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Delivery service order policy with the sharing economy concept using a discrete event simulation system

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ABSTRACT

People's lifestyle, especially in shopping, has shifted from offline shopping, such as in supermarkets, traditional markets, stalls, and so on, to online shopping. Therefore, online business (e-commerce) has increased, resulting in a surge in the business potential of freight forwarder companies. When there is an increase in demand for the delivery of goods by sellers to consumers, companies need to make adjustments to improve their performance. This paper proposed the sequence of goods delivery services for XYZ companies by considering dynamic requests and conditions that vary discretely over time. This paper is based on a case company in Bandung, Indonesia. The method employed queuing models and discrete event simulations using hypothetical data with performance criteria to minimize the total cost of shipping goods. Simulations are carried out using one courier and one zone to compare customer service determination algorithms, namely first-come, first-served, proximity, and predictive control models. The simulation results show that the proximity algorithm produces a minimum total cost of Rp 1,785,749, the smallest cost compared to using first-come, first-served and predictive control models, respectively IDR 2,782,389, and IDR 2,639,291. Then, the Annova test was conducted, which provided information that one policy differed significantly from another, and a Turkey test was carried out, showing that the proximity algorithm produces better performance than other algorithms. The contribution of this paper is to present that the delivery service employed by the company provided a minimum total cost.

INTRODUCTION

Nowadays, the shopping interest of Indonesian people tends to shift from offline purchases such as supermarkets, markets, and others to online purchases. Adibfar et all. [1] and Lastri and Anis [2] discussed that it is challenging to eliminate online shopping habits after the Covid

19 pandemic. Online business, also known as e-commerce, is growing fast as it allows people to carry out buying and selling transactions without being limited by location. Besides that, it can bring

sellers and buyers together in online applications. In addition, online applications can compare prices, display product details, and categorize product details based on consumer input [3]. The seller owns several applications in Indonesia, such as Shopee, Lazada, Tokopedia, JD.id or individual applications. Another advantage of this online business is that payments can be made immediately using credit cards, debit cards, ATM transfers, etc. After the payment has been successfully verified, the seller will prepare the order and send it to the consumer's destination address using the help of a goods delivery service.

Along with online business development, the goods delivery service business has also increased. The growth of goods delivery services has also increased so that actors in the goods delivery industry compete to improve consumer benefits such as fast delivery times with minimal costs. Today the way to increase productivity with limited resources is an interesting topic because it is in real conditions [4]. Companies must manage human resources to increase overall production, including problems [5], [6]. XYZ is a company engaged in shipping services that offer fast, safe, and competitive price delivery of goods. This company applies the concept of economy sharing by providing a platform that can bring together shippers and travelers. This company works with travelers who will travel and are willing to send goods to the same destination; after the work is completed, the traveler will receive payment from the company for his services. With this sharing economy system, PT. XYZ can reduce the cost of shipping goods.

The delivery procedure begins with the sender of the goods handing them over to the courier company after the sender fills in all the data regarding the goods and information needed on the company's online platform. Then, the courier will pick up the goods with an estimated maximum time of 60 minutes. Then the courier will deliver the item to the airport, where the traveler will travel by airplane. Next, the items will be sent using the traveler's remaining baggage.

If the demand for delivery using the sharing economy system is still small, the company can still make deliveries on time; namely, the time to pick up goods by courier is a maximum of 60 minutes. However, if there is a surge in demand for the delivery of goods, the company must innovate in improving services related to customer waiting time for goods to be picked up by the courier to the customer's location. In this paper, the authors consider the operational time of picking up goods by courier to the customer's location and sending the goods back to the traveler at the airport. This paper focuses on determining the number and allocation of couriers whose job is to pick up goods from customers and deliver them to the airport to be brought by travelers. This paper is limited to the city of Bandung by utilizing distance info on Google Maps. The distances calculated are the distances between districts. This task aims to improve the company's service by minimizing customer waiting time by considering the service costs that must be incurred. In this paper, there are several limitations, namely the business processes carried out are limited from picking up goods by the courier to the customer and then the courier delivering the goods to the airport, travelers using the mode of airplane transportation [7], [8] and utilizing the rest of the plane's baggage for storage of goods, service locations are stated in sub-districts. Besides that, it is assumed that the distance between locations is calculated from the closest route [9] between the two sub-districts, the courier always returns to the depot after completing the task of delivering goods, there is no limit to the number of couriers employed, there is no limit to the number of goods transported and no canceling orders is permitted.

