

Optimizing Supply Chain Joint Total Cost (JTC) in The Batik Industry by Considering Workers' Mental Health

UNDERGRADUATE THESIS

**Submitted to the International Undergraduate Program in Industrial Engineering in
Partial Fulfilment of Requirement for the Degree of Sarjana Teknik at the Faculty of
Industrial Technology
Universitas Islam Indonesia**



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Demikian surat keterangan penelitian ini kami buat. Atas perhatiannya dan kerja samanya kami mengucapkan terima kasih.

Wassalamu'alaikum Warohmatullahi Wabarokaatuh

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**OPTIMIZING SUPPLY CHAIN JOINT TOTAL COST (JTC) IN THE BATIK
INDUSTRY BY CONSIDERING WORKERS' MENTAL HEALTH**

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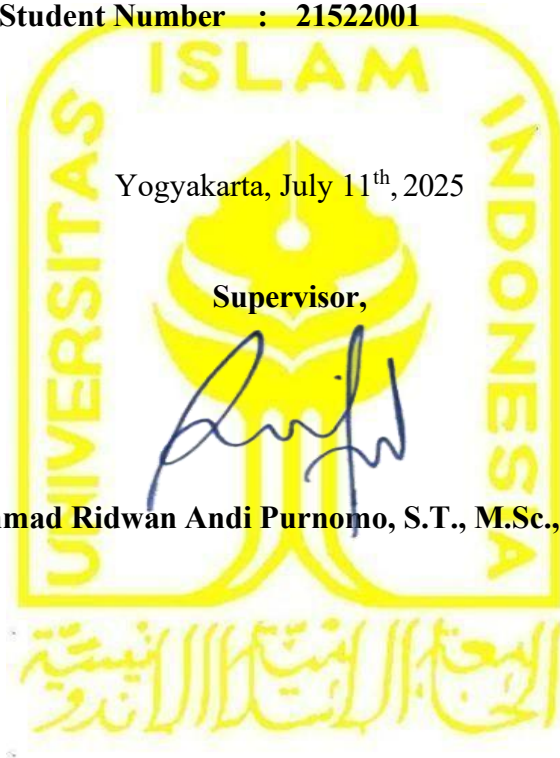
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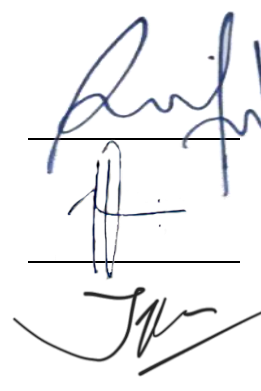
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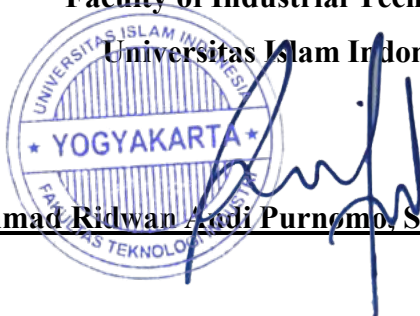
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DEDICATION PAGE

This undergraduate thesis is sincerely dedicated to my beloved parents, *Papa* and *Mama*, who have always supported and prayed for me. Thank you for believing in me, for being my number one supporter, and for standing by my side through every step of this journey. To all my siblings, thank you for your constant encouragement and strength, which has helped me move forward even in the most difficult times.

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Last but not least, I am deeply grateful to myself for holding on, for not giving up, and for fighting until this far.

MOTTO

“Indeed, with hardship comes ease”
(Surah Ash-Sharh [Al-Insyirah]: 6)

“Allah does not burden a soul beyond that it can bear”
(Surah Al-Baqarah: 286)

PREFACE

Assalamu’alaikum Warahmatullaahi Wabaraakatuh

All praises and gratitude be to Allah SWT, for His mercy, grace, and guidance that have enabled the author to complete this undergraduate thesis entitled "Optimizing Supply Chain Joint Total Cost (JTC) in the Batik Industry by Considering Workers' Mental Health". This undergraduate thesis is submitted as a partial fulfillment of the requirements to obtain a Bachelor's degree in Industrial Engineering, Faculty of Industrial Technology, Universitas Islam Indonesia. The completion of this thesis would not have been possible without the support, guidance, and encouragement from various individuals and institutions. Therefore, the author would like to express sincere appreciation and deepest gratitude to the following:

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11. To someone who has supported the author and accompanied the author through every step of this journey.
12. All parties who have assisted the author throughout the undergraduate thesis research that cannot be mentioned individually.

The author is fully aware that this thesis may still contain imperfections. Constructive criticism and suggestions are highly welcomed for the improvement of future research. Finally, the author hopes that this thesis may provide useful insights and contribute to the academic discourse in the field of Industrial Engineering.

Wassalamu'alaikum Warahmatullahi Wabarakatuh

Yogyakarta, July 1st, 2025

A handwritten signature in black ink, appearing to read 'Lulu R. N.' with a stylized flourish.

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ABSTRACT

Batik is one of the creative economic sectors that is growing rapidly and involves a large workforce across industrial centers and SMEs in Indonesia. Along with the growth of the batik industry, the demand for batik products has also increased significantly, creating a challenge in meeting this demand while managing the workload of each worker. Managing this workload is crucial, as excessive workload can lead to mental health issues among workers. Preliminary studies indicate that six workers are potentially experiencing mental health problems. Logistic Regression equation used to predict the mental health issues among workers. This study aims to address the challenge by analyzing the supply chain to fulfill demand while simultaneously considering the condition of the workers. In order to optimize the overall supply chain system, the optimization must consider the Joint Total Cost (JTC) between all of the chain. But on the other hand, the batik industry also needs to consider the workers' condition. The optimization results using the Solver function in Microsoft Excel indicate that the total cost was successfully reduced from IDR 2,055,708,000 to IDR 1,325,152,000. This reflects a cost reduction of IDR 730,556,000 or an improvement of 35.53%, demonstrating the effectiveness of the optimization in minimizing the joint total cost across the entire supply chain. Furthermore, by reallocating the workload, the prediction result of the number of workers experiencing mental health issues decreased from 6 to 3 workers, indicating a positive impact of workload distribution on employee well-being.

Keywords: Joint Total Cost, Logistic Regression, Mental Health, Prediction, Supply Chain

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CHAPTER I

INTRODUCTION

1.1 Background

Batik is part of Indonesia's cultural heritage that has been recognized by UNESCO. It is widely appreciated by many people, as each motif carries a unique identity and reflects Indonesia's rich cultural values. In the modern era, batik has gained significant popularity in the fashion industry. This phenomenon has driven the rapid growth of the batik industry, both in local and international markets (Kurniasih et al., 2024).

Along with the changing times and globalization trends, batik has undergone a significant transformation in the modern fashion world. Not only worn during traditional events or ceremonies, but batik has also now become part of urban and modern lifestyles, both domestically and internationally. Designs between local artisans and fashion designers have contributed to Batik's presence in various international fashion events. This increased exposure has had a positive impact on the growth of the batik industry, as reflected in the increasing production volume and export value of Indonesian batik in recent years, and can sustain the Indonesian economy (Xiao, 2024).

In the current era, batik has evolved and is now produced in large quantities to meet the demand of the textile industry. There are many types of batik in Indonesia, with each region or province having its own unique characteristics. The techniques used in its development vary, including traditional methods using a canting (a pen-like tool filled with hot wax), cap (stamp batik using molds or screen printing), and even digital printing machines. In addition, people have become more fashion-conscious, often combining batik with modern fashion styles, making batik more appealing to people from all walks of life (Sugiarto et al., 2023).

Particularly in the international market, Indonesia's batik industry experienced a steady upward trend from 2020 to 2022, before seeing a slight dip in early 2023. The range of exported batik products is impressively diverse, with men's shirts, suits, dresses, cotton fabrics, and trousers topping the list. This wide variety of fashion items that can be combined with batik reflects its strong appeal and high market demand. Notably, in 2022 alone, Batik exports reached a remarkable value of USD 744.79 million.

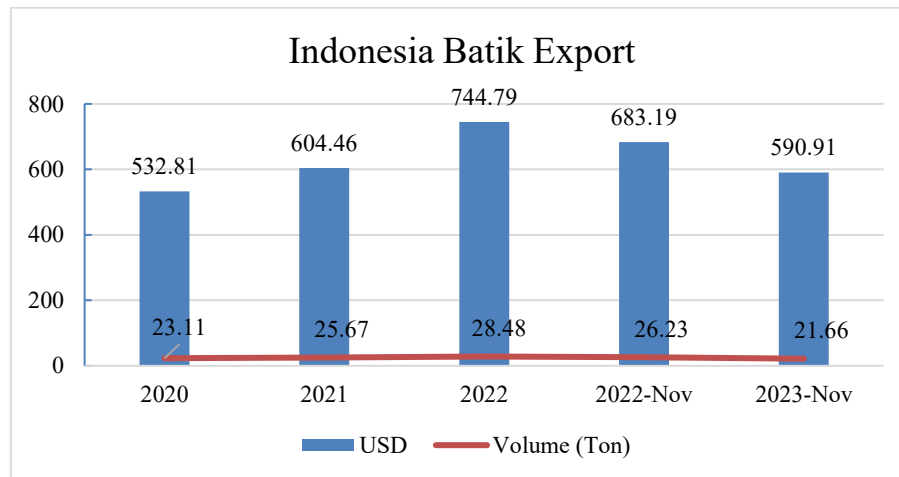


Figure 1. 1 Export Batik History

(Source: Kementerian Perdagangan RI – Realisasi Ekspor Impor Batik Indonesia)

Along with the growth of the batik industry, the demand for batik products has also increased. The marketing process for batik products is carried out by retailers, who sell directly to customers. Retailers play a crucial role in the batik industry as the main distributors, delivering finished products to consumers. A successful retail business is characterized by its ability to manage product sales, administrative and financial needs, supply chain management, marketing strategies, and business relationships with partners. In line with its function, retail primarily focuses on marketing products to end customers for their personal use (Chaniago et al., 2019).

The batik industry is one of the creative economic sectors with high cultural value, experiencing an increasing number of enthusiasts each year. According to the Ministry of Industry, the domestic batik industry had employed approximately 200.000 workers as of August 2024. These workers are spread across 201 industrial centers and 5.946 small and medium-sized enterprises (SMEs) in 11 provinces (Kompas.id). According to data from the Center for Handicrafts and Batik (BBKB) of the Ministry of Industry from 2018 to 2022, as shown in Figure 1.2, approximately 2.951 batik MSMEs were operating across Indonesia. The batik industry is predominantly in the micro and medium scale sectors and has experienced significant growth within communities. This development has had a positive impact on the economy through the manufacturing industry. Employment data indicates that the garment industry ranks second in terms of the highest proportion of workers compared to other industrial sectors. The textile industry, which includes batik, is a promising sector to pursue, as it contributes to the national economy while simultaneously empowering workers on a large scale.

