Commercium : Journal of Business and Management
E-ISSN : 3031- 9889
Volume. 3 Issue 1 February 2025
Page No: 41-52

Optimization of Distribution Routes of Imported Pipeline Products Using Saving Matrix Analysis and System Dynamics.

Maryadi Tirtana Siregar[1], Subekti[2], Amrin Rapi[3]
Politeknik APP Jakarta, Indonesia [1,2]
Politeknik STMI Jakarta, Indonesia [3]
Correspondent: tirtana.mts@poltekapp.ac.id [1]

Received : January 24, 2025
Accepted : February 10, 2025
Published : February 27, 2025

Citation: Siregar, M, T., Subekti., & Rapi, A. (2025). Optimization of Distribution Routes of Imported Pipeline Products Using Saving Matrix Analysis and System Dynamics. Commercium: Journal of Business and Management, 3(1), 41-52. https://doi.org/10.61978/commercium.v3i1

ABSTRACT: Innovation is carried out systematically to develop and market breakthrough products, systems, or services that can solve customer problems. Companies that do not innovate or are not at a high-quality level become stagnant and can even go bankrupt. PT Arita Prima Indonesia Tbk was established on October 5, 2000, in Jakarta, Indonesia, and engaged in import, distribution, and service for valve, fitting, instrumentation, and control products. The expedition division is responsible for shipping goods to customers. In previous studies, implementing the nearest insert and nearest neighbor methods in shipping route planning can help minimize travel distances and increase the efficiency of the distribution process of imported products. The saving matrix method focuses on adding nearby consumers to complete existing routes. The system dynamics approach shows the unity of interaction between elements of an object within a specific scope that work together to achieve goals. This provides structure to the object, can differentiate it from other objects, and affects the state of the object. The highest total expenditure from month 1 to month 120 was on the carry box car amounting to 2681.32 million rupiah or Rp2,681,320,000. The lowest total expenditure from month 1 to month 120 was on the canter box car amounting to 2503.75 million rupiah or Rp2,503,750. The highest total cost from month 1 to month 120 was on the canter long car with the highest asset value (Rp290,000,000) amounting to 2843.77 million rupiah or Rp2,843,770,000 (two billion eight hundred forty-three million seven hundred seventy thousand rupiah). The lowest total cost from month 1 to month 120 was on the canter box car with the second highest asset value (Rp185,000,000) amounting to 2503.75 million rupiah or Rp2,503,750,000.

Keywords: Distribution, Saving Matrix, System Dynamics.

INTRODUCTION

In today's era, business competition is very tight, which makes every company compete to improve the quality or performance of the existing system. Innovation is carried out systematically to develop and market breakthrough products, systems, or services that can solve customer problems. Companies that do not innovate or are not at a high-quality level become stagnant and

can even go bankrupt. The ASEAN Economic Community (AEC), which took place in 2016, is an initiative to change the free market in Southeast Asia (Mangiaracina et al., 2015). This will affect the market in Indonesia, because it will attract many foreign companies to enter the Indonesian market and seize the existing market share. This will worry Indonesian businesses about profits (Acquaye et al., 2018; Al-Odeh & Smallwood, 2012).

PT Arita Prima Indonesia Tbk was established on October 5, 2000, in Jakarta, Indonesia, and engaged in import, distribution, and service for valve, fitting, instrumentation, and control products. Through excellent performance with improvement from time to time, PT Arita Prima Indonesia Tbk became the first and only valve company to go public in Indonesia in 2013. PT Arita Prima Indonesia Tbk is supported by 47 branches, 5 sales divisions, 8 product support divisions, and 14 subsidiaries. PT Arita Prima Indonesia Tbk comes with a vast distribution system so that it can reach customers more easily throughout Indonesia, Arita group is divided based on segmentation, products, and services. The distribution route problem is caused by several routes having quite diverse locations and can be caused by several factors. If the distribution route requires different transportation for each area, then the transportation cost will be higher and the transportation efficiency will be lower (Manupati et al., 2020). The consistency of the product quality received by consumers can also be a problem, if the products received by consumers at each location are different, then the consistency of product quality will be more challenging to maintain. The distribution route requires different management for each location, then the management cost will be higher and the management efficiency will be lower (Ariyanti et al., 2015; Manzouri & Rahman, 2013; Pratiwi et al., 2021).