Research on the first-come, first-served service order policy has been carried out in [10], [11], but in this study only used one algorithm, and there was no comparison with other algorithms, likewise with research [10], [12] in determining the equilibrium solution in the queue but only using the first-come, first-served method. In addition, research on customer order scheduling problems has been carried out by [13], but this study aims to minimize total delays. The weakness of some of the studies above is not comparing several algorithm models. This

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study compares three algorithms to determine customer service sequence policies by building discrete and dynamic models, which few studies still proposed. In this study, the number of requests for the delivery of goods differs every time, so it can be called a real-time problem. Model development refers to the dynamic model, and the development framework refers to the general model in [14]. Several previous studies [11], [15]–[18] have studied determining the policy of delivery items to consumers with each method.

However, up until now, there has been a lack of utilization of discrete event simulation to conduct a comparative analysis of the three goods delivery services due to the dynamic and discrete nature of demand fluctuations over time. This study contributes to address this gap by employing a discrete event system that enables a more sophisticated simulation. The primary objective of this research is to assess the effectiveness of three delivery services and establish optimal customer service policies that can uphold the promised service level while minimizing the internal courier travel costs associated with pick up and delivery of goods to travelers at the airport.

METHOD

The investigation was conducted as a case study in Bandung, Indonesia, utilizing Google Maps to accurately measure the distances between different districts. This research endeavors to establish optimal service policies for PT. XYZ, a company operating in the goods delivery domain through a sharing economy system, while minimizing associated costs. To achieve this objective, quantitative models and simulations are employed to arrive at an optimal solution. The focus lies in determining the customer service order policy through discrete event simulations, specifically by considering a scenario with one courier operating within a single zone, namely the city of Bandung. The simulation incorporates essential parameters such as customer arrival rates, locations, and service rates. The primary performance criterion for evaluation is cost minimization, which encompasses both customers waiting time and courier travel time.

In addition to the aforementioned stages, the problem-solving approach initiates by comprehensively defining the system, encompassing key elements such as the decision maker, system objectives, performance criteria, and decision variables. Subsequently, the appropriate model and method are selected as a basis for resolving the problem. Leveraging these chosen models and methods, a precise mathematical formulation is devised, tailored to the specific system requirements and data inputs. Once all research stages are duly completed, an exhaustive analysis and discussion of the obtained results will ensue.

Simulation using a discrete event system has been widely used in several studies, especially in exposure to workloads and manufacturing systems, as in [19]–[23]. In this study, the discrete event system is used to determine customer ordering policies to minimize the cost of shipping goods by courier from the customer's location to the airport where the traveler is located.

1. Description of the system

PT. XYZ is a company that delivers goods that offer fast, safe, and competitively priced delivery services. To consumers, this company promises delivery in less than 24 hours. In addition to using delivery with a cargo system, this company also offers the concept of sharing economy by utilizing the remaining baggage allowance for travelers, who will receive incentives from the company. It is assumed in this paper shipping by traveler uses an airplane so that goods picked up at the customer's place by the courier will be sent to the airport. This paper is limited to picking up the goods at the location by the courier until they are delivered to the airport. There are differences in system behavior that are not following expectations when returning goods. This is called a problem. Problem characteristics are also called problem elements [24]. In accordance with the research objectives, we write the problem elements in this paper: the decision-maker is the management of PT. XYZ, the aim being the order policy for customer service to produce a minimum total cost, the decision criteria are cost minimization, the performance measure is total operational costs, the alternative course of action is the order of customer service, the context of the system is narrow system of interest, wider system of interest, and environment. Narrow system of interest is picking up goods to the customer's location by courier and delivering them to the airport, wider system of interest is the delivery of goods by travelers until they reach the destination city. Environmental is economic growth and people's lifestyles that affect demand for delivery of goods. Apart from the problem element, there are also four stakeholders in this system including the problem owner, namely the management of PT. XYZ.

