

## RISK ANALYSIS OF SUSTAINABLE PHARMACEUTICAL SUPPLY CHAINS IN INDONESIA USING THE BEST WORST METHOD

Bram Hik Anugraha<sup>1</sup>, Arviansyah

Faculty of Economic and Business, Universitas Indonesia  
Jl. Salemba Raya No.4, Kota Jakarta Pusat, DKI Jakarta 10430, Indonesia

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### ABSTRACT

**Background:** The COVID-19 pandemic exposed critical vulnerabilities in pharmaceutical supply chains. This concentration risk prompted pharmaceutical companies to pursue supply chain diversification strategies, seeking suppliers across multiple countries to reduce their single-source dependencies. Within pharmaceutical supply chains, inadequate risk mitigation threatens not only company performance but also public health outcomes, as disruptions can compromise the availability and quality assurance of medications. These challenges underscore the need for integrated strategies that balance operational efficiency with supply chain resilience and sustainability objectives

**Purpose:** This study conducts a literature survey and review to identify and analyze critical risk factors affecting sustainable supply chain management in Indonesia's pharmaceutical industry.

**Design/methodology/approach:** A comprehensive literature review identified forty-four risk factors in pharmaceutical supply chain management. A Pareto analysis was applied to prioritize the ten highest-impact risk factors from the initial set. The Best-Worst Method was then utilized to systematically evaluate and rank these ten critical factors based on expert judgment, generating weighted priority values for each risk factor.

**Results:** Expert interviews utilizing the Best–Worst Method identified five critical risk factors for sustainable pharmaceutical supply chain management in Indonesia. Experts ranked ten pre-selected risk factors from the Pareto analysis on a scale of one–ten. The analysis revealed that cost management emerged as the primary concern, encompassing raw materials, packaging, investment, personnel, transportation, and maintenance expenditures.

**Conclusion:** This study identifies ten significant risk factors affecting Indonesia's pharmaceutical supply chain management, with cost-related factors emerging as the highest priority through the Best–Worst Method analysis. To address these challenges, pharmaceutical industry management must pursue operational efficiency improvements, cultivate strong relationships with suppliers, distributors, regulators, and government agencies, develop strategic product portfolios with effective marketing approaches, and maintain robust cash-flow management.

**Originality/value (State of Art):** This study represents an initial comprehensive examination of sustainability-focused supply chain risk factors, specifically within Indonesia's pharmaceutical industry, providing a foundational framework for future research and industry practice.

**Keywords:** pharmaceutical supply chain, sustainable supply chain, supply chain risks, Best–Worst Method, Indonesia

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<sup>1</sup> Corresponding author:

Email: [bramhikanugraha@gmail.com](mailto:bramhikanugraha@gmail.com)

## INTRODUCTION

Supply chain management involves coordinating all supply chain activities, starting with raw materials and ending with satisfied customers. Therefore, the supply chain includes suppliers, producers and/or service providers, distributors, wholesalers, and/or retailers who deliver products and/or services to end customers. (Heizer, 2017). The Triple Bottom Line (TBL) concept, designed by Elkington, emerged in 1996, supporting and operationalizing the implementation of sustainable development. TBL is also presented as the three Ps: profit, planet and people. TBL comprises three dimensions: economic, environmental, and social. (Nogueira, 2022). Moktadir and Dwidevi, based on Iddrisu and Bhattacharyya (2015) stated that five dimensions of sustainability must be considered: social, environmental, economic, technical, and institutional. Improving sustainability in the pharmaceutical supply chain (PSC) is a key concern for all stakeholders (Moktadir and Dwidevi, 2021). PSCs pose a major challenge for management because they have heavier economic, social, and environmental responsibilities than other supply chains. (Romdhani, 2022). The pharmaceutical industry is noted to have a high level of external uncertainty and supply chain complexity, mostly in the form of high operating costs, complicated regulations, complex supply chains, and long research durations (Donkor and Spiegler, 2021).

Risk is described as the level of ambiguity that an industry must understand and manage efficiently while implementing strategies to achieve its business goals and generate value (Moktadir, 2021). The application aspect of risk management involves relationships between people, objects, and systems, which form a dynamic, real-time optimized, and self-organizing cross-company value creation network that can impact all industrial processes (Tupa, 2017). Risks in the pharmaceutical supply chain can affect company performance and human life. Therefore, it is important to manage risks in the supply chain. Many supply chain risk management approaches focus on operational risks (Gomez, 2020). Risks in the pharmaceutical supply chain (PSC) have increased recently. Risk assessment and mitigation in PSC are important issues for controlling and counteracting these risks.

During the COVID-19 pandemic, the pharmaceutical industry faced a moderate increase in demand for pharmaceutical products related to handling

COVID-19; however, the demand for unrelated products decreased. More than 90% of the raw materials used in the national pharmaceutical industry are imported. However, the government, through the Ministry of Health and the Ministry of Industry (Kemenperin), continues to encourage the realization of independence and increase the competitiveness of the domestic pharmaceutical industry. The COVID-19 pandemic has also impacted the pharmaceutical industry. Most national pharmaceutical raw materials are imported from China and India. As a result, when the pandemic hit the world and the two countries supplying raw materials had to close access (lockdown), the national supply of pharmaceutical raw materials was hampered. This condition disrupts the business processes of pharmaceutical companies. Given these obstacles, the national pharmaceutical industry is beginning to consider diversifying its raw material supply chain. This means that it depends not only on China and India but also on imports from other countries. In addition, not all national pharmaceutical industries have diverse product portfolios. (Kardoko, 2020).

