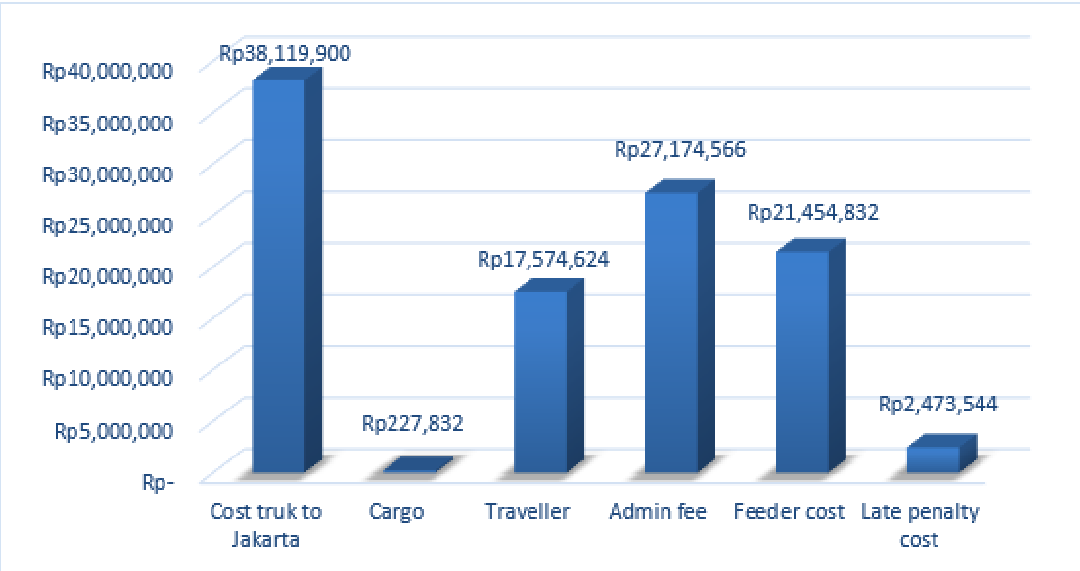

Fig. 2. Total cost Alternate 2 (/month)

The results of first alternative and second alternative that have been simulated need to be compared to choose which is the best alternative. Comparison of the two alternatives is carried out against the performance criterion, namely total operational costs. It is graphically presented in Table 6.

Table 6. Cost comparison of each alternative

Cost	Alternative 1	Alternative 2
Cost of Shipping	IDR 9,782,355	IDR 227,832
Admin fee	IDR 20,903,512	IDR 27,174,566
Feeder cost	IDR 21,444,728	IDR 21,454,832
Traveler cost	IDR 10,276,010	IDR 17,574,624
Cost of vehicle to Jakarta	0	IDR 38,119,900
Cost of penalty	IDR 1,101,426	IDR 2,473,544

The costs compared are the cost of shipping goods (including cargo costs, travelers' incentives), the cost of shipping goods to Jakarta, airport admin salaries / month, feeder fees, and late delivery penalties. In shipping goods to Jakarta there are quite striking costs, in first alternative there is no cost because there is no delivery to Jakarta. Second alternative requires considerable costs because the utility of the vehicle used is very low so that shipping goods to Jakarta is expensive. Then the admin salary is different because in first alternative there are 5 admins at each origin and destination airport, but in second alternative there is an addition of 1 admin at Soekarno Hatta International Airport.

The final step is to test the hypothesis to see if there is no significant difference in the total cost performance criteria of the two alternatives using the t test. The hypotheses used are as follows:

H_0: There is no significant difference between the first alternative and the second alternative

H_1: There is significant difference between the first alternative and the second alternative

Based on the results of the t-test, information was obtained that the value of t-stat < -t crit then a decision was made to reject Ho. This means that there is a significant difference between first alternative and second alternative. From the simulation results, first alternative is the chosen alternative because it provides the smallest cost. This is by research on distribution optimization using air services with the function of minimizing costs (Glass et al., 2022; Rodriguez et al., 2021).

4. Conclusion

The change in shopping behavior of Indonesian people to online shopping increases the growth of logistics service companies. The company is trying to increase customer satisfaction in the delivery of goods. One of the features of the growing delivery service is that it is less than 24 hours of delivery. PT X has a unique way of doing this service, namely by using the remaining baggage of travelers who will travel to the destination city. However, the implementation of this service technique still experiences obstacles, namely many goods that do not arrive in less than 24 hours. Based on the company's historical data, there are 15% of goods that do not arrive in less than 24 hours, this results in the company having to pay a penalty of 100% to customers. This research aims to solve the problem of late delivery of goods at minimum cost. The method used is an experimental method with a system model, the model built will be simulated with various alternatives. In this study, there are two alternatives, the first alternative is that goods that are not suitable for travelers in Bandung will be sent by air cargo at Husein Sastranegara Airport. The second alternative is goods that do not match the traveler and are not expected to arrive within 24 hours will be sent to Soekarno Hatta Airport using a company car and / or a rented third party car, after the goods arrive in Jakarta it will use the services of a traveler in Jakarta or with air cargo. The simulation results provide total costs for alternatives 1 and 2 of Rp. 69,779,084.40/month and Rp. 107,025,296, respectively, items that do not meet delivery less than 24 hours for alternative 1 which is 9 goods/month or 1% of total delivery and alternative 2 which is 19 goods or 2% of total delivery. The simulation results provide results, namely the first alternative is chosen as the best alternative. The simulation results show that the goods successfully delivered over 24 hours using alternative 2 are 19 items per month out of 467 items sent. This means that 2% of goods experience delays in delivery. This alternative is quite good compared to actual conditions, considering that the delay reaches 15% in actual conditions. The weakness of this study is the change in the location of Bandung airport to Kertajati Airport, which ignores the distance and travel time when shipping goods to the airport. In this study, travelers who use airplanes and models do not consider fuel and overtime cost fluctuations.

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