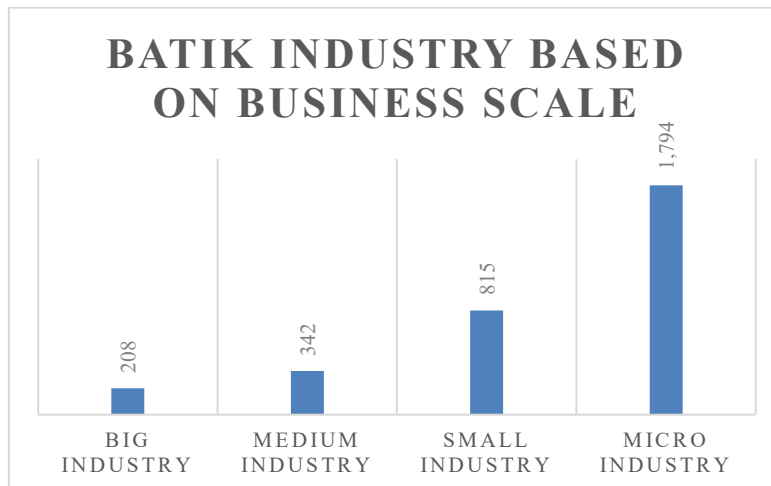


Figure 1. 2 Batik Industry Development

(Source: katadata.co.id)

Regarding production, retailers source products from manufacturers, commonly referred to as production vendors. Retailers maintain relationships with vendors and batik-producing factories to meet customer demand. This relationship forms a critical supply chain connection that must be maintained to ensure mutual success (Martadisastra & Faisal, 2021). In this context, vendors play a crucial role in fulfilling product demands according to the needs of buyers or retailers. Additionally, vendors are responsible for meeting the target production quantity and ensuring timely delivery (Zakaria, 2021).

The production fulfillment process involves various aspects, including resource and capacity management, which encompasses the use of raw materials, the implementation of technology in production, and the management of distribution capacity and labor. Efficiency in managing these aspects is essential for maintaining a smooth supply chain and ensuring customer satisfaction. In the industrial world, the imbalance between demand and availability of goods often causes two main problems, namely overstock and stockout. Both of these conditions have a direct impact on increasing total costs in the supply chain. On the other hand, the results of a preliminary study showed that six workers had the potential to experience mental health problems. Optimizing relationships in the supply chain aims to maximize the efficiency of business processes through strategic steps, such as minimizing operational costs, reducing excess inventory, and reducing other costs such as transportation, manufacturing, and distribution.

Business actors in the supply chain management (SCM) system certainly expect maximum profits with minimal losses. For this reason, transparent communication is needed

between all stakeholders in every operational activity, especially those related to costs (Damodaram et al., 2022). Efforts to reduce costs must maintain the smooth running of the business system and be able to meet customer demand optimally. In this context, attention to worker welfare is also no less important. High work pressure due to supply chain inefficiencies can increase the risk of mental health disorders. Therefore, the researcher took an integrative approach that combines cost efficiency in the supply chain with the management of workers' mental health risks as a case study that needs to be studied further in this research.

Besides that, labor management aims to balance workloads by ensuring that vendors can meet retail demands effectively. This effort can be achieved by considering workforce availability, distributing tasks evenly, and enhancing workers' skills. Such an approach significantly impacts workers' mental well-being, making it an important consideration in improving productivity and overall quality of life (Tertia, 2022). Based on interviews conducted with workers, it was found that the existing overtime system creates an imbalance in workload distribution among workers. Some workers stated that the long overtime hours can lead to severe fatigue. This condition not only affects physical exhaustion but also causes psychological pressure, resulting in high levels of stress. Therefore, to prevent stress among workers, it is necessary to evaluate workload distribution to ensure a fair and equitable allocation. Furthermore, companies must consider all aspects related to employee welfare to prevent any disruptions in the production process and ensure that target goals are successfully met.

The production performance of vendors or companies can be disrupted if the manpower experiences mental health issues or disturbances. This can also negatively impact the company's performance records. Additionally, buyers (retailers) may become dissatisfied due to subpar production services, potentially affecting the overall success of the company's business operations (Widyana & Firmansyah, 2021). Such circumstances threaten the previously established supplier relationship management. A loss of trust may occur if manufacturers fail to deliver products in the required quantity and specifications. Both vendors and retailers may suffer financial losses due to increased costs resulting from delays in the supply chain process. As a preventive measure, both parties must maintain open communication and develop strategies to minimize failures in business processes and batik product marketing. To address this issue, researchers utilize historical inventory or production data from vendors to determine the optimal best order quantity for future use. However, since this work involves human

resources, it is essential to consider an equitable workload distribution to ensure that the productivity of workers involved in supply chain management remains unaffected.

A previous study titled “Application of Logistic Regression Model in Mental Health Evaluation: A Case Study of Farmers Working Under High Voltage Transmission Line (HVTL)” by Fatima et al., (2022), examined the psychological health effects of electromagnetic fields generated by high-voltage transmission lines (HVTL) on farmers in Pakistan. This research employed the logistic regression method to predict the likelihood of psychological disorders among 200 farmers exposed to electromagnetic fields from HVTL. The variables used in the study included gender, age, transmission line type, working duration, and prior health condition. The findings revealed that female farmers, particularly those aged 46-69 who worked under 220 KV transmission lines for up to six hours per day, were at a higher risk of experiencing psychological disorders. The impact of these issues could disrupt farmers' ability to work effectively and manage daily agricultural activities, ultimately affecting their crop yields and economic stability.

Another study titled “Application of Economic Order Quantity and Reorder Point Methods in Improving the Efficiency of Coffee Raw Material Supply (Case Study at PT. Herbal Salam)” by Susilowati & Aria (2022), focused on effective inventory control to prevent production halts and minimize excessive inventory costs. This research applied the Economic Order Quantity (EOQ) and Reorder Point (ROP) methods to analyze the management of coffee raw material inventory at PT. Herbal Salam. The objective was to enhance the efficiency of raw material supply and improve inventory management performance within the company. The study's findings indicated that the coffee raw material inventory system at PT. Herbal Salam was not yet optimized and had not achieved minimal inventory costs. As a result, improvements were implemented, leading to cost savings of more than 50% compared to the company's existing inventory policy.

From the two studies mentioned, it can be observed that the logistic regression method was applied to predict the likelihood of psychological disorders in specific subjects. Logistic regression was chosen because it can handle binary classification effectively, in accordance with the characteristics of mental health data, which are generally divided into two classes, such as "suffer from mental health" and "not suffer from mental health". This algorithm also provides flexibility in assigning weights to each predictor factor, making it easier to identify and interpret the relative influence of various variables on workers' mental condition. In addition, Logistic

Regression is suitable for use on data that is not too complex and has a simple interpretation (Wahyuningsih et al., 2024).

This study aims to examine the supply chain collaboration between vendors and retailers in fulfilling customer demand for batik products. This process requires consideration of several factors that may impact workers' mental health during production management, ensuring that orders are fulfilled according to the buyer's requested quantity.

Employee mental health is a crucial aspect that directly contributes to productivity, performance, and overall well-being in the workplace, including in the batik industry. Numerous studies have shown that mental health is influenced by various psychological and social factors. One of the primary factors is stress level. A study conducted by He et al. (2025), involving 817 college students, revealed that perceived stress has a significant negative impact on mental health. Individuals experiencing prolonged stress are more likely to suffer from fatigue, difficulties in time and task management, and reduced self-control, all of which can eventually disrupt psychological stability.

Stress levels are closely related to the workload received by workers. A heavy workload can increase psychological pressure, which in turn affects emotional balance and overall mental health (Purbasari & Purnomo, 2019). In addition to workload, sleep duration also plays a vital role in maintaining mental health. Research by Fasokun et al. (2025) indicates that sleep deprivation can weaken the immune system, elevate stress levels, cause emotional instability, and impair cognitive performance in completing work-related tasks.

Furthermore, burnout serves as a highly relevant indicator in assessing the mental condition of workers. Burnout is characterized by emotional exhaustion, decreased motivation, and feelings of helplessness, which can develop into chronic stress, anxiety, and even depression (Papathanasiou, 2015). This condition is commonly triggered by prolonged work-related stress, lack of social support, and insufficient recovery time.

Demographic factors such as age and years of work experience have also been shown to affect mental health significantly. Older workers generally have lower physical endurance and require longer recovery periods compared to younger workers, even when facing the same workload. This is due to physiological changes associated with aging, which can impact stamina and work resilience (Hidayatunikhmah & W, 2025). On the other hand, workers with longer work experience tend to develop better coping mechanisms under pressure, are more adept at solving complex problems, and are better able to maintain psychological stability. More

experienced workers are also typically more motivated and exhibit fewer symptoms of mental health issues (Eklund et al., 2021).

Based on these findings, the selection of variables, such as Stress Level, Workload of Employee, Sleep Duration, Burnout Level, Age of Employee, Experience Year in Working, and Dependent on Company Board is highly relevant and essential in developing a predictive model to assess the mental health condition of workers in the batik industry using logistic regression. By considering psychological and social dimensions, the predictive model is expected to provide a comprehensive overview of mental health issues in industrial work settings.

1.2 Problem Formulation

Based on this research background description, the problem formulation is as follows:

- a. How much is the Joint Total Cost (JTC) after optimization by considering workers' mental health in the vendor?
- b. How much did the number of employees experiencing mental health problems decrease after the optimization process in the vendor was implemented?

1.3 Research Objectives

The following are the research objectives that will be achieved based on the results of the problem formulation that has been determined:

- a. Able to determine the optimized Joint Total Cost (JTC) between sellers and buyers in the vendor.
- b. Able to identify the decrease in the number of employees experiencing mental health problems after the optimization process in the vendor.

1.4 Research Limitations

The following are the research limitations that will be achieved based on the results of the problem formulation that has been determined:

- a. This study was conducted on a batik-producing vendor that supplies its products to five retailers in Yogyakarta.
- b. This study only focuses on the implementation of the pull system and does not consider the push system in the batik industry supply chain.

- c. This study does not consider the product quality in its analysis. All products produced in this study are assumed to have consistent quality and be free of defects, regardless of any variability that may exist in the production process.

1.5 Research Benefits

The following are the research benefits that will be achieved based on the results of the problem formulation that has been determined:

- a. This study increases researchers' understanding of the factors influencing mental health issues in supplier relationship management.
- b. It provides insights for companies in determining the best order quantity during the procurement process in retail to minimize costs.
- c. Additionally, this research establishes a theoretical foundation based on study findings and offers a new perspective as a reference for future research.