Supply Chain Management (SCM) organizes and manages the distribution of goods and services from suppliers to customers through various stages, including design, procurement, production, distribution, and returns. Logistics management is conventionally defined as the strategic management process of moving and storing goods, parts, and finished goods from suppliers to company facilities and customers. The bullwhip effect is a phenomenon in which small fluctuations in consumer demand can trigger larger fluctuations in demand along the supply chain. This occurs because information about demand does not flow smoothly from the consumer to the supply chain's supplier end. When a small change in demand occurs at the consumer end, the company's tendency along the supply chain is to adjust consumer orders to estimates of demand that may be excessive or insufficient rather than actual demand. This can result in increased stock, higher storage costs, and difficulty planning efficient production(Asmira et al., 2015; Faridl, 2016).

Based on several problems mentioned above, efforts are needed to minimize errors in each activity, one of which is by optimizing distribution routes with the bullwhip effect through the nearest insert and nearest neighbor methods. In previous studies, applying the nearest insert and nearest neighbor methods in shipping route planning can minimize travel distances and increase the efficiency of the distribution process of imported products (Syarief et al., 2022). The nearest insert method focuses on adding the closest consumers to complete existing routes. In contrast, the nearest-neighbor method adds new consumers based on the closest consumers not yet included in the route. Meanwhile, bullwhip effect analysis is important in the supply chain to identify which branches require further supervision (Pettit et al., 2019). By understanding and reducing the

bullwhip effect, the company can improve supply chain efficiency and reduce costs associated with demand fluctuations. By combining the efficient route method and bullwhip effect analysis, the company can optimize the distribution process of imported products, reduce operational costs, and increase customer satisfaction (Zagloel et al., 2024). The system dynamics approach shows the unity of interaction between elements of an object within a certain scope that work together to achieve goals. This provides structure to the object, can differentiate it from other objects, and affects the state of the object (Yuniarti & Astuti, 2013). Therefore, a study is needed to optimize distribution activities used in the shipping industry (Hanif et al., 2022).

METHOD

In the problems mentioned previously, methods are used to solve the problems, especially improving distribution routes, minimizing costs, and reducing shipping times with the following details. The saving matrix method aims to determine the most efficient distance, route, time, and shipping cost of goods from the company to customers effectively and efficiently (Suparjo, 2017).

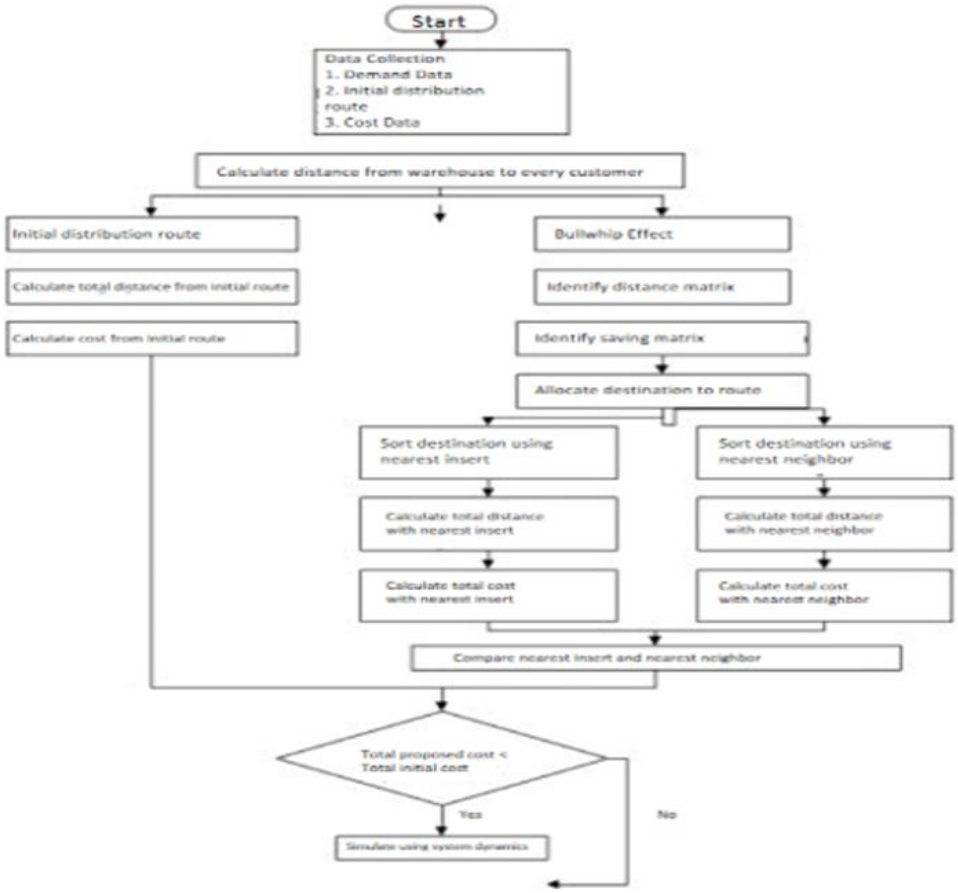
A system is used to show the unity of interaction between elements of an object within a certain scope that work together to achieve goals. This provides structure to the object, can differentiate it from other objects, and affects its state. The elements of the system are determined by function (Rohmer et al., 2019; Tan et al., 2010).