2. Model of service sequence policy determination

The policy in determining customer service order uses discrete event simulations by assuming that the city of Bandung is one zone. This simulation uses only one courier, and the system is dynamically modeled whose state changes every time [25], [26]. Time step is denoted by which is a positive integer. Every time a customer and courier finish serving the previous customer, the t value will move. This dynamic modeling aims to present the system with customers who arrive at dynamic and uncertain times. In this paper, the algorithms compared in determining the order of service policies are:

1. First-come first-served, namely service based on the order in which customers arrive.
2. Location proximity, namely services based on the location of the customer's proximity to the airport. This means that if there are requests for more than one customer at any time, the courier will first come to the customer with the farthest location from the airport. Mathematically, the proximity value is large.
3. Predictive control models, it is generation of possible customer service sequences and evaluating costs incurred for each horizon.

The simulation model component consists of:

1. Problem: comparing algorithms to determine customer service order policies
2. Decision variable: service order policy
3. Performance criteria: cost minimization
4. Limitations: requests from customers must be fulfilled
5. Parameters: average customer arrival time, service time, customer location, distance between districts, and average driving speed in the city of Bandung.

3. Mathematical models

The objective function in this paper aims to minimize the total cost required in delivering goods by courier to customers [15]-[18]. This model is the sum of the total waiting customer costs and the total courier travel costs.

The total customer waiting cost is the multiplication of the waiting cost and the total waiting time [27]. Mathematically written in Equation (1).

$$W \times \sum_{n=1}^{|\mathbb{D}|} \omega_n(t) \tag{1}$$

with W waiting customer costs (Rupiah/minute), n is the customer index ($n \epsilon \mathbb{Z}$), t is the time it takes the courier on the service, $\mathbb{D}$ is the set of customers and $\omega_n(t)$ is the length of time the customer waits which is calculated by adding up the time the courier starts the service with the length of the journey time minus the time the customer arrives in the system.

Then the total cost of the courier trip, which is the multiplication of the total courier time on the way with the cost of the courier's travel time, is written following Equation (2).

$$D \times \sum_{t,n=1}^{|\mathbb{D}|} (\sigma(t) - \beta_n(t)) \tag{2}$$

With D is the cost of the courier's travel time (Rupiah/minute), $\sigma(t)$ is the length of time the courier works in one service stage which is the difference between the time the courier finishes

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work and the time between customer arrivals, $\beta_n(t)$ is the length of time for customer service, namely the length of time for picking up goods and solving administrative problems.

From Equations (1) and (2), a mathematical model of the objective function Equation is obtained to minimize the total cost, namely as in Equation (3).

$$Total\ cost = W \times \sum_{n=1}^{|\mathbb{D}|} \omega_n(t) + D \times \sum_{t,n=1}^{|\mathbb{D}|} (\sigma(t) - \beta_n(t)) \tag{3}$$

4. Verification and validation model

If viewed from the resulting dimensions in Equation (3) where the units of the left side are in $Rupiah/day$ and the units on the right-hand side as well $Rupiah/day$ it can be concluded that the model built is logically consistent.

Model validation is carried out to ensure that the model that has been built is a representation of the actual system. However, validation could not be carried out in this study because the system had not run according to the designed dynamics. Therefore, we use hypothetical data and real data to see the logic.