1.6 Systematic Research

The systematics of writing this final assignment report are structured into six chapters as follows:

CHAPTER I INTRODUCTION

This chapter provides the research background, including the problems, research direction, and challenges faced in the study. Generally, it explains the problem formulation, research objectives and benefits, as well as the systematic structure of the research.

CHAPTER II LITERATURE REVIEW

This chapter presents a literature review covering supporting theories related to the study. It also includes a comparative study using previous research articles on similar topics, which serve as a foundation for strengthening the research framework.

CHAPTER III RESEARCH METHOD

This chapter describes the research framework for solving the identified problem. It explains the subjects, objects, equipment, and materials used in the study, the data collection methods, and the research mechanism or workflow.

CHAPTER IV DATA COLLECTION AND PROCESSING

This chapter is a crucial stage of the study, presenting the data processing procedures and results using relevant methods or algorithms.

CHAPTER V DISCUSSION

This chapter discusses the findings from the previous chapter, interpreting them through a theoretical basis while providing a detailed analysis.

CHAPTER VI CONCLUSION AND RECOMMENDATION

This chapter presents the conclusions derived from the analysis and discussion. The findings are used to answer the research objectives or problem formulation. Additionally, this chapter includes recommendations based on the research findings and suggestions for future studies.

CHAPTER II

LITERATURE REVIEW

2.1 Theoretical Basis

2.1.1 Supply Chain Management

Supply chain management (SCM) is a series of activities and production processes that encompass the acquisition of raw materials, value-adding processes that convert raw materials into finished goods, inventory management, and the distribution of these goods. The supply chain process is designed to meet the competitive demand from customers (Yusuf, 2022).

SCM refers to the internal and external relationships between suppliers, the focal company, distributors, and customers/consumers to ensure an efficient and effective flow of materials, information, and finances that meet stakeholder requirements (Sharma et al., 2021). The effective implementation of supply chain management enables companies to optimize their operational processes, thereby increasing efficiency and reducing production costs. A well-coordinated supply chain also allows companies to provide better service to customers, ultimately enhancing customer satisfaction and loyalty.

2.1.2 Supplier Relationship Management

Supplier Relationship Management (SRM) is a process that involves managing, developing, strengthening, and terminating relationships with suppliers, including monitoring their performance to create and enhance value in collaboration. This process is divided into three sequential stages: External Supplier Management, Internal Supplier Management, and Supplier Dissolution Management (Moeller et al., 2006). SRM plays a crucial role in ensuring efficient operations, allowing the procurement process to run smoothly without disruptions in the supply chain. Effective SRM management not only impacts business operations and supplier performance but can also influence working conditions and the mental well-being of vendor workers. This is related to managing the order quantity that vendor workers must fulfill within a specific timeframe.

If vendor workers are required to work overtime continuously to meet short deadline demands, their workload will increase excessively. This can lead to stress, fatigue, and even burnout, especially if the set targets do not align with their work capacity (Aghniya & Aulia, 2022). By managing supplier relationships effectively, the quality of collaboration between

retailers and vendors can be maintained, and operational efficiency in retail can be improved. To ensure the effective implementation of SRM, continuous evaluation of vendor performance is necessary.

2.1.3 Retailer

Retail is a business sector that plays a role in selling and providing goods or services individually to end customers. The products sold are not intended for further business use but solely for the consumer's personal use (Vaja, 2015). Over time, retail has evolved into two main types: traditional retail and modern retail. The key difference between them lies in their management processes. Traditional retail is typically owned by individuals and operates with a conventional management system.

It often lacks detailed facilities and pricing information on products. On the other hand, modern retail is more systematically managed, offers a more comprehensive range of products, and is operated by a business entity or organization. In terms of physical infrastructure, modern retail is more advanced and utilizes the latest technology to facilitate transactions with customers (Sugiharto & Deniar, 2021).

2.1.4 Resource and Capacity Management

A company or organization always has target objectives that it aims to achieve by implementing various efforts. Success can be attained by maximizing and managing resources effectively, including raw materials, equipment, and human labor. Resource and capacity management is one of the key aspects that must be carefully considered. Proper management has a positive impact on business performance, employee well-being, and profitability (Hernita et al., 2021).

Generally, companies rely on human labor as their primary workforce, and these workers indirectly bear significant responsibility for the company's success. Therefore, providing adequate competency development and skill mastery for all workers is essential. Additionally, workload affects workers' mental health and work motivation. Poor performance can lead to losses for the company. Hence, mental health is a crucial aspect to consider, as it directly relates to resource capacity and overall performance.

2.1.5 Mental Health

In the modern era, mental health issues have become increasingly important and a growing concern. This is driven by rapid social, economic, and technological changes (Negara, 2024). According to the World Health Organization (WHO), mental health is a state in which individuals recognize their potential, can cope with life's stresses, work productively, and contribute to their community.

One of the factors affecting work productivity is mental health. As a result, mental health has gained attention, as it directly influences worker efficiency. When productivity increases, efficiency, work systems, and workforce skills also improve (Mardika, 2024). Good mental health plays a crucial role in how individuals think, feel, and interact with others. Therefore, people with mental disorders or illnesses may experience uncontrolled emotions, leading to negative behaviors (Akbar, 2023).

2.1.6 Logistic Regression

Logistic regression is a machine learning algorithm within statistical methods used to describe the relationship between a response variable (dependent variable) with two or more categories and one or more explanatory variables (independent variables) on a categorical or interval scale (Fagerland & Hosmer, 2012). This approach is commonly used to predict decision-making outcomes. One example is predicting whether a customer will purchase a product or not. Another example involves measuring the impact of economic and production-related variables on the amount of energy saved in small and medium-sized enterprises. This type of analysis is appropriate when the dependent variable (ASE) is dichotomous rather than continuous (Neves et al., 2022).

Logistic regression consists of several types, including Binary Logistic Regression and Multinomial Logistic Regression. Binary Logistic Regression is used when there are only two possible response variables (Y), such as purchasing and not purchasing. Meanwhile, Multinomial Logistic Regression is used when the response variable (Y) has more than two categories (Sofiyat et al., 2023). The choice of regression type depends on the category and sequence of the variables.

2.1.7 Mathematical Model

In predictive modelling, various mathematical methods have been applied, ranging from conventional linear regression to modern data mining techniques. In general, mathematical models consist of a series of equations that represent the quantitative relationships between independent variables, dependent variables, and predictors in numerical data form. Model validation is carried out by ensuring that the obtained predictions have a high level of accuracy (Huang & Fang, 2013).

2.2 Research Position

This research was developed based on a thorough literature review of previous studies. As shown in Table 2.1 below, each study had different objectives and methods. By comparing them, a research gap was identified that guided the focus of this study. Unlike previous studies that only covered some aspects, this research integrates the full set of keyword concepts, such as logistic regression, supply chain, cost optimization, prediction, and mental health. This research offers a more comprehensive and holistic approach. This highlights the unique contribution and positioning of this study within the existing literature.

Table 2. 1 Research Positioning

Author	Logistic Regression	Supply Chain	Cost Optimization	Prediction	Mental Health	Methodology or Algorithm
(Susilowati & Aria, 2022)		√	√			Economic Order Quantity (EOQ), Reorder Point (ROP)
(Alparslan et al., 2024)	√			√		Logistic Regression
(Selviana & Faturahman, 2021)	√			√		Logistic Regression
(Fatima et al., 2022)	√			√	√	Logistic Regression
(Alishiri et al., 2008)	√			√	√	Logistic Regression
(Chakraborty et al., 2023)	√			√		Logistic Regression
(Sitompul, 2022)		√	√			Setup Time Reduction Model, Lot Size Determination
(Shafiee & Mutalib, 2020)				√	√	Decision Tree (DT), Naive Bayes (NB), Support Vector

Author	Logistic Regression	Supply Chain	Cost Optimization	Prediction	Mental Health	Methodology or Algorithm
						Machine (SVM), K-Nearest Neighbors (KNN)
(Tate et al., 2020)	√			√	√	Random Forest (RF), Support Vector Machine (SVM), Logistic Regression, Gradient Boosting Machines (GBM)
(Sumathi & Poorna, 2016)				√	√	Naive Bayes (NB), Decision Tree (DT), Support Vector Machine (SVM)
(Azzoni et al., 1995)				√		Deterministic Mathematical Modeling
(Wang et al., 2021)	√			√	√	Logistic Regression, Random Forest, Gradient Boosting Decision Tree, Support Vector Machine
(Iqbal et al., 2023)		√		√		Classification and Regression Tree
(Oktavia, 2023)	√			√		Logistic Regression
(Amalia & Sasongko, 2024)				√		Logistic Regression
(Borucka & Grzelak, 2019)	√					Logistic Regression
(Mahyuddin et al., 2021)	√	√				Logistic Regression
(Rustam et al., 2021)	√			√		Binary Logistic Regression
(Momon & Wijaya, 2015)	√	√		√		Binary Logistic Regression
(Fujia et al., 2022)	√			√		Binary Logistic Regression
Lulu Riesta Nugroho	√	√	√	√	√	Evolutionary Algorithm

The research titled “Analysis of Factors Affecting Customer Satisfaction Using Binary Logistic Regression” by Fujia et al., (2022), focuses on analyzing the factors influencing customer satisfaction at Indomaret using binary logistic regression analysis. This study identifies five independent variables that significantly affect customer satisfaction: service quality, product quality, price, cost, and emotional factors. The results indicate that service quality is the most significant factor influencing customer satisfaction, highlighting the importance of maintaining high service standards in a competitive retail environment. Furthermore, the study discusses the challenges Indomaret faces due to increasing competition from other retail outlets, emphasizing the need for effective strategies to retain customers and enhance satisfaction.

The next study, titled “Production Target Achievement Model Development Using Binary Logistic Regression Method in PT. Hansae Karawang Indonesia” by Momon & Wijaya (2015), focuses on developing a production target achievement model for PT. Hansae Karawang using the binary logistic regression method. This research aims to address challenges faced by a garment company in Indonesia in meeting export shipment targets due to labor fluctuations, machine availability, and overtime work. Using a mathematical modelling approach, the study demonstrates that all analysed factors are statistically significant, and the logistic regression model is effective in predicting production target achievement. The findings emphasize the importance of high-quality input in the production process to meet market demand and enhance competitiveness in the global garment industry.

The next study, titled “Pancreatic Cancer Classification Using Logistic Regression and Random Forest,” by Rustam et al., (2021), investigates the classification of pancreatic cancer using logistic regression and random forest methods for disease prediction and classification on similar datasets. This research evaluates both methods based on accuracy, precision, recall, and F1-score, with varying percentages of training data. The results indicate that the random forest method outperforms logistic regression, achieving a maximum accuracy of 99.38% with 20% training data, compared to the best accuracy of logistic regression at 96.48% with 30% training data. These findings highlight the effectiveness of machine learning in medical diagnostics, particularly for pancreatic cancer classification.