Akorn Pharmaceuticals closed its doors in February 2023. This closure occurred amid an ongoing drug shortage crisis in the US. The bankruptcy of Akorn and the subsequent shutdown are part of a larger crisis caused by the decreasing number of manufacturers in the US producing cheaper generic drugs, slim profit margins for the remaining companies, and an overly complex global supply chain that can leave patients struggling to obtain life-saving medications for months or even years. (Lovelace, 2023). Several pharmaceutical companies are listed on the Indonesian Stock Exchange (BEI). Based on Azizah and Lastanti's (2022) research, which examined five pharmaceutical companies, two companies were in a healthy condition and three in the gray area. In this case, what is meant by the gray area refers to a company in an unhealthy condition that could be at risk of going bankrupt.

Several studies on supply chain management have been conducted in the field of modular integrated construction. Arshad and Zayed (2022) determined the critical factors that influence supply chain management for modular integrated construction. Eirill Bo, Inger Beate Hovi and Daniel Ruben Pinchasik (2023) researched supply chain risk management, resilience and reliability of food and pharmaceutical supply chains in Norway during the COVID-19 disruption. Research has been conducted in the textile and clothing

industries. This research refers to sustainability, risk, and performance in the textile and clothing industry (Warasthe et al. 2022). The risk factors of supply chain management in the leather industry have been researched. This research was conducted in the textile industry of Bangladesh. We are interested in conducting similar research in developing countries, especially in Indonesia. We have not found further research on pharmaceutical industry supply chain management risk factors; however, we have found them scattered in other industrial fields (Moktadir et al. 2021).

The risk factors of supply chain management in the leather industry have been researched. Research has been conducted on supply chain management in developing countries. Research has been conducted in the textile industry in Bangladesh (Moktadir et al. 2021). This study identified five key risk factors for achieving a sustainable leather industry (LISC): inefficient waste management, shifting consumer preferences, improper disposal of solid waste, price and cost volatility, and fiscal policy changes.

The background and formulation of the problem that have been presented previously are the objectives of this research, so this research aims to identify risk factors using a literature review and determine factors that have high risk using Pareto analysis and investigate the importance of risk factors obtained from Pareto analysis using the Best-Worst Method (BWM)

Based on previous research, the researcher formulated the research problem to explore the identification and assessment of risk factors affecting the continuity of supply chain management in the pharmaceutical industry, as well as to examine how these risk factors contribute to achieving sustainable practices and offer practical and managerial insights for industry stakeholders.

This study aims to identify the risk factors in the continuity of supply chain management in the pharmaceutical industry, including the assessment of these risk factors. Furthermore, the study aims to analyze how risk factors contribute to achieving practice sustainability in the pharmaceutical industry and provide practical and managerial insights to pharmaceutical industry managers

## METHODS

This study employed a mixed-methods approach that combined a literature review with expert evaluation. A comprehensive literature review identified forty-four risk factors in pharmaceutical supply chain management. Questionnaires were distributed to 115 industry experts, yielding 56 completed responses in total.

Identify risk factors in the five dimensions of sustainability through a literature review. Investigation of the literature in the context of supply chain risk, management, risk assessment and sustainable operations. A literature survey yielded forty-four potential risk factors associated with sustainable supply chain management in the pharmaceutical industry. A questionnaire was created based on the results of the literature review and then distributed. Questionnaires were distributed to 115 experts, of whom 56 were willing to respond. These experts worked in several pharmaceutical companies and had work experience of more than five years. The experts who responded held positions such as director, deputy director, general manager, manager, assistant manager, and supervisor. Their work areas include procurement, production, warehousing, distribution, PPIC, R&D, and supply chain. In this step, experts were asked to select 10-15 factors that had a higher risk than others. Six experts were selected to identify the best and worst risk factors (Table 1). Five experts were selected from well-known pharmaceutical companies and nominated based on their high years of experience and involvement in the risk assessment process. Communication with experts was conducted via the university's survey link and through direct interviews.

This research was conducted through literature review and quantitatively using a questionnaire and calculations using a solver. The stages for achieving the research objectives and analyzing the risk factors associated with Sustainable Supply Chain Management (SSCM) in the pharmaceutical industry in Indonesia are shown in Figure 1.

### **Stage 1: Identify potential risk factors through literature survey**

In this step, a rigorous literature survey was conducted to identify important SSCM risk factors for the pharmaceutical industry. To identify potential

risk factors, several keywords such as “sustainable supply chain risk”, “risk in supply chain”, “risk and pharmaceutical industry”, “pharmaceutical supply chain”, and “supply chain management”, “five dimensions”, “five-dimensional supply chain” and others, were used to search databases such as ScienceDirect, Scopus, EBSCOhost, and others. The research was conducted in the last five years. The research is classified into five dimensions of sustainability.

**Stage 2: Identify and combine risk factors**

The identified risk factors were validated through an expert survey. We identified and combined risk factors with the same aims and objectives so that the risk factors given to experts were not numerous and were not confusing in subsequent selection.

**Stage 3: Distribution of questionnaires**

Experts were selected to validate the identified SC risk factors, which are important to the pharmaceutical industry. The selection process was performed carefully. A web link (survey.ui.ac.id) was then provided to the experts.

**Stage 4: Identify the most relevant risk factors using Pareto analysis**

In this step, a Pareto analysis was conducted to summarize experts’ opinions and identify the risk factors associated with the five dimensions of sustainability that are important for the pharmaceutical industry. The experts were requested to identify 10–15 factors that exhibited a higher level of risk than the others. Based on the experts’ feedback, the frequency of each risk factor and its cumulative percentage were determined for the Pareto analysis. A Pareto diagram is a widely used technique that highlights key issues

and assists managers and decision-makers (Khan et al. 2019). A Pareto chart is a type of chart that consists of a bar graph and a line graph.