RESULTS AND DISCUSSION

1. Determination of values for all parameters

This paper cannot validate the model because it has not been implemented in a real system. Therefore, a test was carried out using hypothetical data to validate the model in Equation (3) [28]. Model testing is carried out using the help of MATLAB. Because it uses discrete event simulation [19], [29], it is necessary to first define some of the parameters that will be used in the simulation. These parameters are as follows.

i. The parameter is the average time between customer arrivals $\frac{1}{\lambda}$, parameter generated by exponential distribution of random numbers with the assumption that there are 60 customers/day, and the simulation is carried out in 30 replications. By using Matlab, generating data using syntax.

ii. Average service time $\frac{1}{\mu}$, this parameter is the time the courier serves the customer at the location customers and is normally distributed with an average of 5 minutes/customer. Random numbers are generated using MATLAB with syntax $servicerate = exprnd(5{,}60{,}30)$

iii. Customer location (p), customer location determination is obtained by generating a random variable from 0-1 in Matlab using the syntax $varloc = rand(60{,}30)$. Then this random number is considered the cumulative probability that determines the customer's location, obtained using the syntax $loc(n) = sum(varloc(n,k) \geq cumsum([0, probloc])$. Furthermore, for distances between districts using Google Maps.

iv. Average driving (v),Using the help of Google Maps, it is obtained that the average motorbike ride in the city of Bandung is 23 km/hour. Parameters of driving speed with a standard deviation of 8 km/hour, the data is generated using syntax $speedaverage = normrnd(30{,}8{,}60{,}30)$

v. Customer waiting fee W, in this section, it is assumed that picking up goods takes less than 60 minutes, and no customers cancel orders and generate company revenue of Rp 10,000. So, the customer waiting fee is Rp 166.67/minutes.

vi. Courier travel time costs (D), this fee includes the cost of Pertalite type fuel (Rp 10,000/liter), average daily fuel consumption (53 km/liter), and average driving speed in the city of Bandung (30km/hour = 0.5 km/minute). Then the courier's travel time costs Rp 94.34 / minute.

In addition to the above costs, there is also a deterministic customer waiting cost [27], where the customer waiting cost has a multiplier factor of IDR 187.5/minute.

2. Calculating to determine all decision variables

With the established model and defined parameters, the discrete event simulations enable the determination of the most suitable service policy. In this process, three alternative delivery service order policies are compared: first-come, first-served, location proximity, and predictive control models. The evaluation is carried out based on the performance criteria, focusing on customer waiting time and courier travel costs. The simulation encompasses all the parameter data, carefully specified for 30 replications. A comprehensive comparison of the total customer waiting time and courier travel time calculations is presented in Table 1.

Table 1. The comparison of total customer waiting time and courier travel time

Replication	Total customer waiting time (minutes/day)			Total courier travel time (minutes/day)		
	FCFS	Proximity	M P C	FCFS	Proximity	M P C
1	17362.3	13640.9	10506	1537.5	1450.5	1657.8
2	13406.2	8965	19659.8	1419.2	1226.8	1538.7
...	...	...	...	...	...	...
30	13016.5	8114.7	11026.9	1354.9	1175.4	1313.7
Average	14364.3	9106.9	13594.7	1463.8	1285.2	1483.7

The findings pertaining to the total customer waiting time and courier travel time are presented in Table 1. For the first-come, first-served (FCFS) approximation, the average total customer waiting time amounts to 14,364.3 minutes of delay. However, when employing the proximity approximation, this waiting time reduces significantly to 9,106.9 minutes of delay, and the MPC approximation yields a total customer waiting time of 13,594.7 minutes of delay. Clearly, the proximity algorithm demonstrates the most favorable outcome, resulting in the lowest total customer waiting time. Regarding the total courier travel time, the FCFS approximation shows an average delay of 1,463.8 minutes, whereas the proximity approximation remarkably decreases it to 1,285.2 minutes, and the MPC approximation results in 1,483.7 minutes of delay. Once again, the proximity algorithm proves to be the most efficient, leading to the minimum total courier travel time. Table 2 provides a comprehensive comparison of the total delivery performance among the FCFS, proximity, and MPC algorithms.