The next study, titled “Application of Logistic Regression for Production Machinery Efficiency Evaluation” by Borucka & Grzelak, (2019), discusses the importance of operational efficiency and the need for continuous monitoring and evaluation of effectiveness indicators, particularly in companies that lack advanced Manufacturing Execution Systems (MES). This

research applies a mathematical model, specifically logistic regression, to analyze and evaluate production process efficiency in manufacturing companies. The study also emphasizes the correlation between product demand and the production process, highlighting that strategies require verification and modification to maximize machine utilization and reduce idle time.

The next study, titled “Application of Logistic Regression Model in Mental Health Evaluation: A Case Study of Farmers Working Under High Voltage Transmission Line (HVTL)” by Fatima et al., (2022), employs logistic regression analysis to investigate the psychological health impact of electromagnetic fields generated by HVTL on farmers in Pakistan. This research examines factors such as gender, age, transmission line type, working duration, and existing health conditions to assess the likelihood of psychological disorders among 200 farmers (180 men and 20 women). The results indicate that female farmers aged 46–69 working under 220 kV HVTL for up to six hours daily are at a higher risk of psychological issues. The applied logistic regression model demonstrates statistical significance, explaining 32.7% to 47.3% of the variance in psychological disorders, with 60% sensitivity and 92.4% specificity.

The next study, titled “Utilizing Logistic Regression for Analyzing Customer Behavior in an E-Retail Company,” by Alparslan et al., (2024), explores the application of machine learning algorithms, particularly logistic regression, to analyze large datasets generated by e-retail websites. This approach aims to understand customer behavior, enhance product recommendation systems, and predict purchasing decisions in real-time. The study achieves a predictive model accuracy of 79.73%, demonstrating the effectiveness of machine learning in improving customer satisfaction and boosting sales in the highly competitive e-commerce environment.

The next study, titled “Prediction of Mental Health in Medical Workers During COVID-19 Based on Machine Learning,” by Wang et al., (2021), introduces a new predictive model using machine learning techniques to assess the mental health of medical workers during COVID-19. This model integrates various factors affecting mental health and achieves a prediction accuracy of 92.55%. The study underscores the urgent need for mental health services for medical workers, who are at high risk of anxiety and depression due to the stress and challenges of the pandemic.

The next study, titled "Analysis and Prediction of Rockfalls Using a Mathematical Model," by Azzoni et al., (1995), involves the use of a mathematical model, specifically the

CADMA model, developed by ISMES and ENEL CRIS, which enables a more rational and iterative analysis of rockfalls. This model, combined with field testing, has significantly enhanced the understanding of rockfall phenomena, allowing for more accurate predictions and the development of effective protective structures. The study highlights the importance of experimental methods and computer models in rockfall research, focusing on accurate trajectory and energy assessments to improve risk zoning and defense systems in densely populated mountainous regions such as the Alps.

The next study, titled "Application of Economic Order Quantity and Reorder Point Methods in Improving the Efficiency of Coffee Raw Material Supply (Case Study at PT. Herbal Salam)," by Susilowati & Aria, (2022), analyzes the inventory management of coffee raw materials at PT. Herbal Salam using the Economic Order Quantity (EOQ) and Reorder Point (ROP) methods to enhance efficiency and reduce costs. The research findings indicate that the optimal order quantity for raw materials is 5,280 kg per year, with a total inventory cost of IDR 20,437,800. The company should place orders 14 times a year, approximately every 26 days. Additionally, it is recommended that the company maintain a safety stock of 38 units and set the reorder point (ROP) at 720 kg to prevent stock shortages. This study highlights that the current raw material supply system is not optimal, and implementing the EOQ method can lead to significant cost savings of over 50%. Furthermore, it underscores the importance of effective inventory management in meeting production demands.

Based on the literature review on logistic regression, supply chain, and mental health, these studies will serve as references for the current research. This study focuses on predictive mental health in the supply chain of the batik industry, where the industry acts as a vendor and maintains relationships with multiple suppliers (buyers). The production and distribution processes are carried out to meet customer demand for batik products. By applying logistic regression, this research aims to assist batik vendors in determining production quantity targets while considering various resource availability factors. Workers are a crucial resource in the production process. To ensure optimal productivity, companies must take into account mental health factors for the workers involved, ensuring a sustainable and efficient supply chain system.

CHAPTER III

RESEARCH METHOD

3.1.1 Research Subject

The subjects of this research are vendors and retailers who have a collaborative relationship in the batik production supply chain. Vendors play a role in fulfilling the demand for several products that are distributed to customers through retailers. Several retailers collaborate with vendors to meet customer demand by carrying out distribution or delivery activities for batik products.

3.1.2 Research Object

The object of this research is a multi-echelon supply chain system with lateral transshipment. This process is carried out by considering the mental health issues of vendor workers who produce batik to be distributed to retailers. The batik industry under study comprises a single vendor and five buyers, engaging in a multi-product business model.

3.1.3 Problem Identification

At this stage, the process of observing problems that occur in the field is carried out, where the results of the observations will be analyzed to find the main issues that need to be studied further. This stage aims to find the gap between the ideal condition and the actual condition that is currently occurring. The process of identifying problems needs to be carried out so that researchers understand the problems that are occurring as a whole before formulating the focus of the research.

3.1.4 Problem Formulation

After thoroughly identifying the problem, the researcher must formulate the research problem that will serve as the focus of the study. This formulation is presented in the form of specific questions, which will be addressed in the conclusion. In this study, there are two research questions that focus on Joint Total Cost and workers' Mental Health, both of which can be systematically analyzed and investigated.

3.1.5 Literature Survey

At this stage, a literature survey is conducted to understand the theoretical foundations and previous findings relevant to the research topic. This process is essential for identifying the research gap that can serve as the basis for a new study. By analyzing various scientific sources such as journals and previous articles, researchers can develop a research concept with a certain approach.

3.1.6 Supply Chain System Description

This study refers to the supply chain system for batik products in Yogyakarta, where one vendor is supplying five batik products to five buyers (retailers). To manage uncertain demand, a buyer may source products from another buyer, allowing for quicker replenishment and lower ordering costs. The supply chain configuration is shown in Figure 3.1 below.

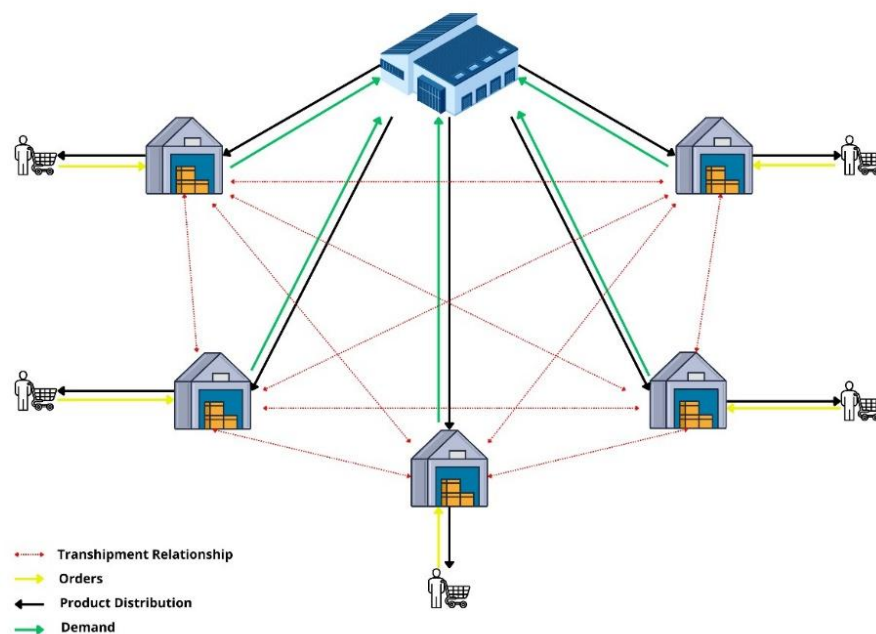


Figure 3. 1 The Supply Chain System Diagram

3.1.7 Mathematical Model Development

a. Variables and Parameters Definition

In this study, there are several variables used in the calculation process. The variables consist of parameter and decision variable. The variables and parameters of this study are explained by lists below.

Parameters

<i>A</i>	: Ordering Cost
<i>H</i>	: Holding Cost
π	: Profit loss
<i>I</i>₀	: Beginning Inventory
<i>P</i>	: Period of order/Lead time

Decision Variables

<i>R</i>	: Reorder Point
<i>P</i>_Q	: Production Quantity

Variables

<i>SL</i>	: Stress Level
<i>WL</i>	: Workload of Employee
<i>SH</i>	: Sleep Hours
<i>BS</i>	: Burnout Score
<i>Ag</i>	: Ages of Employee
<i>Ey</i>	: Experience Year in working
<i>D</i>	: Dependent on company board
<i>I</i>	: Interaction

b. Mathematical Model

Mathematical Model Development is a mathematical representation in the form of an equation or model system formulated to obtain results logically and quantitatively. The following is the mathematical model formula used in this study. According to the historical data, the demand of the buyer is following statistical distribution, namely normal and uniform. Equation 1 is used to simulate normal distribution while Equation 2 is used to simulate uniform distribution.

$$\textbf{Demand (Normal)} = \text{round}(\text{norm.inv}\left(\text{rand}(\quad), \frac{\text{mean}}{\text{days}}, \frac{\text{deviation}}{\text{days}}\right), 0) \quad (1)$$

$$\textbf{Demand (Uniform)} = \text{round}\left(\text{randbetween}(\quad), \frac{\text{mean, deviation}}{\text{days}}, 0\right) \quad (2)$$

Buyer Demand

$$\begin{aligned}
&= \text{round}(\text{if}(\text{mod}(t_n, 7) \\
&= 6, \text{if}(\text{rand}(\quad) \\
&> 0.5, \frac{\text{randbetween}(20, 100)}{30, 0}), \text{if}(\text{and}(\text{demand}_{n-1} = 0, \text{mod}(t_n, 7) \\
&= 0), \text{randbetween}(20, \frac{100}{30, 0}), 0)
\end{aligned} \tag{3}$$