Sometimes, the term element is better known as a subsystem. In system dynamics, a boundary or scope separates the system's state from the external environment. This boundary can be divided into two: a closed-loop system, which is considered impermeable to the external environment's influence, and an open system, which is influenced by the external environment. For example, this process can be seen in the event of a decline in sales value due to incompetence in the marketing field. All supporting factors are expected to be objective or their truth is unquestionable based on several studies. Therefore, this process shows the transformation towards the actual state (Tian et al., 2014).

This process refers to feasible and acceptable targets that can be anticipated to become reality. These two criteria limit the plan's ability to remain stable and dynamic to changes. Gaps or differences must be able to be solved both qualitatively and quantitatively. For example, in qualitative research, there must be a system capable of handling the condition/quality of employee problems; in contrast, quantitative research must handle financial problems such as sales and purchases. This process aims to correct the gaps to produce a future-oriented system model which can adapt to past actions through feedback (loop).

The final stage of the system dynamics process produces output in the form of intervention alternatives to be selected after testing (in this case using Powersim Studio 10 software) to ensure the intervention's safety and effectiveness (Wamba et al., 2020).

Figure 1. Research Methods



RESULT AND DISCUSSION

The collected data was then analyzed to evaluate the saving matrix. The analysis was done by identifying observation data, interview results, and field notes. The author analyzed the distance traveled and costs generated from shipping activities using the saving matrix method and then compared the distance and costs before and after using the method. The next step is to design a savings matrix by connecting one customer to another in one travel route. This aims to calculate the savings matrix by choosing the largest numbers and distances first. The savings matrix calculation process can use the following formula (Endrawati & Siregar, 2018).

$$S(x,y) = J(G,x) + J(G,y) - J(x,y)$$

Description:

S (x,y) = Distance saving (Saving Matrix)
J (G,x) = Distance from warehouse to first customer
J (G,y) = Distance from warehouse to second customer
J (x,y) = Distribution from the first customer to the second customer

Table 1. Distance Matrix.

Distance Matrix								
Branch Name	Warehouse	Arita Bogor	Arita Bekasi	Arita Tanggerang	Arita karawang	Arita Cikande	Arita Glodok	Arita Sukabumi
Warehouse	0							
Arita Bogor	63	0						
Arita Bekasi	41	41	0					
Arita Tanggerang	61	55	79	0				
Arita karawang	60	81	28	98	0			
Arita Cikande	98	87	110	38	122	0		
Arita Glodok	28	50	65	39	76	66	0	
Arita Sukabumi	137	82	141	144	113	128	128	0

Table 1 calculates the savings matrix with the following formula. S (customer 1, customer 2) = travel distance from the warehouse to Arita Bogor + from the warehouse to Arita Bekasi – from Arita Bogor to Arita Bekasi. You must find the largest number to find the calculation route using the saving matrix method. Table 1 above shows the largest number can be obtained, namely 121. This number is obtained from the Arita Tangerang to Arita Cikande route.