**Stage 5: Implementation of the Best-Worst Method**

In this step, the ranking of the identified associated risk factors was determined by applying the BWM. The BWM consists of five steps (Rezaei, 2015):

- a. A set of associated risk factors  
In this step, a series of related risk factors from the five dimensions of sustainability that need to be ranked are identified through Pareto analysis.
- b. Determination of the best and worst risk factors  
In this step, experts and decision-makers selected the best and worst risk factors from a list of identified associated risk factors. If there is a tie between two risk factors, the best or worst can be chosen arbitrarily. This condition is entirely at the discretion of the decision maker.
- c. Comparison of the best risk factor with respect to all other risk factors
- d. Comparison of all other risk factors with respect to the worst risk factor
- e. Calculation of optimal weights for risk factors using an optimization model.

Solving the above-mentioned model in Excel Solver can obtain the optimal weight for each risk factor. The optimal weight of each relevant risk factor can also be obtained by solving other expert models. Next, the consistency ratio of the pairwise comparisons was checked using an input-based threshold (Liang, 2020). From the input-based thresholding, it can be observed that all pairwise comparisons are reliable. The average of the optimal weights obtained from the five expert models was calculated to obtain the final result. The final optimal weight and ranking of each risk factor are presented in tabular and graphic forms (Moktadir, 2022).

Table 1. List of Selected Experts Interviewed from well-known pharmaceutical companies

ID	Company	Role	Working Area	Years of Experience
29	PT. CA	Plant Manager	Production	14
79	PT. DA	Director	Production	20
68	PT. LA	Vice Director	Supply Chain	14
52	PT. GA	Director	Production	20
114	PT. AA	General Manager	Production	23
115	PT. EA	Director	Production	27

Supply Chain Management in the Pharmaceutical Industry faces many obstacles and risks. These obstacles and risks must be identified, solutions exist, and follow-up actions can be taken to address them. However, we need to know what risks exist in the implementation of supply chains in the Pharmaceutical Industry. In previous research, a supply chain management

risk factor analysis was conducted. However, the Leather Industry has been studied. This research was conducted using five dimensions of sustainability. The five dimensions of sustainability are economic, social, environmental, technical, and institutional. The conceptual framework of this study in Figure 2.