Ending Inventory

$$\begin{aligned}
&= \max(0, (\text{beginning inv} + \text{vendor ord} + \text{buyer ord}) \\
&- \text{sum}(\text{demand} + \text{buyer demand}))
\end{aligned} \tag{4}$$

$$\begin{aligned}
\text{Lost Sales} &= \max(0, \text{sum}(\text{demand} + \text{buyer demand}) \\
&- (\text{beginning inv} + \text{vendor ord} + \text{buyer ord}))
\end{aligned} \tag{5}$$

$$\text{Order Status} = \text{if}(\text{mod}(t_n, P) = 0, 1, 0) \tag{6}$$

$$\begin{aligned}
\text{Vendor Order} &= \text{if}(\text{offset}(\text{order status}_n, -\text{lead time}, 0) \\
&= 1, R - \text{offset}(\text{ending inventory}_n, -\text{lead time}, 0), 0)
\end{aligned} \tag{7}$$

$$\text{Ordering Cost (A)} = \max(0, \text{order status} \times \text{ordering cost} \times \left(\frac{R - \text{ending inventory}}{4}, 0\right) \tag{8}$$

$$\text{Holding cost (H)} = h \times \text{ending inventory}_n \tag{9}$$

$$\text{Lost sales cost } (\pi) = \pi \times \text{ending inventory}_n \tag{10}$$

$$\text{Joint Total Cost (JTC)} = A + H + \pi \tag{11}$$

$$\text{Grand Total Cost (GTC)} = JTC_{P1} + JTC_{P2} + JTC_{P3} + JTC_{P4} + JTC_{P5} + JTC_{\text{vendor}} \tag{12}$$

$$\text{Product Workload (PW)} = \text{round}\left(\frac{\text{employee}_n}{\sum \text{employee}_{n1 \sim 12}}\right) \times ((PQ \times 5), 0) \tag{13}$$

$$\begin{aligned}
\text{Weekly Workload (WW)} &= ((PW_1 \times \text{process time}) + (PW_2 \times \text{process time}) + (PW_3 \times \text{process time}) \\
&+ (PW_4 \times \text{process time}) + (PW_5 \times \text{process time}))
\end{aligned} \tag{14}$$

$$\text{Stress Level (SL)} = \frac{(SL_n - \min(SL_{n1 \sim 12}))}{\max(SL_{n1 \sim 12}) - \min(SL_{n1 \sim 12})} \tag{15}$$

$$\text{Weekly Workload (WW)} = \frac{(WW_n - \min(WW_{n1 \sim 12}))}{\max(WW_{n1 \sim 12}) - \min(WW_{n1 \sim 12})} \tag{16}$$

$$\text{Sleep Hours (SH)} = \frac{(SH_n - \min(SH_{n1 \sim 12}))}{\max(SH_{n1 \sim 12}) - \min(SH_{n1 \sim 12})} \tag{17}$$

$$\text{Burnout (B)} = \frac{(B_n - \min(B_{n1 \sim 12}))}{\max(B_{n1 \sim 12}) - \min(B_{n1 \sim 12})} \tag{18}$$

$$\text{Ages (As)} = \frac{(Ag_n - \min(Ag_{n1 \sim 12}))}{\max(Ag_{n1 \sim 12}) - \min(Ag_{n1 \sim 12})} \quad (19)$$

$$\text{Experience Years (Ey)} = \frac{(EY_n - \min(EY_{n1 \sim 12}))}{\max(EY_{n1 \sim 12}) - \min(EY_{n1 \sim 12})} \quad (20)$$

$$\text{Dependents (D)} = \frac{(D_n - \min(D_{n1 \sim 12}))}{\max(D_{n1 \sim 12}) - \min(D_{n1 \sim 12})} \quad (21)$$

$$\text{Interaction and Sleep (IS)} = \frac{(IS_n - \min(IS_{n1 \sim 12}))}{\max(IS_{n1 \sim 12}) - \min(IS_{n1 \sim 12})} \quad (22)$$

$$\begin{aligned} &\text{Prediction} \\ &= if \left(\frac{1}{1 + \exp(-(b_0 + b_1 \times SL_n + b_2 \times WW_n + b_3 \times SH_n + b_4 \times B_n + b_5 \times Ag_n + b_6 \times EY_n + b_7 \times D_n + b_8 \times IS_n))} \right) \\ &\geq 0.5, 1, 0) \end{aligned} \quad (23)$$

$$\text{Optimize JTC} = \text{Optimize Objective Function} \times (1 + \text{sum of value of Mental Health Index}) \quad (24)$$

3.1.8 Data Collection Method

The data used in this research is secondary data obtained from the company's database, which was previously collected by other researchers. Additionally, the researcher gathered several literature reviews from various articles and past studies to serve as references for the current research.

3.1.9 Data Processing

The data processing began with the integration of datasets from several participating retailers and vendors. Based on these data, a simulation was conducted on the supply chain inventory using predefined probability distributions. This process aimed to provide an overview of the supply chain relationships within the transshipment process. Subsequently, a model was developed to optimize the Joint Total Cost (JTC) using Excel Solver, while also incorporating considerations for workers' mental health condition. The results of the optimization revealed the optimal allocation of workloads and a minimized Joint Total Cost.

3.1.10 Discussion and Analysis

At this stage, discussion and analysis are conducted based on the data processing results obtained in the previous phase. This stage aims to gain a comprehensive understanding of the research findings and align them with the relevant theoretical framework. The results provide

insights into and answers to the core research problem concerning the optimization of the Joint Total Cost (JTC) within a multi-echelon supply chain relationship in the batik industry.

3.1.11 Conclusion and Recommendations

At this stage, the researcher presents several conclusions that align with the problem formulation established as the core issue of the study. The findings serve as the basis for addressing the research objectives previously defined. In addition, recommendations are provided as an effort to improve and resolve potential issues in the future.

3.1.12 Research Flow and Mechanism

The following describes the research flow and mechanisms implemented in this study:

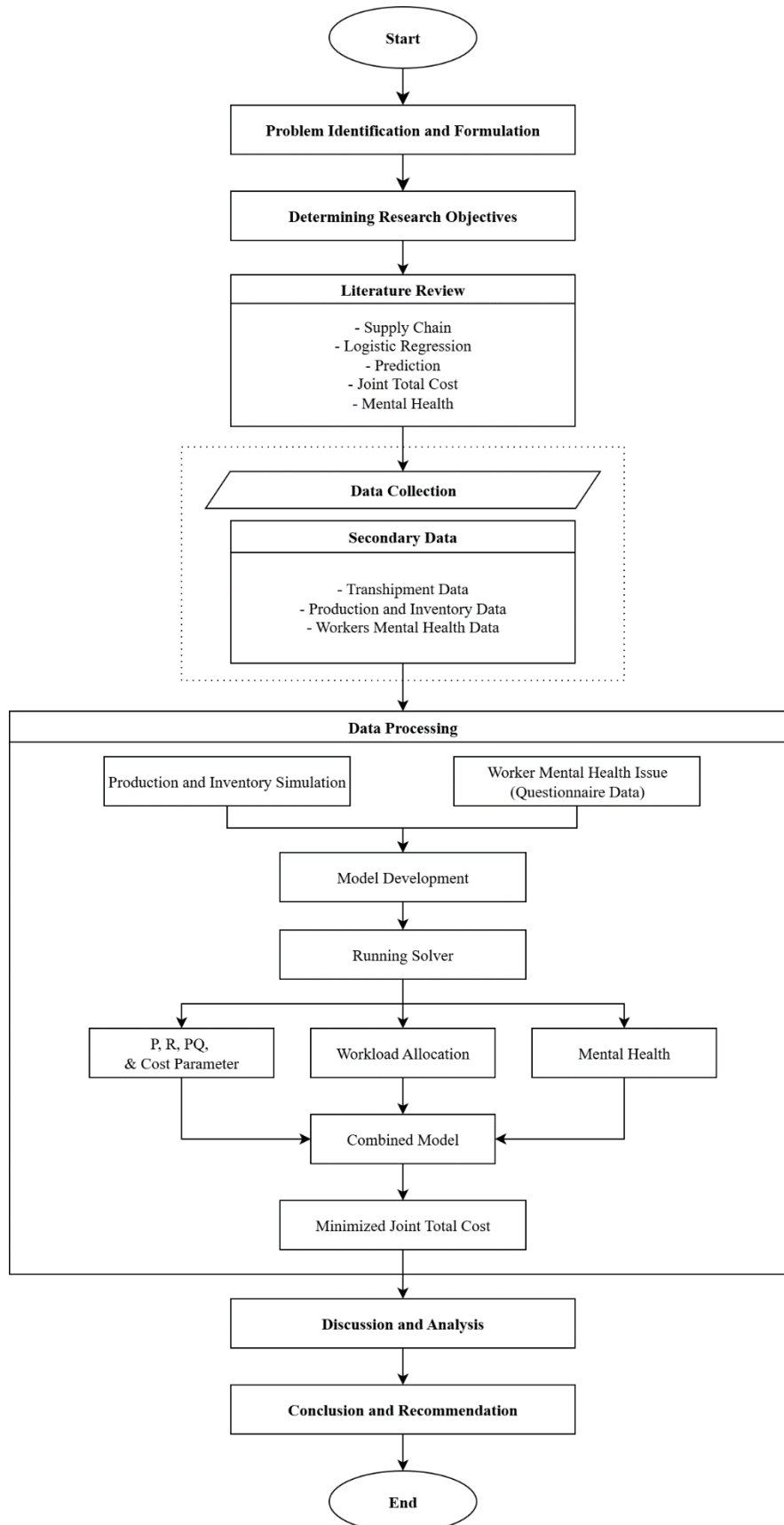


Figure 3. 2 Research Methodology

The research flow in the diagram above illustrates the detailed implementation process from start to finish. The following is an explanation of each stage in the research flow:

1. Start

2. Preliminary Study

This stage is the initial step in the research, aimed at understanding the problem to be studied. In this phase, preliminary information related to the problem's context is gathered, serving as the foundation for formulating research objectives and determining the appropriate methodology.

3. Problem Identification and Problem Formulation

At this stage, problem identification is carried out to determine the issue to be studied. Then, problem formulation is conducted to develop relevant solutions and outcomes.

4. Determining Research Objectives

This stage is conducted to establish research objectives clearly and systematically. Defining the research objectives ensures that the study has a specific focus and can produce relevant outcomes.

5. Literature Review

The literature review is conducted to understand previous studies related to the research topic. This is done by searching for reference sources from journals or books that discuss predictive mental health in the supply chain using a logistic regression approach. By conducting a literature review, the researcher can gain insights into the development of research on this topic.

6. Data Collection

At this stage, secondary data is collected from the company's database, which was previously gathered by other researchers. Those data consist of transshipment data, production and inventory data, and mental health data that are collected through the questionnaire. Additionally, the researcher collects several articles or research journals relevant to the current research topic to be used as reference sources in completing the study.

7. Data Processing

At this stage, data processing is carried out using a specific method. This is being done to ensure that the results obtained can be further analyzed and produce valid findings.