The results indicate that the total cost of goods delivery using the first-come, first-served algorithm amounts to IDR 2,782,389.1. In contrast, the proximity algorithm significantly reduces this cost to IDR 1,785,749.7, and the predictive control model algorithm results in a total cost of IDR 2,639,291.6. Consequently, the simulation outcomes unequivocally demonstrate that the proximity algorithm offers the most cost-effective solution for delivering goods, with the minimum expenditure recorded among the three algorithms.

Table 2. The comparison of total delivery

Replication	Total cost of delivery (Rupiah/day)		
	FCFS	Proximity	M P C
1	2029643	1468586	2223743
2	3338244	2219018	3731662
...	...	...	...
30	2521334	1592713	2049198
Average	2782389	1785750	2639292

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3. Analysis and Discussion

The three alternative algorithms for determining customer service orders are compared using discrete event simulation. The first-come, first-served algorithm serves customers based on the order of their arrival regardless of their location, resulting in a large courier travel time. This causes the customer's waiting time to increase and of course results in the greatest total cost. Then the predictive control model algorithm, namely the algorithm determines the order of service by evaluating the total cost arising from every possible order of customer service in the rolling horizon certain. This algorithm also has a large total cost because it keeps some customers waiting for a long time and selects the newly arrived customers to be served first.

The smallest total cost is obtained by applying the location proximity algorithm, where customer service order is based on location origin. This method can save courier travel time without causing customers to wait too long. Figure 1 shows the comparison service order algorithm.

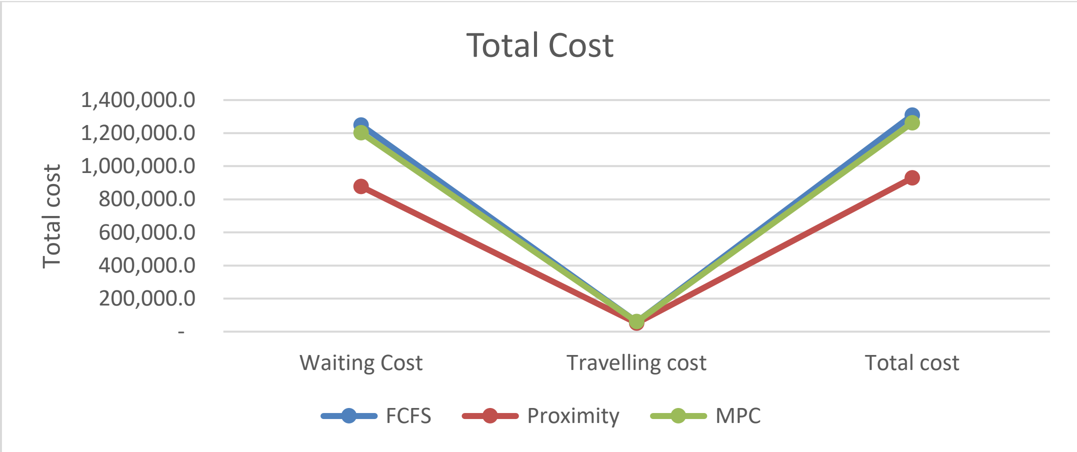

Figure 1. The comparison of service order algorithms

Then an analysis of variance or ANOVA is performed to compare different schemes in each simulation result carried out on the total cost variable [30]. This ANOVA test was conducted to test the following hypothesis.

$$H_0 : \mu_1 = \mu_2 = \cdots = \mu_t$$
$$H_1 : There\ are\ at\ least\ two\ different\ averages$$

Testing is done by setting a value = 0.05 with 30 replications and Table 3 is as an analysis of variation.

Table 3. Analysis of variation

Source of variation	Sum of square	Degrees of freedom	Mean square	F	P-value	F-crit
Among grup	1.74E+13	2	8.71E+12	19.44335	1.05E-07	3.1012
in grup	3.90E+13	87	4.48E+11			
Total	5.64E+13	89				

From the results of the analysis of variation in Table 3, it was found that the F value was greater than the F-crit value, so accept H_1 . This means that at least one policy is significantly different from other policies. The Tukey pairwise comparison test will be used using SPSS to see which policies are significant. This test uses a significance level of 0.05 with degrees of freedom $v = 87$.SPSS output is obtained as presented in Table 4.