Table 2. Saving Matrix

Distance Matrix								
Branch Name	Warehouse	Arita Bogor	Arita Bekasi	Arita Tanggerang	Arita karawang	Arita Cikande	Arita Glodok	Arita Sukabumi
Warehouse								
Arita Bogor		0						
Arita Bekasi		63	0					
Arita Tanggerang		69	23	0				
Arita karawang		42	73	23	0			
Arita Cikande		74	29	121	36	0		
Arita Glodok		41	4	50	12	60	0	
Arita Sukabumi		118	47	54	84	107	37	0

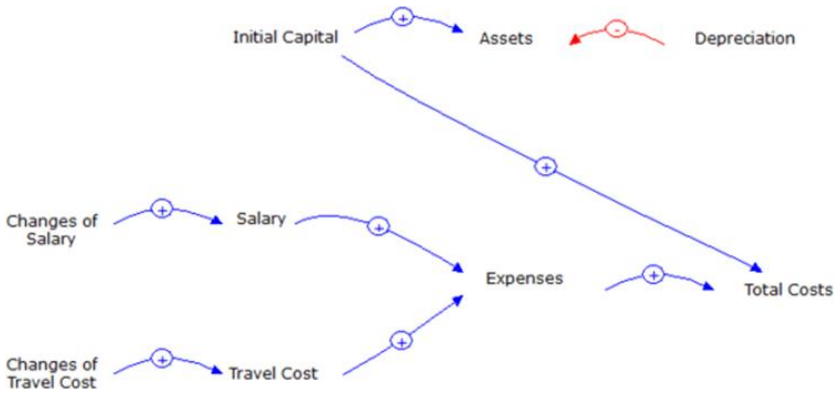
Source: Data processed, 2024

To simulate a model, software is needed that can quickly see the behavior of the model created, one of which is Powersim Studio 10. A dynamic model is a collection of variables that influence each other over some time. Each variable corresponds to a quantity that has its magnitude. All have numerical values and are already part of themselves. This study analyzed the total costs incurred on three types of vehicle models for 120 months (10 years), namely canter box car (1),

canter long car (2), and carry box car (3) which are influenced by driver salaries, travel costs, and asset depreciation. In this study, travel costs used the best value from the results of the saving matrix analysis that had been carried out previously, namely using the results of the nearest neighbor, then the change in driver salaries was assumed to be 3.38% per year based on Government Regulation (PP) Number 51 of 2023 on Wages (Piaralal et al., 2015; Siregar et al., 2019).

Causal Loop Diagram, often abbreviated as CLD, refers to the characteristics of the system as mentioned in the previous section, namely the presence of supporting elements, internal or external feedback, and equilibrium. CLD is a pre-condition before continuing the flow diagram process in System Dynamics software, namely Powersim Studio 10. The causal relationship in CLD is dynamic or changes every unit of time. This relationship has two types, namely unidirectional or mutually supportive, marked with a (+) sign, where if one variable increases, the other variable that has a relationship will also increase. Furthermore, the opposite relationship is marked with a (-) sign, meaning that if one variable increases. Furthermore, the opposite relationship is marked with a (-) sign, meaning that the other variable will decrease if one variable increases. In this study, the causal loop diagram formed in figure 2 (Masudin et al., 2018).

Figure 2. Cause loop



In this study, initial capital provides a positive or unidirectional relationship with asset value, meaning that the higher the initial capital, the higher the assets. This also occurs in changes in salary to salary and changes in travel costs to travel costs, where the higher the change, the higher the salary and travel costs. Salary and travel costs are fixed expenses as long as the business continues to run (Marchet et al., 2014). The total cost PT Arita Prima Indonesia Tbk incurred for 120 months is the accumulation of initial capital with expenses.

$$\text{LEVEL} = \frac{\text{dINFLOW}}{dt} - \frac{dOUTFLOW}{dt}$$

$$\text{LEVEL (t)} = \text{LEVEL}\ (t-1) + \frac{\text{dINFLOW}}{dt} - \frac{dOUTFLOW}{dt}$$

Mathematically, the system in this study is as follows, where t (time) is in months. The changes in salary and travel costs occur once every 12 months or annually.

$$SALARY\ (t) = SALARY\ (t-1) + \frac{dCHANGES\ of\ Salary}{dt\ (12*n)},\ \text{n} = 1,2,3\ldots.10$$

$$TRAVEL\ COST\ (t) = TRAVEL\ COST\ (t-1) + \frac{dCHANGES\ of\ Travel\ Cost}{dt\ (12*n)}, \text{ n} = 1,2,3\ldots..10$$