The data used in the processing stage includes inventory data and mental health data. The following are the steps of data processing:

a) Production and Inventory Simulation

This data is used to simulate the distribution processes between vendors and retailers. The simulation includes both normal and uniform distribution types, which are used to understand demand patterns and the quantity of products to be produced.

b) Worker Mental Health Issue

Mental health data were collected through questionnaires distributed to 12 workers. All workers were asked to answer the provided questions to assess their current mental health status. This data was then normalized using a coefficient, referred to as value B, which was obtained through an optimization process utilizing a solver. The solver's results provide the value of B, which is subsequently used in the optimization model to predict mental health condition.

c) Model Development

The model was developed using the Solver feature in Microsoft Excel. This process involves setting the objective cell, which is the Joint Total Cost (JTC), to be minimized. Selected cells were designated for adjustment to satisfy the requirements of product-related variables, namely P, R, PQ, and work allocation. Constraints were then defined to limit the value ranges, including upper and lower bounds, as well as specifying integer data types.

d) Running Solver

This stage involves executing the developed model using Solver to obtain the most optimized outcome in minimizing the JTC value.

e) P, R, PQ, and Cost Parameter

The resulting variables and cost parameters were integrated to do the optimization process together.

f) Workload Allocation

The amount of workload allocated, as determined by the Solver, reflects each worker's capacity. In addition, a specific formula was used to

normalize the results to align with the study's objective: a single product workload equals PQ multiplied by 5 workdays.

g) Mental Health

This phase provides a comparative analysis between the existing condition before optimization and the condition after optimization, particularly in relation to the processing time or cycle time for each employee.

h) Optimization Result

Upon completion of the optimization process, the results are analyzed across all relevant variables and parameters. Furthermore, a comparison is conducted to determine whether there has been any improvement, especially in reducing the number of workers affected by mental health issues.

i) Minimized Joint Total Cost (JTC)

Based on the overall results obtained, the minimized JTC serves as the primary objective of this study, particularly in the context of transshipment within supply chain relationships between retailers and vendors.

8. Discussion and Analysis

At this stage, analysis and discussion are conducted on the processed data from the previous step. The analysis results are also linked to theoretical foundations from previously reviewed reference sources to obtain valid findings.

9. Recommendation and Conclusion

This stage presents a comprehensive summary, including the research findings and recommendations to address the predetermined research objectives.

10. End

CHAPTER IV

DATA COLLECTION AND PROCESSING

4.1 Data Collection

The data obtained in this study consists of historical order data between the retailer and the vendor, as well as mental health condition data of the involved workers. All collected data will be processed and analysed to determine the outcome in the form of Joint Total Cost optimization, with consideration of the mental health issues experienced by the workers. These data will then be substituted into the mathematical model developed in this study to execute the optimization process. The data used in this study is processed using an integrated optimization approach. The aim is to reduce the costs arising from the production process and the management of mental health issues.

4.1.1 Retailer and Vendor Data

The historical supply chain data from the retailer and vendor includes several variables such as holding cost, profit loss, beginning inventory, lead time, reorder point, and production quantity. The operational cost data of vendors and retailers are shown in Table 4.1 and Table 4.2 below.

Table 4. 1 Vendor Data

Item	Cost	Dimension
Setup	5700	/setup
h1	3500	/unit/month
π 1	5500	/unit
h2	3500	/unit/month
π 2	6500	/unit
h3	3500	/unit/month
π 3	4000	/unit
h4	3500	/unit/month
π 4	7000	/unit
h5	3500	/unit/month
π 5	4000	/unit

Table 4. 2 Vendor Data

Item	Cost					Dimension
	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5	
Ordering	13000	8000	10000	8000	13000	/4 pcs
h1	2000	2000	2000	2000	2000	/unit/month
π 1	20000	25000	25000	35000	25000	/unit

Item	Cost					Dimension
	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5	
h2	2000	2000	2000	2000	2000	/unit/month
π 2	25000	25000	30000	25000	25000	/unit
h3	2000	2000	2000	2000	2000	/unit/month
π 3	20000	25000	25000	25000	25000	/unit
h4	2000	2000	2000	2000	2000	/unit/month
π 4	20000	25000	30000	25000	35000	/unit
h5	2000	2000	2000	2000	2000	/unit/month
π 5	25000	25000	25000	25000	30000	/unit

Within the retailer-vendor relationship, there exists a supply chain cycle that integrates various business aspects. The supply chain plays a crucial role in supporting enterprise management through the coordination of elements such as facilities, manpower, and costs. These elements are critical to ensuring smooth cooperation between all parties involved. In terms of cost, this study uses the terms Grand Total Cost and Joint Total Cost. Both refer to the aggregation of all cost elements used in financial analysis. Fundamentally, the objective of both the retailer and vendor is to minimize expenses and maximize revenue by leveraging available resources.

4.1.2 Mental Health Data

Mental health data is utilized to identify the psychological conditions experienced by workers. Based on interview results, each employee's mental health status is predicted to determine whether they are experiencing severe mental health issues.

The mental health data was collected from 12 workers involved in the batik industry's supply chain process. Data collection was conducted through surveys to assess levels of stress and burnout among the workers. The following is the raw data that has been tested and presented in the appendix. Table 4.3 and Table 4.4 below originate from the scoring of several questionnaire items, which were processed to generate values for the stress and burnout variables in the context of predicting mental health issues.

Table 4. 3 Raw Data of Stress Variable

No	Interview Question	Scoring Guide	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
Q1	How often do you feel overwhelmed with your workload?	1 (Never) to 5 (Very Often)	5	2	5	2	4	1	5	3	4	2	5	2
Q2	Do you feel that you have control over your tasks and decisions at work?	1 (Always) to 5 (Never)	3	2	4	1	3	2	5	2	3	3	4	1
Q3	How frequently do you receive conflicting demands from different people?	1 (Rarely) to 5 (Very Frequently)	4	3	4	2	4	2	5	3	4	2	5	3
Q4	How supported do you feel by your supervisor or team?	1 (Very Supported) to 5 (Not at All)	3	2	4	2	3	2	4	3	3	3	3	2
Q5	How concerned are you about losing your job or not meeting performance targets?	1 (Not Concerned) to 5 (Very Concerned)	4	2	5	2	3	2	4	2	4	2	5	2
Q6	How often does work interfere with your personal life (family, rest, hobbies)?	1 (Rarely) to 5 (Very Often)	4	3	3	2	4	1	5	3	4	3	3	2
Total			23	14	25	11	21	10	28	16	22	15	25	12
Stress Level			7	3	8	2	6	2	9	4	7	4	8	3

Table 4. 4 Raw Data of Burnout Variable

No	Interview Question	Dimension	Notes	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
Q1	How often do you feel emotionally exhausted at work?	EE	Classic burnout signal	5	2	5	2	4	1	5	3	5	3	5	2
Q2	How often do you feel you can't face another day at work?	EE	Chronic emotional fatigue	4	3	5	2	4	2	5	3	4	3	5	2
Q3	How often do you feel physically drained by the end of the workday?	EE	Physical + emotional fatigue	5	2	4	2	4	2	5	3	4	3	5	2
Q4	How often do you feel disconnected or distant from your work tasks?	DP	Depersonalization	4	2	5	2	3	1	5	3	4	2	5	2
Q5	How often do you feel cynical or negative about your job?	DP	Negative attitudes	4	2	4	2	3	2	4	3	4	3	5	1
Q6	How often do you find it difficult to care	DP	Motivation decline	4	2	4	1	3	2	4	3	4	2	4	2

No	Interview Question	Dimension	Notes	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
Q7	about your job performance? How often do you feel proud of the work you accomplish? (reverse scored)	PA	More pride = less burnout	4	2	5	2	3	2	5	3	4	3	5	2
Q8	How often do you feel effective and productive at work? (reverse scored)	PA	Competence = lower burnout	3	2	4	2	4	1	4	3	4	3	5	2
Q9	How often do you feel you're making a meaningful impact at work? (reverse scored)	PA	Purpose reduces burnout	4	3	4	3	4	3	5	3	4	3	5	3
Q10	How often do you feel confident in your ability to do your job well? (reverse scored)	PA	Confidence = less burnout	4	3	4	3	4	3	5	3	4	3	5	3
Total				41	23	44	21	36	19	47	30	41	28	49	21
Burnout				8	3	9	3	7	2	9	5	8	5	10	3

Information

EE : Emotional Exhaustion

DP : Depersonalization

PA : Reduced Personal Accomplishment

Additionally, questionnaires were distributed to gather general information such as age, sleep duration, work experience, number of dependents, and social interactions. The mental health data collected in this study are shown in Table 4.5 below.

Table 4. 5 Mental Health Data

E	SL	WL	SH	BS	Ag	Ey	D	I	Severe Mental Health Issue (Yes/No)	Score
E1	7	50	6	8	35	10	2	42	Yes	1
E2	3	40	7	3	28	4	1	21	No	0
E3	8	55	5	9	42	20	3	40	Yes	1
E4	2	38	8	3	30	5	1	16	No	0
E5	6	48	6	7	38	15	2	36	Yes	1
E6	2	36	7	2	25	3	0	14	No	0
E7	9	60	5	9	45	22	4	45	Yes	1
E8	4	42	7	5	32	8	2	28	No	0
E9	7	52	6	8	40	18	3	42	Yes	1
E10	4	40	7	5	29	6	1	28	No	0
E11	8	55	5	10	47	25	5	40	Yes	1
E12	3	38	8	3	27	3	1	24	No	0
Sum										6

4.2 Data Processing

4.2.1 Retailer and Vendor Data

The retailer and vendor maintain a mutual relationship that facilitates the exchange of products through purchase transactions. This dynamic is referred to as a multi-buyer system, in which retailers can place orders with one another. For instance, Retailer 1 may order products from Retailer 2. However, both retailers may simultaneously require the same products from the vendor.

Table 4. 6 Transshipment Buyer Relationship

	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5
Buyer 1		●	●		
Buyer 2				●	
Buyer 3					
Buyer 4					
Buyer 5	●				

Notes:

● : order from or order to

The table above illustrates an example of such interactions or transshipment, showing purchase orders from Buyer 1 to Buyer 2, from Buyer 1 to Buyer 3, from Buyer 2 to Buyer 4, and from Buyer 5 to Buyer 1. These purchase transactions are interconnected, indicating a supply chain relationship among the retailers. Importantly, each buyer also places direct orders with the vendor.

Historical data was collected from each retailer and the vendor that contains the existing condition of the supply chain process that occurred. This initial condition will be improved and optimized during this research, which aims to minimize the operational cost in the batik industry. The improvement will be processed using a solver with a mathematical model to compare the existing and the simulated data of each product and retailer.

Table 4. 7 Lead Time and Reorder Point of Existing Condition

Product	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5
P1	3	3	3	3	3
R1	20	20	10	10	20
P2	3	3	3	3	3
R2	20	20	10	10	20
P3	3	3	3	3	3
R3	15	20	20	25	30
P4	3	3	3	3	3
R4	10	10	15	20	20
P5	3	3	3	3	3

Product	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5
R5	15	10	20	20	20

Table 4. 8 Production Quantity of Existing Condition

	Product 1	Product 2	Product 3	Product 4	Product 5
Daily PQ	30	30	30	30	30
Weekly PQ	150	150	150	150	150

The simulations were conducted for specific products to analyse the interrelationships among retailers and to determine the Joint Total Cost for each product. The simulation was carried out using Microsoft Excel Solver to identify the minimum required cost. Each buyer was assigned different ordering and production levels. The simulation was designed for a 60 working day scenario to reflect the duration needed for order fulfilment, whether between buyers or from buyers to the vendor.