The results obtained from the Tukey test, as presented in Table 4, indicate that the Proximity algorithm exhibits a significantly lower overall average compared to the first-come, first-served, and predictive control model algorithms. These findings, supported by the Annova and Tukey tests, provide conclusive evidence that the proximity algorithm outperforms other algorithms in terms of performance criteria. Notably, the study highlights that the Proximity algorithm consistently achieves a smaller total average than both the first-come, first-served algorithm and the predictive control model algorithm. This observation implies that the proximity algorithm offers the most cost-effective delivery solution and, therefore, represents a favorable choice for PT. XYZ to adopt as their preferred customer service approach. Furthermore, earlier research aligns with these findings, stating that the proximity algorithm's effectiveness is particularly pronounced when applied to large-dimensional data sets, thereby supporting its robustness [28], [31].

Table 4. Output tukey test

Algorithm	N	Subset for alpha=0.05	
		1	2
Proximity	30	1,785,749.7	
MPC	30		2,639,291,568
FCFS	30		2,782,389,898
Sig.		1,000	0.687

CONCLUSION

This research considers the dynamic and discrete nature of a system whose state changes over time. Model development refers to dynamic modeling and the modeling framework in [32, 33]. Three algorithms were compared: 1) first-come, first-served, where customers are served based on the order of arrival, 2) location proximity, a service based on the location of the customer's proximity to the airport; and the predictive control model, which generating possible sequences of customer service and evaluating costs incurred for each horizon. The location proximity algorithm was selected as the optimal approach for minimizing total costs. With this algorithm, customers situated farthest from the depot to the airport are prioritized for service. The simulation results demonstrate that the proximity algorithm achieves the lowest total cost of IDR 1,785,749.7, significantly lower compared to the costs incurred using the first-come, first-served and predictive control models, which is IDR 2,782,389.1 and IDR 2,639,291.6, respectively. Next, an ANOVA test was conducted, revealing significant differences among the policies. A Tukey test was then performed, confirming that the proximity algorithm outperforms others.

REFERENCES

[1] A. Adibfar, S. Gulhare, S. Srinivasan, and A. Costin, "Analysis and modeling of changes in online shopping behavior due to Covid-19 pandemic: A Florida case study," Transp Policy (Oxf), vol. 126, pp. 162–176, Sep. 2022, doi: https://doi.org/10.1016/j.tranpol.2022.07.003

[2] W. A. Lastri, and A. Anis, "Pengaruh E-Commerce, Inflasi dan Nilai Tukar Tukar Terhadap Pertumbuhan Ekonomi Indonesia." Jurnal Kajian Ekonomi Dan Pembangunan 2, no. 2 (2020): 25-28, doi: http://dx.doi.org/10.24036/jkep.v2i2.12638

[3] J. Liu, J. Chen, R. Bo, F. Meng, Y. Xu, and P. Li, "Increases or discounts: Price strategies based on customers' patience times," Eur J Oper Res, vol. 305, no. 2, pp. 722–737, Mar. 2023, doi: https://doi.org/10.1016/j.ejor.2022.06.015

[4] Y. Giat, "Allocation of scarce resources in a network with periodic deliveries and customer tolerable wait," Comput Ind Eng, vol. 159, Sep. 2021, doi: https://doi.org/10.1016/j.cie.2021.107462

[5] D. K. Baroroh and C. H. Chu, "Human-centric production system simulation in mixed reality: An exemplary case of logistic facility design," J Manuf Syst, vol. 65, pp. 146–157, Oct. 2022, doi: https://doi.org/10.1016/j.jmsy.2022.09.005

 10.12928/ijio.v4i2.7483

[6] C. Liu and S. C. I. Chen, “A Novel Integrated Freight Forwarding Information System Based on Block-Chain Technology,” WSEAS Trans Inf Sci Appl, vol. 19, pp. 186–192, 2022, doi: https://doi.org/10.37394/23209.2022.19.19.