$$ASSET\ (t) = ASSET\ (t-1) - \frac{dDEPRECIATION}{dt}$$

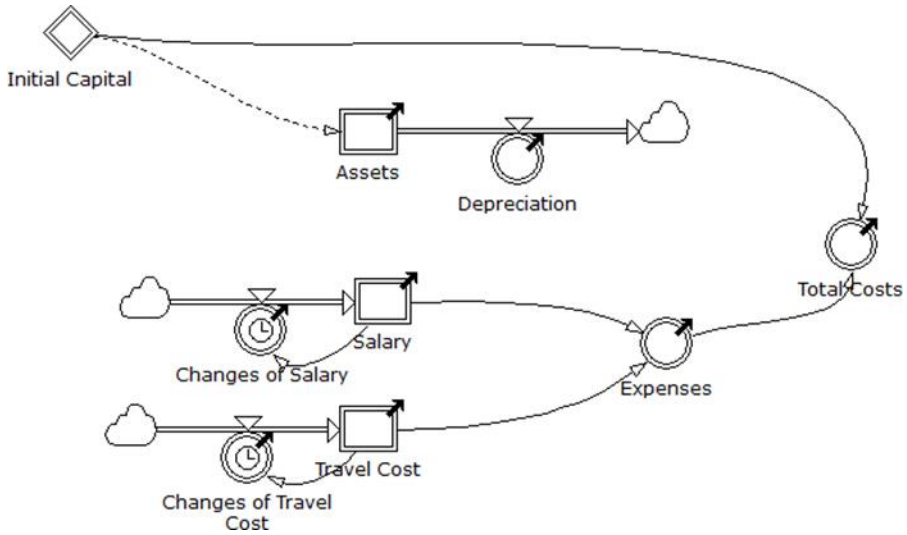
$$EXPENSES\ (t) = TRAVEL\ COST\ (t) + SALARY\ (t)$$

$$TOTAL\ COST = INITIAL\ CAPITAL\ (t=1) + \sum EXPENSES\ (t)$$

t = 1

The relationship between variables and their system is as follows in Figure 3.

Figure 3. system dynamics



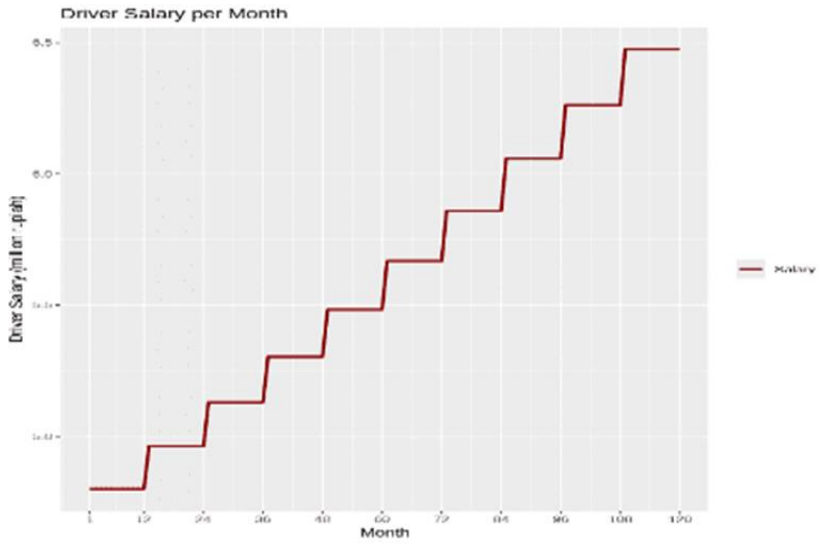
The table below shows the results of system dynamics in calculating assets, driver salaries and their changes of 3.38% per year based on Government Regulation (PP) Number 51 of 2023 on Wages, then travel costs with the best value from the saving matrix analysis using the nearest neighbor method with the assumption that the change in travel costs is 12.96% per year based on historical fuel price data from 1990 - 2024, while depreciation which reduces the value of assets per month is fixed, namely IDR 1,541,667 (canter box), IDR 2,416,667 (canter long), and IDR 1,250,000 (carry box) (Magazzino et al., 2021).

Table 3. Total expenses and cost

Total Expenses (million rupiah)			**Total Cost (million rupiah) = Initial Capital + Total Expenses**		
Canter Box	**Canter Long**	**Carry Box**	**Canter Box**	**Canter Long**	**Carry Box**
2503.75	2553.77	2681.32	2688.75	2843.77	2831.32

The table above can be displayed in a graph as follows.