Table 4. 9 Lead Time and Reorder Point of Proposed Condition

Product	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5
P1	2	2	2	3	2
R1	24	32	36	46	49
P2	3	1	2	2	2
R2	34	36	33	29	32
P3	1	3	3	2	2
R3	25	43	41	43	40
P4	2	2	2	2	2
R4	29	41	33	34	35
P5	1	1	1	1	1
R5	15	25	22	25	25

In this context, P denotes the lead time, representing the interval in days between order placements. Meanwhile, R indicates the production capacity per cycle. Both P and R are utilized

to simulate the supply chain condition in batik production over a 60-period (or approximately two months) timeframe.

Table 4. 10 Production Quantity of Proposed Condition

	Product 1	Product 2	Product 3	Product 4	Product 5
Daily PQ	8	6	25	32	16
Weekly PQ	40	30	125	160	80

PQ represents the daily production quantity. To better reflect a weekly production schedule, the PQ value is multiplied by five, corresponding to a standard five-day workweek. The resulting value is then used in the work allocation analysis through an optimization process using the Excel Solver function.

4.2.2 Mental Health Data

Mental health data is processed to predict the mental health condition of all workers. This process aims to assess the severity of mental health issues using a set of variables and predictive formula calculations. The predicted mental health status is derived from variables such as stress level, workload, sleep hours, burnout score, age, work experience, number of dependents, and level of social interaction. Each variable's value is obtained through a combination of questionnaire responses and interview questions, which are then calculated to produce a final score.

The variables stress level and burnout score are derived from specific interview questions, with each score scaled from 1 to 10. For the stress level variable, six questions were asked to assess psychosocial risk factors in both workplace and personal life contexts. These questions addressed topics such as work-life balance, workload and stress, and social support in the workplace. Each question was rated on a 1–5 Likert scale.

The burnout score variable was calculated based on ten questions aimed at evaluating each worker's level of burnout. These questions were structured around the three core dimensions of burnout defined in the Maslach Burnout Inventory (MBI), such as Emotional Exhaustion (EE), Depersonalization (DP), and Personal Accomplishment (PA). The ten interview questions administered to workers were designed to identify burnout levels and explore the most negatively impactful aspects of their work experience, whether emotional or related to personal achievement.

The next step involves data normalization, aimed at standardizing the value ranges of each variable to facilitate further data processing. Each variable is multiplied by a specific normalization factor as shown in the table below. After all of the input was normalized, equation 22 is optimized, and the result is shown in Table 4.11

Table 4. 11 Optimized Value

b0	b1	b2	b3	b4	b5	b6	b7	b8
-3.288	8.817	7.424	0.374	-1.115	-5.104	2.608	-1.210	-1.713

By substituting all of the B values into equation 22 and the mental health prediction is shown in Table 4.12. Based on Table 4.12, it was proven that the result of the prediction formula is accurate because it has 0 value of error.

Table 4. 12 Mental Health Prediction of Existing Conditions

E	SL	WL	SH	BS	Ag	Ey	D	I	Severe	Prediction	Error
E1	0.714	0.583	0.333	0.750	0.455	0.318	0.400	0.903	1	1	0
E2	0.143	0.167	0.667	0.125	0.136	0.045	0.200	0.226	0	0	0
E3	0.857	0.792	0.000	0.875	0.773	0.773	0.600	0.839	1	1	0
E4	0.000	0.083	1.000	0.125	0.227	0.091	0.200	0.065	0	0	0
E5	0.571	0.500	0.333	0.625	0.591	0.545	0.400	0.710	1	1	0
E6	0.000	0.000	0.667	0.000	0.000	0.000	0.000	0.000	0	0	0
E7	1.000	1.000	0.000	0.875	0.909	0.864	0.800	1.000	1	1	0
E8	0.286	0.250	0.667	0.375	0.318	0.227	0.400	0.452	0	0	0
E9	0.714	0.667	0.333	0.750	0.682	0.682	0.600	0.903	1	1	0
E10	0.286	0.167	0.667	0.375	0.182	0.136	0.200	0.452	0	0	0
E11	0.857	0.792	0.000	1.000	1.000	1.000	1.000	0.839	1	1	0
E12	0.143	0.083	1.000	0.125	0.091	0.000	0.200	0.323	0	0	0

Based on Table 4.12 above, it can be observed that the prediction results reflect the mental health status experienced by the workers, as determined through the selected variables. The final column, labelled Mental Health Status, indicates a binary classification: a value of 0 denotes that the individual does not experience mental health issues, while a value of 1 signifies

the presence of such issues. Among all participating workers, 6 out of 12 were identified as suffering mental health issues.

4.3 Result Comparison

4.3.1 Joint Total Cost (JTC)

In any business, cost allocation plays a crucial role. In the case of a multi-buyer and vendor system, various cost components are interrelated and support the overall business process. These combined costs are referred to as the Joint Total Cost (JTC), which represents the estimated expenses required to process orders, including holding costs, profit and loss, ordering costs, and other related financial aspects.

Given the large number of products involved in this study, it is necessary to aggregate the data comprehensively to identify the specific costs associated with each product and each buyer. Additionally, vendor-related costs must also be calculated to gain optimal insight into the financial flow. The aggregation of all GTCs across products and buyers/vendors is referred to as the Joint Total Cost (JTC).

Table 4. 13 Optimized JTC

Existing	After Optimized	Improvement (%)
IDR 2,055,708,000	IDR 1,325,152,000	↓ 35.53 %

Based on Table 4.13 above, it was shown that the GTC decreased from the previous data condition. By using a mathematical model, we can reduce the overall operational costs and simulate the supply chain process, which includes demand and inventory management. The Joint Total Cost (JTC) above represents the total JTC across all buyers for each product. This value has been optimized to achieve the minimum possible cost while considering the mental health index.

Table 4. 14 Cost Summary of Existing Condition

P	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5	Vendor	GTC
P1	7,020,000	7,086,000	7,624,000	5,066,000	1,318,000	3,120,000	31,234,000
P2	7,434,000	16,785.500	23,240,000	14,757,000	13,168,000	3,120,000	78,504,500
P3	10,202,000	4,074,000	8,450,000	1,408,000	2,246,000	3,210,000	29,590,000
P4	2,384,000	8,281,000	17,560,000	5,195,000	25,021,000	3,210,000	61,651,000
P5	6,761,000	19,933,000	11,973,000	3,549,000	10,558,000	3,210,000	55,984,000

Table 4. 15 Cost Summary of Proposed Condition

P	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5	Vendor	GTC
P1	5,268,000	11,959,000	8,262,000	2,489,000	5,049,000	14,954,000	47,981,000
P2	4,932,000	30,091,000	23,602,000	3,396,000	12,868,000	23,706,000	98,595,000
P3	6,707,000	8,257,000	13,844,000	2,870,000	3,916,000	5,162,000	40,756,000
P4	4,053,000	18,718,000	13,956,000	2,902,000	7,666,000	7,972,000	55,267,000
P5	18,274,000	25,886,000	13,889,000	10,532,000	14,948,000	5,160,000	88,689,000

The data presented above reflect the Grand Total Cost (GTC) values for each product across all of the buyers.

4.3.2 Workload Allocation

The allocation of workload or the number of products to be produced was optimized using Excel Solver Function, by considering the workers' mental health and Joint Total Cost. Table 4.16 illustrates the detailed workload allocation of the existing condition for each product completed by every employee before optimization. Table 4.17 shows the workload allocation after the optimization process. By comparing both of them, the vendor needs to consider the result of workload reallocation to decrease the number of workers who suffer from mental health issues.

Table 4. 16 Weekly Employee Workload Allocation of Existing Condition

	Product 1	Product 2	Product 3	Product 4	Product 5
E1	18	12	22	5	13
E2	13	3	7	23	13
E3	11	7	13	12	13
E4	7	12	24	5	11
E5	15	4	9	5	8
E6	4	12	7	20	13
E7	17	12	2	16	21
E8	11	10	4	7	19
E9	16	20	15	15	6
E10	12	17	9	2	25
E11	16	22	11	23	2
E12	11	20	28	18	6

	Product 1	Product 2	Product 3	Product 4	Product 5
Total	151	151	151	151	150

Table 4. 17 Weekly Employee Workload Allocation of Proposed Condition

	Product 1	Product 2	Product 3	Product 4	Product 5
E1	5	2	3	11	5
E2	4	3	3	11	9
E3	3	2	9	14	6
E4	2	2	18	11	5
E5	2	2	15	11	8
E6	4	2	6	9	5
E7	2	2	6	11	9
E8	4	2	12	6	6
E9	5	2	18	14	8
E10	3	4	15	3	3
E11	3	2	6	14	9
E12	3	3	15	43	8
Total	40	28	126	158	81

Table 4.17 data show the distribution of workload by specifying the production quantity of each product assigned to individual workers after optimization. For example, Product 1 results in a total production of 40 pieces, which is distributed differently among the 12 workers. This allocation is intended to create a balanced workload, improve efficiency, and reduce the risk of overburdening specific individuals.

4.3.3 Mental Health

Mental health data processing was conducted to validate the earlier prediction results. This process aimed to assess the extent to which mental health issues affect workers in the batik industry. The results were then compared with the optimized condition that incorporates cost minimization considerations.

Table 4. 18 Comparison of Mental Health Status Between Existing and Proposed Conditions

E	SL	WL	SH	BS	Ag	Ey	D	I	Existing Condition	Proposed Condition
E1	0.714	0.003	0.333	0.750	0.455	0.318	0.400	0.903	1	0
E2	0.143	0.083	0.667	0.125	0.136	0.045	0.200	0.226	0	0
E3	0.857	0.167	0.000	0.875	0.773	0.773	0.600	0.839	1	1
E4	0.000	0.235	1.000	0.125	0.227	0.091	0.200	0.065	0	0
E5	0.571	0.228	0.333	0.625	0.591	0.545	0.400	0.710	1	0
E6	0.000	0.000	0.667	0.000	0.000	0.000	0.000	0.000	0	0
E7	1.000	0.069	0.000	0.875	0.909	0.864	0.800	1.000	1	0
E8	0.286	0.074	0.667	0.375	0.318	0.227	0.400	0.452	0	0
E9	0.714	0.435	0.333	0.750	0.682	0.682	0.600	0.903	1	1
E10	0.286	0.028	0.667	0.375	0.182	0.136	0.200	0.452	0	0
E11	0.857	0.160	0.000	1.000	1.000	1.000	1.000	0.839	1	0
E12	0.143	1.000	1.000	0.125	0.091	0.000	0.200	0.323	0	1
Sum									3	3

Based on the optimization results above, a comparison can be made between the existing condition and the condition after optimization. It can be observed that employee number 1 was previously predicted to have mental health problems. However, after optimization, there is no potentiality to have mental health problems. Employee number 2 shows a consistent outcome, with no indication of mental health problems both before and after optimization. Employee number 3 continues to indicate potential signs of mental health problems in both conditions. Similarly, employee number 4 shows no potential for mental health problems in either the initial or optimized condition. Employee number 5 was initially predicted to experience mental health problems, but the optimization process suggests no potentiality to have mental health problems. Employee number 6 shows no mental health problems in both scenarios. Employee number 7 previously predict to have mental health problem, but after optimization there is no potentiality to have mental health problems. Employee number 8 does not present any indication of mental health problems in either condition. Employee number 9 continues to indicate potential signs

of mental health problems in both conditions. Employee number 10 maintains a stable and healthy mental condition throughout. Employee number 11 was previously predicted to have mental health problems. However, after optimization, there is no potentiality to have mental health problems. Lastly, employee number 12 was initially considered no mental health problems, but the optimization results indicate a potential emergence of mental health problems.