[7] J. Azucena, B. Alkhaleel, H. Liao, and H. Nachtmann, “Hybrid simulation to support interdependence modeling of a multimodal transportation network,” Simul Model Pract Theory, vol. 107, Feb. 2021, doi: https://doi.org/10.1016/j.simpat.2020.102237.

[8] P. Saraev, S. Blyumin, A. Galkin, and A. Sysoev, “Mathematical Remodeling Concept in Simulation of Complicated Variable Structure Transportation Systems,” in Transp Res Procedia, Elsevier B.V., pp. 475–482, 2020, doi: https://doi.org/10.1016/j.trpro.2020.03.041

[9] U. Hwang and S. Guhathakurta, “Exploring the Impact of Bike Lanes on Transportation Mode Choice: A simulation-based, route-level impact analysis,” Sustain Cities Soc, vol. 89, Feb. 2023, doi: https://doi.org/10.1016/j.scs.2022.104318.

[10] D. Wang and F. Liao, “Analysis of first-come-first-served mechanisms in one-way car-sharing services,” Transp Res Part B: Methodological, vol. 147, pp. 22–41, May 2021, doi: https://doi.org/10.1016/j.trb.2021.03.006.

[11] G. Battumur, K. Gantumur, and W. Kim, “Factors affecting satisfaction with the postal delivery service,” Int J Adv Appl Sci, vol. 10, no. 1, pp. 111–120, Jan. 2023, doi: 10.21833/ijaas.2023.01.015.

[12] O. Bueker, B. Kim, and J. Kim, “Customer equilibrium and optimal pricing in an M/G/1 queue with heterogeneous rewards and waiting cost rates,” Oper Res Lett, vol. 48, no. 2, pp. 152–156, Mar. 2020, doi: https://doi.org/10.1016/j.orl.2020.01.007.

[13] L. R. de Abreu, B. de Athayde Prata, A. C. Gomes, S. A. Braga-Santos, and M. S. Nagano, “A novel BRKGA for the customer order scheduling with missing operations to minimize total tardiness,” Swarm Evol Comput, vol. 75, Dec. 2022, doi: https://doi.org/10.1016/j.swevo.2022.101149.

[14] Q. Jiang, J. Penn, and W. Hu, “Real payment priming to reduce potential hypothetical bias,” J Choice Modell, vol. 45, Dec. 2022, doi: 10.1016/j.jocm.2022.100383.

[15] N. Yiming and B. Z. Guo, “Asymptotic behavior of a retrial queueing system with server breakdowns,” J Math Anal Appl, vol. 520, no. 1, Apr. 2023, doi: https://doi.org/10.1016/j.jmaa.2022.126867.

[16] Q. Sun, M. Dong, and A. Tan, “An order allocation methodology based on customer repurchase motivation drivers using blockchain technology,” Electron Commer Res Appl, vol. 56, Nov. 2022, doi: https://doi.org/10.1016/j.elerap.2022.101218.

[17] K. Chargui, T. Zouadi, A. El Fallahi, M. Reghioui, and T. Aouam, “Berth and quay crane allocation and scheduling with worker performance variability and yard truck deployment in container terminals,” Transp Res E Logist Transp Rev, vol. 154, Oct. 2021, doi: https://doi.org/10.1016/j.tre.2021.102449.

[18] B. de A. Prata, C. D. Rodrigues, and J. M. Framinan, “A differential evolution algorithm for the customer order scheduling problem with sequence-dependent setup times,” Expert Syst Appl, vol. 189, Mar. 2022, doi: https://doi.org/10.1016/j.eswa.2021.116097.