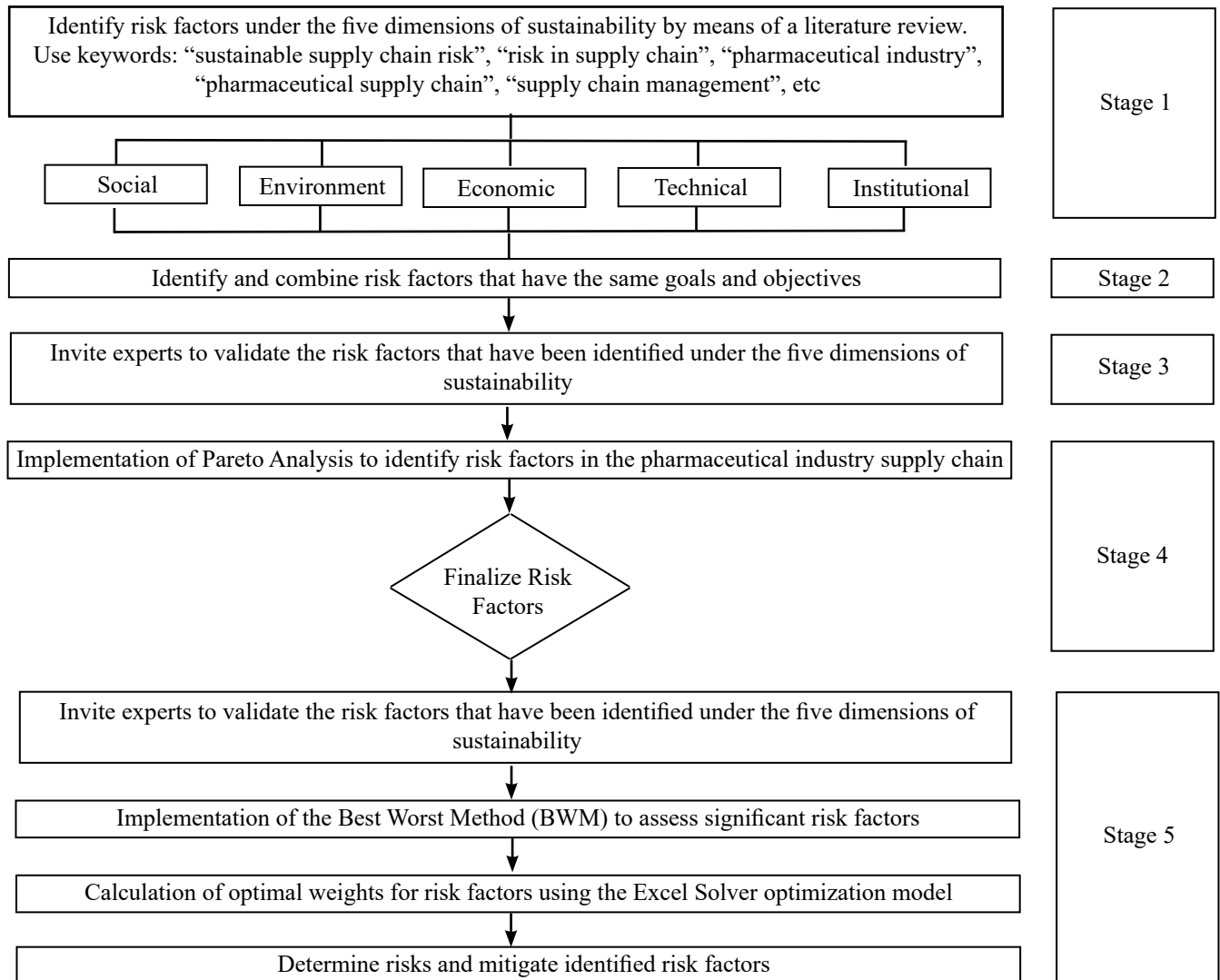


Figure 1. Stages of the research process to determine risk and mitigation

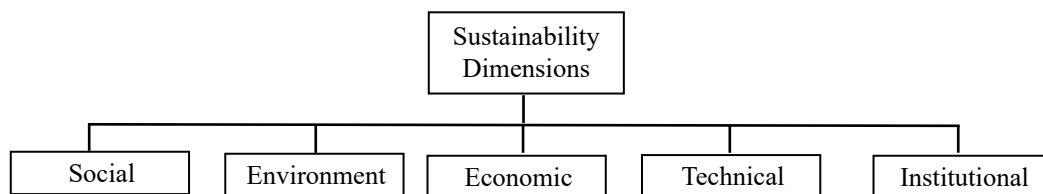


Figure 2. Conceptual framework of sustainability dimensions

## RESULTS

### Literature Review

Identify risk factors in the five sustainability dimensions through a literature review. Investigating the literature in the context of supply chain risk, management, risk assessment and sustainable operations. A literature survey yielded forty-four potential risk factors associated with sustainable supply chain management in the pharmaceutical industry.

### Distribution of questionnaires

A questionnaire was created based on the literature review results and then distributed. These experts worked in several pharmaceutical companies and had work experience of more than five years. The experts who responded were a director, deputy director, general manager, manager, assistant manager, and supervisor. Their work areas include procurement, production, warehousing, distribution, PPIC, R&D, and supply chain. In this step, experts were asked to select 10-15 factors with a higher risk than others. Questionnaires were distributed to 115 experts, of whom 56 were willing to respond (Figure 3).

### Identify the most relevant risk factors using Pareto analysis

Based on the experts' feedback, the number of each risk factor and its cumulative percentage were determined for the Pareto analysis. From the Pareto analysis, it can be seen that of the forty-four risk factors identified, ten risk factors have a value of 50% of the risk in supply chain management in the pharmaceutical industry in Indonesia (Figure 3). The ten risk factors are price and cost volatility, costs (raw materials, packaging materials, salaries, transportation, maintenance, etc.), market competitiveness (market share performance, technological capabilities), company financial capabilities (profitability, financial stability, credit strength (solvency)), waste management, energy efficiency, partnerships between supply chain partners (raw material suppliers, distributors, etc.), government (Ministry of Health, Ministry of Industry, Department of Manpower, etc.) and regulators (BPOM, etc.), competitive pressure (competition with other companies), and scarcity of raw materials.

### Best-Worst Method calculation

The selected experts were interviewed and ranked from 1 to 10 for the ten risk factors selected from the Pareto analysis. However, two or three existing risk factors can have the same order if the risk levels are considered the same. Then, it was calculated using Excel Solver, and a weight value for each risk factor was obtained from the experts. The weight calculations from the experts were averaged, as shown in Table 2.

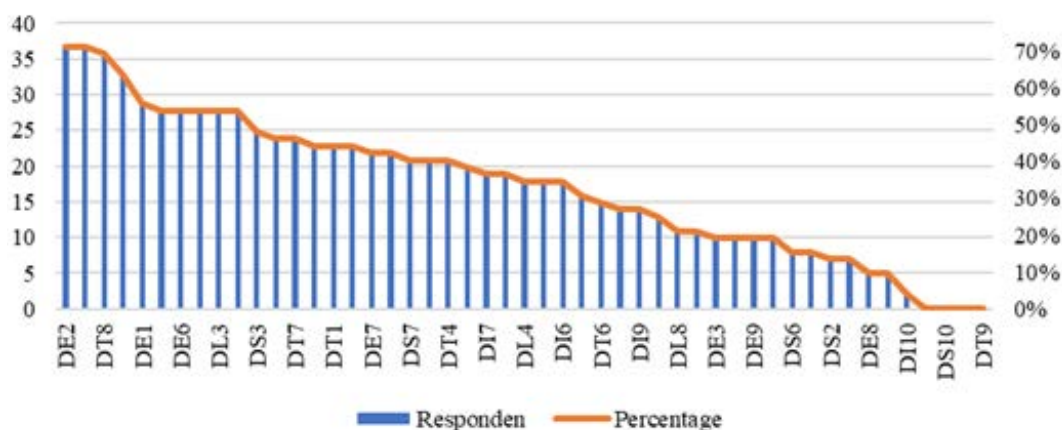


Figure 3. Pareto analysis of identified risk factors from 56 experts

Table 2. Risk factors ranking order based on the average of weight value

Rank	Risk Factors	Expert 1 (A1)	Expert 2 (A2)	Expert 3 (A3)	Expert 4 (A4)	Expert 5 (A5)	Expert 6 (A6)	Average
1	DE2	0.1767	0.2393	0.1271	0.2116	0.1117	0.0612	0.1546
2	DS1	0.0442	0.1457	0.2143	0.1255	0.1676	0.1225	0.1366
3	DT8	0.0707	0.0971	0.2143	0.1255	0.1117	0.1837	0.1338
4	DE1	0.1767	0.2393	0.1271	0.0502	0.1117	0.0919	0.1328
5	DS4	0.0505	0.0728	0.0635	0.0837	0.1117	0.3018	0.1140
6	DE6	0.1178	0.0486	0.0847	0.2116	0.0838	0.0459	0.0987
7	DS5	0.1767	0.0416	0.0508	0.0627	0.0838	0.0525	0.0780
8	DE5	0.0589	0.0583	0.0508	0.0627	0.0838	0.0735	0.0647
9	DL3	0.0393	0.0364	0.0424	0.0418	0.0670	0.0408	0.0446
10	DL5	0.0884	0.0208	0.0249	0.0246	0.0670	0.0262	0.0420