Figure 4. Driver salary per month



Based on the data above, the following conclusions can be drawn: The highest total expenses from month 1 to month 120 were in the carry box car, amounting to 2681.32 million rupiahs or Rp2,681,320,000 (two billion six hundred eighty-one million three hundred twenty thousand rupiahs). The lowest total expenses from month 1 to month 120 were in the canter box car amounting to 2503.75 million rupiah or Rp2,503,750,000 (two billion five hundred three million seven hundred fifty thousand rupiah). The highest total costs from month 1 to month 120 were in the canter long car with the highest asset value (Rp290,000,000) amounting to 2843.77 million rupiah or Rp2,843,770,000 (two billion eight hundred forty-three million seven hundred seventy thousand rupiah). The lowest total cost from month 1 to month 120 was found in the canter box car with the second highest asset value (IDR185,000,000) of 2503.75 million rupiah or IDR2,503,750,000 (two billion five hundred three million seven hundred and fifty thousand rupiah). For the carry box car, although the initial capital tends to be lower, when totaled with the capacity reflected in travel costs, the total expenses are higher than the canter box (Magazzino et al., 2021).

CONCLUSION

The company has not implemented regular shipping scheduling in dividing shipping routes. Routes are only selected manually by writing them in the shipping route book. After conducting observations in the field, this causes irregular shipping, such as suboptimal valve product distribution routes to branches and waste of costs and time in shipping goods to branches. Route selection uses the saving matrix method and the Nearest Insert & Neighbor algorithm. The total distance traveled using the Nearest Insert algorithm is 748 km, and it has succeeded in saving 88 km compared to the actual shipping route of 836 km. The total distance traveled using the Nearest Neighbor algorithm is 700 km, which has succeeded in saving 136 km when compared to the actual route. Furthermore, in determining shipping time, based on the Nearest Insert & Nearest Neighbor algorithm, the total shipping time generated using the Nearest Insert algorithm was

1213, thus saving 143 minutes when compared to the actual shipping time of 1356 minutes. The total shipping time using the Nearest Neighbor algorithm was 1135, thus saving 221 minutes when compared to the actual shipping time. Based on the shipping cost calculation, the total shipping cost generated using the Nearest Insert algorithm was Rp46,085,667, thus saving Rp1,505,143 compared to the total shipping cost of Rp47,590,810. However, the total shipping cost using the Nearest Neighbor algorithm was Rp45,541,667, thus saving Rp2,049,143 compared to the actual total cost. To further research to enhance logistics and shipping efficiency, future research could explore the following areas: Integration of Advanced Algorithms, Hybrid Algorithms, and Dynamic Optimization.

REFERENCE

Acquaye, A., Ibn-Mohammed, T., Genovese, A., Afrifa, G. A., Yamoah, F. A., & Oppon, E. (2018). A quantitative model for environmentally sustainable supply chain performance measurement. *European Journal of Operational Research*, *269*(1), 188–205.

Al-Odeh, M., & Smallwood, J. (2012). Sustainable supply chain management: Literature review, trends, and framework. ... ... *Engineering & Management*.

Ariyanti, R., Khairil, K., & Kanedi, I. (2015). Pemanfaatan Google Maps Api Pada Sistem Informasi Geografis Direktori Perguruan Tinggi Di Kota Bengkulu. *Jurnal Media Infotama*, *11*(2).

Asmira, A., Leiwakabessy, A., & Patty, R. (2015). Penerapan Depresiasi Aset Tetap Terhadap Laporan Laba Rugi Pada PT Bosowa Berman Motor Di Kota Ambon. *Jurnal Maneksi (Management Ekonomi Dan Akuntansi*, *4*(2), 22–34.

Endrawati, T., & Siregar, M. T. (2018). Analysis of logistic distribution performance of good supply from PT. In *Mentari Trans Nusantara distribution center to branches using Smart PLS 3.0*.

Faridl, M. (2016). *TA: Rancang Bangun Sistem Administrasi Pengiriman Barang Berbasis Web di PT Graha Prima*. Institut Bisnis dan Informatika Stikom Surabaya.

Hanif, R., Oktyajati, N., & Nugraheni, D. D. (2022). PENENTUAN RUTE DISTRIBUSI UNTUK MEMINIMALKAN BIAYA TRANSPORTASI MENGGUNAKAN METODE SAVINGiMATRIX DAN NEARESTiINSERT. *Journal of Research and Technology Studies*, *1*(1), 25–34.