[19] C. G. Cassandras and S. Lafortune, “Introduction to discrete event systems,” in Boston, MA: Springer US, 2008, doi: https://doi.org/10.1007/978-0-387-68612-7_11

[20] J. Balun and T. Masopust, “On verification of D-detectability for discrete event systems,” Automatica, vol. 133, Nov. 2021, doi: https://doi.org/10.1016/j.automatica.2021.109884.

[21] C. Peng and F. F. Chert, “Parallel Discrete Event Simulation of Manufacturing Systems: A Technology Survey,” Comput Ind Eng, vol. 31, 1996, doi: https://doi.org/10.1016/0360-8352(96)00142-8.

[22] X. Han, K. Zhang, J. Zhang, Z. Li, and Z. Chen, “Strong current-state and initial-state opacity of discrete-event systems,” Automatica, vol. 148, Feb. 2023, doi: https://doi.org/10.1016/j.automatica.2022.110756.

[23] D. Mourtzis, “Simulation in the design and operation of manufacturing systems: state of the art and new trends”, Int J Prod Res, vol. 58, no. 7, pp. 1927–1949, Apr. 2020, doi: https://doi.org/10.1080/00207543.2019.1636321
[24] H. G. Daellenbach and D. C. Mcnickle, “Management science Decision making through systems thinking”. Bloomsbury Publishing, 2017. Available online: http://lms.aambc.edu.et:8080/xmlui/bitstream/handle/123456789/152/Management_science_Decision_making_throu.pdf?sequence=1
[25] W. Adrianus, M. R. S. P. Edwin, and Y. Yanfi, “Furpare: Third-party application as furniture comparison in Indonesia’s e-commerce,” Procedia Comput Sci, vol. 216, pp. 77–85, 2023, doi: https://doi.org/10.1016/j.procs.2022.12.113.
[26] J. Perez, M. P. de Looze, T. Bosch, and W. P. Neumann, “Discrete event simulation as an ergonomic tool to predict workload exposures during systems design,” Int J Ind Ergon, vol. 44, no. 2, pp. 298–306, Mar. 2014, doi: https://doi.org/10.1016/j.ergon.2013.04.007.
[27] O. Bueker, B. Kim, and J. Kim, “Customer equilibrium and optimal pricing in an M/G/1 queue with heterogeneous rewards and waiting cost rates,” Oper Res Lett, vol. 48, no. 2, pp. 152–156, Mar. 2020, doi: https://doi.org/10.1016/j.orl.2020.01.007.
[28] W. Hu, Y. Lu, and J. Ren, “A fixed-point proximity algorithm for recovering low-rank components from incomplete observation data with application to motion capture data refinement,” J Comput Appl Math, vol. 410, Aug. 2022, doi: https://doi.org/10.1016/j.cam.2022.114224.
[29] Y. Liu, J. Komenda, T. Masopust, and Z. Li, “Modular control of discrete-event systems using similarity,” Automatica, vol. 142, Aug. 2022, doi: https://doi.org/10.1016/j.automatica.2022.110431.
[30] R. E. Walpole, R. H. Myers, S.L. Myers, and K.Ye , “Probability and statistics for engineers and scientists,” New York: Macmillan, 1993.
[31] N. Dvir, R. Hassin, and M. Haviv, “On equilibrium threshold strategies when choosing between observable and unobservable queues,” Oper Res Lett, vol. 50, no. 5, pp. 555–560, Sep. 2022, doi: https://doi.org/10.1016/j.orl.2022.08.004.
[32] M. Liu, R. Liu, and X. Yang, “Workforce assignment in assembly line considering uncertain demand,” in IFAC-PapersOnLine, Elsevier B.V., Sep. 2019, pp. 223–228, doi: https://doi.org/10.1016/j.ifacol.2019.11.120.
[33] Z. Jiang, L. Lei, J. Zhang, C. Wang, and S. Ye, “Spatio-temporal evolution and location factors of port and shipping service enterprises: A case study of the Yangtze River Delta,” J Transp Geogr, vol. 106, Jan. 2023, doi: https://doi.org/10.1016/j.jtrangeo.2022.103515.

 10.12928/ijio.v4i2.7483