The BWM calculation shows that DE2 costs (raw materials, packaging materials, investment, salaries, transportation, maintenance, etc.) have the highest weight value of 0.1546. The second is DS1 partnerships between supply chain partners (raw material suppliers and distributors). The weighted value obtained for this risk factor was 0.1366. The third is DT8, which is the scarcity of raw materials; the weight value in the best–worst method assessment is 0.1338. DE1 Price and cost volatility is the next risk factor, with a weight value of 0.1328. DS4 Government (Ministry of Health, Ministry of Industry, Department of Manpower, etc.) and Regulators (BPOM, etc.) are the fifth of the ten selected risk factors, with a weight value of 0.1140. The sixth is DE6, the company’s financial capability (profitability, financial stability, and credit strength solvency) with a weight value of 0.0987. Seventh is DS5, the competitive pressure risk factor, weighing 0.0780 in the best–worst method. DE5 Market competitiveness ranked eighth among the selected risk factors, with a weight of 0.0647. DL3 Waste management was one of the risk factors selected by fifty-six respondents, with a weight value of 0.446. The tenth place is DL5, a competitive pressure risk factor weighing 0.0420 in the best–worst method.

### Risk and Mitigation

Costs (Raw Materials, Packaging Materials, Investment, Salaries, Transportation, Maintenance, etc.)

Inefficient costs increase the Cost of Goods Manufactured (COGM); however, these costs can still be controlled because they originate from internal company operations. When the components of the cost of goods manufactured remain high, competitiveness with competitors becomes very tight, especially

when compared with internal prices that have a large difference, that is, much higher. Prices cannot be lowered, but they can be controlled through assured quality. Mitigation that can be carried out from the operational side is through efficiency and improvement initiatives, with the hope of maintaining quality while using lower costs and controlling the increase in operational costs. According to Bhattacharyya (2012), companies must consider cost effectiveness and potential costs from supply as well as operational costs. From the investment side, careful and feasible business assessments are necessary to ensure that the investment costs incurred are worth creating and can generate a quick return. According to tollskog (2008), investment costs must be considered directly in the medium- and long-term. One study mentioned that investment can encourage companies to achieve sustainability (Moktadir, 2021).

Lean Manufacturing is a continuous improvement process that can be implemented for price efficiency, especially in the production stage. Negotiations with suppliers through contracts can be done to obtain more competitive prices, reviewing competitor prices, labor costs, as well as from the side of raw materials and overhead costs, to determine whether there are any expenses that can be saved to reduce the cost of goods manufactured. Another approach is to implement process automation to reduce production costs.

Partnerships Between Supply Chain Partners (Raw Material Suppliers, Distributors, etc.)

This partnership is important because it supports supply chain power and is related to financial capability. When the partnership is good, the supplier will automatically become a priority because the supplier needs certainty.

Companies must establish and maintain relationships with raw material suppliers, packaging material suppliers, and distributors. With a good relationship, it is hoped that their timely supply and quality will be maintained. With a good partnership, the impact on payments can be relaxed to 30-60 days after the goods arrive. Suppliers can provide economical or cheaper goods through long-term partnerships and joint operation strategies. Sourcing becomes critical when resources are limited, and this partnership is key, but solutions will emerge from supplier partners. If we do not have better, cheaper, and faster materials, two critical components are needed: cheap and high-quality raw materials. Partnerships with distributors are also important because there will be no added value if there are no buyers, and the business will be stuck. Customers can keep up, so they cannot take them elsewhere. We can make long-term contractual agreements to ensure that the supply is safe. We can determine how we partner with vendors in the procurement quadrant. A strategy can be implemented next year to procure raw materials by determining the Pareto product. Maintaining good relations with vendors is achieved by meeting with them and showing appreciation.

#### Scarcity of Raw Materials

The pharmaceutical industry in Indonesia is highly dependent on imported raw materials. When shortages occur or when partnerships in the supply chain are not strong, the entire national supply chain is affected. Mitigation can be achieved by strengthening external integration, especially with suppliers abroad, and establishing contractual cooperation for critical or specific materials. From this long-term partnership, technology transfer and the development of raw material production facilities in Indonesia can occur, so that better integration in the country can be achieved. Strategic mapping with portfolio analysis can be used to identify which materials are rare and supplied by a limited number of suppliers and which materials are widely available commodities. From that, procurement strategies can be created, for example, for commodities, procurement can be done through competition by comparing supplier prices to obtain the lowest cost.

Critical and essential raw materials also need to be mapped in sourcing portfolios, spending, and risk. Then, an assessment must be carried out to determine whether the material depends on one source or requires an additional supplier. If no other sources are available,

collaboration and communication with vendors must be strengthened. Suppliers need to be informed about one-year purchase requirements, and then a discussion is carried out to maintain inventory stocks to ensure supply continuity. Mitigation can also be carried out by making alternative sourcing from different continents, for example, from Asia and Europe, or from different areas, such as East China and West China, so that risk can be reduced. For materials produced by only one manufacturer, cooperation is required with the related ministry to discuss the company's needs and ensure the availability of raw materials.

When there are difficulties in production, information must be shared earlier so that mitigation can be performed as soon as possible. In the long term, dependence on a single source should be avoided. Companies need to re-plan production routes by considering raw material shortages and optimizing resource use (Eskandari et al. 2022). One of the main problems faced by manufacturers during political instability and pandemics is the scarcity of raw materials and supply delays. Preparing materials with minimal waste can support sustainability.