The findings identified two scenarios such as the before (actual condition) and after (cost optimization) phases. Under the actual condition, six workers were identified as experiencing mental health issues. After optimization, the number decreased to three workers. This reduction reflects a positive impact of the optimization efforts on employee psychological wellbeing, although some individuals still encounter psychological pressure. These results indicate that mental health should remain a key consideration and be continuously improved as part of a sustainable production optimization strategy.

CHAPTER V

DISCUSSION

5.1 Discussion on Supply Chain Optimization

5.1.1 P, R, & PQ

In the processing of batik production supply chain data, several variables are utilized for each product and buyer, including P, R, and PQ. These variables are optimized to obtain the minimum possible cost in the Joint Total Cost (JTC). This cost incorporates multiple factors such as lead time, production quantity, and the mental health index of the workers, ensuring that cost efficiency is achieved while still accounting for the psychological well-being of the workforce.

P refers to the lead time from the ordering of a batik product to the delivery of the finished goods. A longer production lead time implies that customers must place their orders earlier to avoid stockouts. The aim is to ensure that products are delivered before the inventory of batik goods in storage is depleted. This highlights the crucial role of coordination between buyers and vendors in maintaining agreed lead times throughout the supply chain relationship.

The reorder point, or R, represents the minimum inventory level between buyer and vendor, which triggers the continuation of the batik production process. When simulations indicate that inventory levels have reached the reorder point, buyers must place new orders with vendors, or vendors must replenish inventory for the buyers. Failure to adhere to this protocol could lead to critical inventory shortages, potentially disrupting the supply chain.

Once the production system reaches the reorder point, immediate action is required to initiate the batik production process. The production quantity (PQ) must be aligned with the output capacity of the workers or machines. This becomes a performance target necessary for fulfilling orders and maintaining customer (buyer) trust. In practice, workers typically possess varying levels of skills and capacities, which directly affect daily and weekly production outputs. Furthermore, both internal and external factors influence the agility and capabilities of workers, potentially impacting the continuity and productivity of the batik production process in either positive or negative ways.

5.1.2 Grand Total Cost (GTC)

In the supply chain relationship between buyers and batik-producing vendors, cost management plays a critical role. As previously discussed, cost directly influences the sustainability of the batik business, particularly in terms of company profits and losses. Given the dynamic nature of batik ordering and production, both parties are expected to engage in strategic cost arrangements aimed at minimizing unnecessary expenditures and maintaining a balanced corporate cash flow.

In this context, the Grand Total Cost (GTC) represents a comprehensive overview of each cost incurred for each product ordered by every buyer. Specifically, it encompasses the total expense of each batik product order, considering the ordering cost incurred per transaction. Due to product variety and design complexity, the cost per item may vary. Ideally, order costs should be minimized within a given period while maximizing the quantity of products received, thus improving overall cost efficiency.

Another component of the GTC is the holding cost, which refers to the expenses associated with ordering cost and holding cost. This element must be managed efficiently to maintain a smooth flow of goods in and out of storage facilities. The longer a product remains in storage, the higher the incurred holding costs. In contrast, direct-shipped products or items with shorter storage durations significantly reduce the storage burden on both buyer and vendor.

Beyond ordering and holding costs, the GTC also considers the profit and loss component of the supply chain. Integrating this element encourages both buyers and vendors to maintain financial transparency and foster a mutually beneficial relationship that ensures the continued operation of the batik trade. Furthermore, in the multi-buyer system where buyers can order from and supply one another, it becomes imperative to sustain product availability and collaborative support. This collective effort ensures that end-customer demand is consistently met, contributing to the resilience and adaptability of the batik supply chain.

5.1.3 Joint Total Cost (JTC)

Joint Total Cost (JTC) represents the overall cumulative cost derived from the total GTC of all buyers across all products. This aggregation of costs from each product and buyer is used to determine the total expenditure required over a 60-day (two-month) period. Each buyer and product incur varying cost values, influenced by multiple dependent variables, particularly

those related to production processes. Similarly, vendors involved in the production of each product also have associated JTC values, which are included in the overall cost calculation.

Among the five available batik products, Product A recorded the lowest JTC, whereas Product B showed the highest JTC relative to the others. This JTC value serves as a critical reference point for evaluating how efficiently buyers and vendors allocate expenditures, especially when considering the mental well-being of workers. The output generated during the batik production process is closely linked to the motivation and psychological condition of the workforce. Hence, optimizing costs while considering worker mental health becomes essential for sustainable supply chain performance and long-term operational efficiency.

5.2 Discussion of Workload Allocation

5.2.1 Daily Production Quantity

Production Quantity (PQ) refers to the daily production output generated by all workers for each product. The daily PQ value is calculated by summing the total production quantity from 12 workers assigned to a single product. This value is then multiplied by 5 to represent the weekly production quantity, based on the five-day workweek implemented in the batik industry.

The PQ value varies across vendors, as it is derived from the optimized Joint Total Cost (JTC) calculation, which also considers the production quantity (PQ) variable specific to each vendor. A higher PQ value typically indicates a higher level of customer demand. Therefore, maintaining an effective relationship between buyer and vendor is crucial to prevent profit loss within the batik production process. If a vendor is unable to meet customer demand, it may negatively affect customer trust and satisfaction. To avoid such risks, an evaluation of production capacity should be conducted regularly to ensure a balanced supply. This can be achieved by carefully assessing available stock levels prior to initiating the production process or placing product orders.

5.2.2 Workload Allocation Result

The results of production planning allocation per employee were obtained through an optimization process based on the Joint Total Cost (JTC). This optimization process considered the fair distribution of production planning quantities across all workers. As a result, the assigned workload for each employee was adjusted to ensure that no individual was overburdened, thereby helping to reduce the risk of stress and mental health issues.

The final production allocation was multiplied by each employee's respective process time. Since process times differ based on work experience and skill level, the values were expressed in minutes and then converted to hours by dividing by 60. The variation in employee skills significantly impacts the production workload allocation. Workers with longer work experience tend to possess more advanced skills, allowing them to work more efficiently. Therefore, individual process times vary depending on several influencing variables, including experience, proficiency, and product type.

5.3 Discussion of Mental Health Prediction

Workers play a crucial role in this study, serving as the foundation for all production and order fulfillment processes. Their performance is directly linked to productivity and output levels. Higher levels of employee motivation contribute positively to the continuity and efficiency of production processes. Conversely, a lack of enthusiasm or the presence of psychological stress can significantly hinder production output.

In this context, the optimization study of total operational production cost for batik in a multi-buyer scenario considers the extent to which mental health and worker motivation influence performance. The existing condition indicates that 6 workers involved in this study reported experiencing mental health problems during work. This figure is considered critical and poses a potential risk to both buyers and batik vendors.

To address this issue, a simulation-based optimization using Solver was conducted to determine a more balanced allocation of production quantities across all workers. This equitable distribution of tasks is expected to enhance employee performance and reduce the negative impact of mental health issues. The outcome showed that only 3 workers were predicted to experience mental health problems, a 50% reduction from the existing condition based on employee surveys. The results indicate an improvement, as the number of workers predicted to suffer from mental health problems decreased from six to three. This optimization result is referred to as the Mental Health Index (MH Index) and plays an integral role in the calculation of total business costs in the multi-buyer and vendor system.

5.4 Cost Comparison

After conducting the optimization process, the researcher will compare the Joint Total Cost in the existing condition with the condition after optimization. This is done to know how much the cost can be minimized after conducting the optimization process by considering workers' mental health. In the existing condition, the initial costs generated are IDR 2,055,708,000, and after optimization, the cost generated is IDR 1,325,152,000. Based on the result, it can be known that there is a decrease in the Joint Total Cost (JTC) of IDR 730,556,000, which is about 35.53% of the optimization by incorporating considerations for employee mental health.

CHAPTER VI

CONCLUSION

6.1 Conclusion

The following are several key conclusions derived from this study:

1. By simulating inventory and demand data using the Solver Function in Microsoft Excel, the Joint Total Cost (JTC) was significantly reduced from IDR 2,055,708,000 to IDR 1,325,152,000 when considering both operational efficiency and workers' mental health. This optimization represents an improvement of approximately 35.53%, with cost savings of IDR 730,556,000. This study also highlights the importance of a multi-buyer relationship in the batik industry, which enables flexibility in procurement and distribution among retailers
2. By reallocating workloads through optimization, the number of workers experiencing mental health issues decreased from 6 to 3. This demonstrates that minimizing supply chain costs by considering the workers' condition can lead to both economic and social improvements in the batik supply chain. The results showed that the weekly workload allocation after optimization was 433 pieces, with the following product allocations: Product 1 is 40 pieces, Product 2 is 28 pieces, Product 3 is 126 pieces, Product 4 is 158 pieces, and Product 5 is 81 pieces. In comparison, the weekly workload allocation before optimization was 754 pieces, with the following allocations: Product 1 is 151 pieces, Product 2 is 151 pieces, Product 3 is 151 pieces, Product 4 is 151 pieces, and Product 5 is 150 pieces.

6.2 Suggestion

The following are several suggestions for future research:

1. Consider the defect factor in batik products, as the quality of batik is highly influenced by the precision of the printing process. By considering product defects, a more comprehensive understanding of quality issues and supply chain efficiency in the batik industry can be achieved.
2. Integrate sustainability dimensions, particularly from an environmental perspective, such as energy consumption and CO₂ emissions generated during the batik production

process. This would provide a more holistic insight into the environmental impact of the batik industry.

3. Expand the scope by including the supply aspect from the batik vendor's suppliers, where there is a possibility of defective raw materials that do not meet quality standards. Analyzing this relationship is important to enhance the reliability of the supply chain and minimize the risk of quality degradation in the final product.

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