Magazzino, C., Alola, A. A., & Schneider, N. (2021). The trilemma of innovation, logistics performance, and environmental quality in 25 topmost logistics countries: A quantile regression evidence. *Journal of Cleaner Production*. https://www.sciencedirect.com/science/article/pii/S095965262103239X

Mangiaracina, R., Marchet, G., & Perotti, S. (2015). A review of the environmental implications of B2C e-commerce: a logistics perspective. ... ... *& Logistics Management*. https://doi.org/10.1108/IJPDLM-06-2014-0133

Manupati, V. K., Schoenherr, T., & Ramkumar, M. (2020). A blockchain-based approach for a multi-echelon sustainable supply chain. *International Journal*. https://doi.org/10.1080/00207543.2019.1683248

Manzouri, M., & Rahman, M. N. A. (2013). Adaptation of supply chain management theories to lean supply chain management. ... ... *Journal of Logistics Systems*. https://doi.org/10.1504/IJLSM.2013.051019

Marchet, G., Melacini, M., & Perotti, S. (2014). Environmental sustainability in logistics and freight transportation: A literature review and research agenda. ... ... *Technology Management*. https://doi.org/10.1108/jmtm-06-2012-0065

Masudin, I., Fernanda, F. W., & Widayat, W. (2018). Halal logistics performance and customer loyalty: From the literature review to a conceptual framework. *International Journal of Technology*, *9*(5), 1072–1084.

Pettit, T., Croxton, K., & Fiksel, J. (2019). The evolution of resilience in supply chain management: a retrospective on ensuring supply chain resilience. *Journal of Business Logistics*. https://doi.org/10.1111/jbl.12202

Piaralal, S. K., Nair, S. R., & Yahya, N. (2015). An integrated model of the likelihood and extent of adoption of green practices in small and medium-sized logistics firms. *American Journal Of*. https://www.academia.edu/download/75345805/10.5923.c.economics.201501.32.pdf

Pratiwi, I. T., Zulfikar, Z., & Widya, M. A. A. (2021). Sistem Informasi Manajemen Paket Ekspedisi CV. *MK Express*. *Jurnal SITECH: Sistem Informasi dan Teknologi*, *4*(1), 7–18.

Rohmer, S. U. K., Gerdessen, J. C., & Claassen, G. D. H. (2019). Sustainable supply chain design in the food system with dietary considerations: A multi-objective analysis. *European Journal Of*. https://www.sciencedirect.com/science/article/pii/S0377221718307525

Siregar, M. T., Puara, Z. P., & Leonardb, P. (2019). *Design of Application Information Systems For Monitoring Enterprise Activities Integrated with Android Operating Systems*.

Suparjo, S. (2017). Metode Saving Matrix Sebagai Alternatif Efisiensi Biaya Distribusi (Studi Empirik Pada Perusahaan Angkutan Kayu Gelondongan Di Jawa Tengah. *Media Ekonomi dan Manajemen*, *32(2*, 2503–4464.

Syarief, F., Kurniawan, A., Widodo, Z. D., Nugroho, H., Rimayanti, R., Siregar, E., & Siregar, Z. H. (2022). *Manajemen sumber daya manusia: Penerbit Widina*.

Tan, K., Ahmed, M., & Sundaram, D. (2010). Sustainable enterprise modelling and simulation in a warehousing context. ... ... *Process Management Journal*. https://doi.org/10.1108/14637151011076511

Tian, Y., Govindan, K., & Zhu, Q. (2014). A system dynamics model based on evolutionary game theory for green supply chain management diffusion among Chinese manufacturers. *Journal of Cleaner Production*. https://www.sciencedirect.com/science/article/pii/S0959652614005551

Wamba, S. F., Queiroz, M. M., & Trinchera, L. (2020). Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation. *International Journal of Production Economics*, *229*, 107791.

Yuniarti, R., & Astuti, M. (2013). Penerapan metode saving matrix dalam penjadwalan dan penentuan rute distribusi premium di SPBU Kota Malang. *Jurnal Rekayasa Mesin*, *4*(1), 17–26 2477–6041.

Zagloel, T. Y. M., Siregar, M. T., Hidayatno, A., & Setiawan, A. D. (2024). Development of sustainable logistics performance model using system dynamics in urban logistics service companies in Indonesia. *Cogent Business & Management*, *11*(1), 2286684.