#### Price and Cost Volatility

In developing countries, competition in the pharmaceutical industry is generally price-based. For example, the National Health Insurance (BPJS) program in Indonesia tends to prioritize lower-priced medicines. Fluctuations or volatility in raw material prices affect the company's profit margin, which also influences supplier selection. Price and cost volatility are external risk factors that cannot be controlled; however, several strategies can be used to mitigate them. One mitigation effort is to diversify suppliers. The use of several suppliers can balance price changes by dividing procurement proportions, for example, the first, second, and third suppliers. Price negotiations can also be conducted with non-USD currencies, such as the Chinese Yuan, to reduce the impact of exchange rate fluctuations. In addition, a contract system can be applied to 30–40% of Pareto products with raw materials at stable prices, based on the accuracy of demand forecasting.

The use of a price trend database for raw materials, especially Pareto and critical materials, needs to be implemented so that price contracts and buffer agreements for 6–12 months can be made. Because

changes in raw material prices can significantly impact the Cost of Goods Manufactured (COGM), margin calculations and supplier planning must be performed to maintain price stability. Price and cost volatility are economic risk factors in sustainable supply chain management (Moktadir, 2021). Price and cost volatility can affect several cost components, such as design, procurement, environmentally friendly raw materials, and production costs. Fluctuations in these cost components can lead to complexities in price and quality management, which can affect the achievement of supply chain sustainability.

“Price and cost volatility” is one of the main risk factors considered in several risk assessment models (Tang and Nurmaya Musa, 2011). Risk interactions in the telecommunications sector and found that price and cost volatility are the second most critical causal risk factors (Song et al. 2017). However, several studies have not included this factor. For example, analyzed 14 manufacturing risk factors but did not include price and cost volatility as risk factors in their study (Rajesh and Ravi, 2015). Likewise, Wang and Hao (2016) did not include price and cost volatility in their risk assessment of agricultural products. Khemiri also did not include this factor in their research on risk in integrated production procurement systems (Khemiri et al. 2017). The difference in the inclusion of these risk factors shows that each industry has its own characteristics.

Government (Ministry of Health, Ministry of Industry, Manpower Office, etc.) and Regulators (BPOM, etc.)

Government policies, such as employment, product formulation, halal certification, and Good Manufacturing Practices (GMP), have become increasingly strict. Consequently, company investments must increase to comply with these regulations. Communication and relationships between institutions and between corporations and the government must be well maintained. When there is a discourse or plan for regulatory change, companies must be able to capture the opportunity and promptly participate in providing inputs. This should be done not only individually by corporations but also through networks such as the GP Pharmacy Association or the Indonesian Pharmacists Association (IAI). The expansion of these networks aims to facilitate communication with the government

when there are changes or updates in regulations. Discussions within the pharmaceutical industry community, such as GP Farmasi, allow companies' aspirations to be voiced collectively to conduct hearings with the regulators. Through this mechanism, companies can gain stronger positions to discuss with the government and regulators, exchange perspectives between the industry and authorities, and seek joint solutions.

Greater attention is also required for sudden regulations. If there is prior socialization, companies will have time to prepare, comply with the regulation, and conduct mitigation. If such regulatory changes are not anticipated, the company may experience a significant loss of opportunity. Mitigation can be achieved by appointing one person as a Person in Charge (PIC) responsible for representing and branding the company to government institutions. The PIC must attend every government-related event, be proactive, access and update the latest regulations, and maintain direct communication with government representatives. In addition, by attending government seminars, companies can expand their networks, get acquainted with government officials, and stay informed about new regulations.

Companies must also be able to assess their level of compliance with existing regulations and identify gaps between company conditions and regulatory requirements. New mandatory regulations must be followed, but compliance with these regulations will also increase the company budget. To address this, cost substitution should be considered in other areas that can be optimized for the process. This highlights the importance of a Lean Manufacturing program. In recent years, the U.S. Food and Drug Administration (FDA) regulations have become stricter for factories that have not yet obtained GMP certification. One of these regulations allows factories to produce their own branded products while requiring them to label products with their generic names. Considering the advantages of waste reduction and recall systems in the production sector, as well as the opportunities that arise from complying with GMP standards, it is important to include this strategy in the agenda to develop factory products and increase sales (Eskandari et al. 2022).

### Company Financial Capability (Profitability, Financial Stability, Strength Credit (Solvency))

Companies need working capital to generate profits, cash flow, and revenue. Without these, chaos will occur because important priorities may be delayed in terms of payment. To sell fast-moving products, the challenge is to maintain a time gap between incoming and outgoing cash (cash-to-cash cycle). In the long term, this requires the company's financial capability to remain strong, as large capital is needed. The fastest distributors may make payments within 60 days, but in some cases, it can take up to 90 days. Therefore, capital remains tied up. The company's financial strength must be maintained to ensure good cash flow so that operations can continue smoothly. For raw material suppliers, flexibility is given to companies that are financially healthy and have good reputations. For smaller pharmaceutical companies, ordering large quantities of raw materials for 3–6 months of buffer stock is not possible because of the high costs. In addition, vendors tend to impose stricter payment terms on companies with no established reputation. Thus, profitability is important for a company's reputation when ordering materials, making investments, and so on.

If financial capability is not controlled, opportunities in the market may arise, but the company cannot seize them because of a lack of financial resources, resulting in lost opportunities. Therefore, the financial strategy must be strong, with proper cost allocation and sourcing of funding for working capital. If internal funds are sufficient, they should be prioritized; if not, external loans may be taken, but careful calculation is needed to ensure that the return on earnings and repayment period are balanced. Running a business must be profitable and stable to support operations. Credit strength must exist because business operations must be bankable (having sufficient cash liquidity), as it affects all aspects of a company. Without sufficient cash, operations become difficult. Supply partners may not be properly served, regulatory improvements cannot be implemented, and as government regulations become increasingly strict, the costs of compliance and facility investments will continue to rise. If a company's financial capability is good, many initiatives can still be developed; otherwise, the company will stagnate and fail to progress.

Mitigation can be achieved by managing finances prudently. The company's cash flow must be maintained in balance between inventory, accounts receivable,

and accounts payable so that the net operating cycle is not too long or too short, ensuring a good cash flow. The company must be able to manage operational cash flow wisely; the business must be profitable with sufficient margins, and those margins must be allocated for operations and investment to enable continuous growth. When venturing into new business areas or competing in existing markets, investments must be made strategically to secure competitive advantages and drive expansion. Financial health refers to the financial situation of an entity, whereas the financial health of the supply chain refers to the financial condition of the entire supply chain network. Financial health is a key component of economic sustainability (Saeed and Kersten, 2018). As previously mentioned, the economic dimension of sustainability aims to maintain long-term and stable financial health, which can be applied to supply chains. Based on the literature, financial health can be defined in terms of the profitability, financial stability, and credit strength of supply chain stakeholders (Saeed and Kersten, 2018; Zhou and Xu, 2018; Zietlow, 2012).

Profitability, an important attribute of the economic sustainability of a supply chain network, is an indicator of efficiency and business performance (Saeed and Kersten, 2018; Hahn and Figge, 2011). Profitability reflects a system's ability to generate profit, and most businesses strive to achieve long-term profitability through sustainability integration (Lefko, 2017). A successful and sustainable supply chain begins with adequate profitability. Financial stability refers to a situation in which the financial condition of the supply chain is resistant to economic failure. In other words, it refers to the creation of a strong financial system that functions effectively. Financial stability in a supply chain ensures capital optimization across all entities. Financial stability can be defined as the ability to maintain the normal financial climate of a system over a certain period of time (Zhou and Xu, 2018). This definition also applies from the supply chain perspective.

Credit strength is a measure that evaluates the creditworthiness of stakeholders in fulfilling their debt and financial obligations. Credit strength, also known as solvency, is usually presented in the form of a detailed report summarizing the borrower's financial history. In general, debt threatens financial stability and economic growth for suppliers. As economic sustainability requires the ability to maintain resources and financial

stability, failure to meet debt obligations threatens economic sustainability. For example, if companies are unable to fulfill their financial obligations, the financial equilibrium of the supply chain economy is disrupted, potentially hindering sustainability.

#### Competitive Pressure (Competition with Other Companies)

To compete with the existence of competitive pressure, we must focus on where our strength lies. Competitiveness is the result at the end; by paying attention to how we operate, we can be competitive. The pharmaceutical industry is not much different from other industries operationally, because entering the pharmaceutical industry requires a large investment. The anticipation is that we must maintain market competitiveness, and products must still be able to compete by carrying out cost efficiency so that we can still have competitive prices in the market. Market competitiveness refers to the ability to provide goods and services that are more creative and efficient than those produced by competitors. Market competitiveness is an important aspect of achieving sustainability (Saeed and Kersten, 2017).

Research and development (R&D) is an important aspect of every pharmaceutical company. Many drugs have received the necessary validation from credible organizations, such as the FDA in the United States, but have not yet been mass-produced in Iran. In addition, the continuous flow of drug combinations to the global market and the publication of new studies on substances that are effective in medicines and supplements emphasize the need to strengthen the R&D sector in the pharmaceutical production line by considering the existing opportunities to formulate and produce drugs that are in high demand (Opportunity 1). The ability to produce products that were previously unavailable can provide a crucial competitive advantage for every pharmaceutical company while improving developmental weaknesses (Eskandari et al. 2022).

With the start of widespread global vaccination, the morbidity and mortality rates related to COVID are expected to begin to decline (Eskandari et al. 2022). However, people with a history of infection will continue to suffer from its side effects. In addition, we can expect the emergence of effective post-pandemic drugs. In accordance with the advantages of the recall system and the manufacturing sector and the factory's ability to produce pharmaceutical products that are in

high demand related to COVID-19, it is important to emphasize the production of these products. For years, attention to environmental issues has been minimal in developing countries such as Iran. However, recently, the market demand for environmentally friendly products has increased, and the number of customers has also increased sharply. Owing to the advantages of waste reduction and the factory's ability to apply green principles in the production and distribution processes, these principles can be applied to increase sales. Currently, many pharmaceutical companies differentiate themselves from their competitors and attract new customers by declaring that they avoid using chemicals as raw materials and use herbal capsules and various packaging with minimal environmental impact (Eskandari et al. 2022).

#### Market Competitiveness (Market Share Performance, Technology Capability)

The average products owned by the Pharmaceutical Industry in Indonesia are me-too products, not originator products. Price is the main concern for market competitiveness. Competitors can significantly reduce the Cost of Goods Manufactured (COGM) by using robotic machines in the packaging process, so that they do not need many workers. Room conditioning technology can immediately make automatic adjustments when deviations occur, which will cause shorter lead times, and in terms of quantity, problems rarely occur. To still be able to face market competitiveness, we need to decide where we want to play, whether on price or quality. If it is at a low price, the price becomes the benchmark in every operation. If the price is high, the company's experience and differentiation must also be considered. If the produced product is not of good quality and the price is not competitive, it will be difficult to penetrate the market, and we must be smart in positioning.

The company needs to determine segmentation and market penetration and implement the required marketing strategy. Implementation can be achieved by approaching hospitals or doctors, renewing the product cycle by adding active substances or changing formulas, or changing packaging designs. All of this is done to add new selling value to the product. In the pharmaceutical industry, market performance is important in price competition because it is more flexible in pricing strategy. One product has a negative margin, but another product has a very high margin.

If we do not take the market, then we risk losing the market not only for that product but also for other products.

Market share is the percentage of total industry sales obtained by a particular company during a certain period of time. It is a metric used to measure a company's performance in relation to its competitors. Market share performance is part of market competitiveness analysis and is used to assess the effectiveness and efficiency of companies or supply chains. Sustainability has become a key factor in market competitiveness (McCann, 2017). In other words, market share performance and sustainability are interrelated. Therefore, it can be said that the more sustainable the supply chain, the higher the market share performance. Technological capability is the ability of an organization to acquire new technology to develop its processes and operations. Technological capability supports technological innovation in supply chain network organizations (Zhou and Xu, 2018). Currently, green and sustainable technology has become a general trend (MW, 2020) because it has several environmental, economic, and social benefits, including improved air quality, cost reduction, and enhanced health. Integrating these technologies into the supply chain helps transform it toward sustainability.

#### Waste management

Waste management already has regulations on what the output specifications should be; mitigation can be established at the beginning, according to the existing regulations. We can identify our capability to process waste to comply with the required specifications. Waste management must be carried out because it affects funding and environmental complaints. The greater the waste output, the higher the cost. Waste management is mandatory because waste from the pharmaceutical industry is classified as hazardous and toxic (B3) waste. Waste management will become crucial if it causes environmental problems, as the pharmaceutical industry deals with chemical materials. If the company does not manage its waste properly and pollution occurs, the sanctions are closure and large fines. Therefore, we can synergize with the environment in which we operate by implementing Corporate Social Responsibility (CSR).

By managing waste properly, to become a bankable company, one of the requirements is environmental compliance (PROPER) with high credibility. If

environmental analysis is not performed properly and the applicable environmental requirements are not fulfilled, the risk can cause the company to be shut down. Waste management includes waste collection, transportation, disposal, and recycling. Several types of waste must be eliminated from the supply chain, including defects, excessive inventory, non-value-added processing, and waiting. (Amrani et al. 2021). Saeed and Kersten (2017) stated that waste management is an attribute of environmental sustainability. To achieve a sustainable supply chain, all types of supply chain waste must be managed and controlled. Because biomass raw materials include solid waste, agricultural residues, and organic residues, the management, recycling, and reuse of these materials are necessary to develop a sustainable supply chain for biomass. Material efficiency is part of sustainable development (Saeed and Kersten, 2017) and is defined as a metric for measuring the level of consumption, incorporation, and disposal of materials. Material efficiency, in the context of the supply chain, includes minimizing materials in production and using recycled objects and waste.

#### Energy efficiency

Energy is a main supporting factor for the production process, and many regulations must be followed with large energy usage. If efficiency is not carried out, it will cause an increase in costs, so that the Cost of Goods Manufactured (COGM) will rise, the product price will become uncompetitive, and profit will not be achieved. This can be mitigated by implementing Lean Manufacturing and green energy. When seeing opportunities in carbon, carbon incentives can be optimized, and capacity utilization can be maximally increased, one of which is through toll manufacturing. We must consider how to save energy because the greater the energy, the greater the cost. The process was designed to be simpler and shorter. One of the components is factory overhead, which includes energy; if it is not efficient, it will impact production costs, small margins, and low profitability, and the company's growth will be slow. Reducing cost efficiencies will impact the company's business.

Energy efficiency is one of the main factors in resource management and is defined as the ability to perform tasks using less energy (Amarani, 2021). Marchi and Zanoni in 2017 stated that energy efficiency, as an important component of sustainable development, provides benefits for various entities. The use of

energy-efficient strategies can lead to increased competitiveness, profitability, and quality improvement. According to Marchi and Zanoni (2017), consumption considerations in supply chain management play an important role in improving energy performance. While the assessment of energy efficiency is based on the total energy consumed by a company for its activities, sustainable supply chain management considers the energy consumed and environmental footprint of the resources used in the supply chain as a whole.

### **Managerial Implication**

This study has significant practical implications. The findings of this study will help policymakers. The results of this study can help them develop proactive, active, and reactive risk mitigation strategies to resolve risks in supply chain management in the pharmaceutical industry. The following managerial implications can be drawn from this study: First, attention should be paid to the rise and fall in costs. If operational costs cannot be controlled, the production cost will increase. Therefore, company management should implement energy efficiency, lean manufacturing, and toll manufacturing efficiencies. Second, the availability of materials and their distribution must be ensured. Maintaining good relationships with suppliers and distributors can ensure material availability and price stability. Therefore, practitioners must be able to create good company communications and impressions of the suppliers and distributors. Third, formulate strategic policies to achieve competitive advantage. Management must determine the right product and marketing strategies. The company remains competitive in the existing market by determining market segmentation and penetration strategies. Fourth, ensure good cash flow. When a company's financial condition is poor, it affects and disrupts the smooth operation of the company. Therefore, decision-makers within the company must ensure that the company's cash flow is operationally stable and grows. Finally, ensure the implementation of regulations. To mitigate risk factors such as 'Government (Kemenkes, Kemenperin, Disnaker, etc.) and regulators (BPOM, etc.)' and 'waste management,' personnel can be appointed to ensure that the company follows all existing regulations and to look for the latest information regarding regulations relating to the company. When this step is completed, companies can maintain the trust of the government, regulators, and consumers.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **Conclusions**

This study identifies ten critical risk factors in Indonesia's pharmaceutical supply chain management, with cost management emerging as the highest priority through the best-worst method analysis. The findings demonstrate that all identified factors pose significant risks, requiring comprehensive mitigation strategies to ensure supply chain resilience and sustainability. To address these challenges, pharmaceutical industry management must implement strategic initiatives. First, operational efficiencies should be established across procurement, production, and distribution processes to effectively control costs. Second, collaborative relationships with key stakeholders, including suppliers, distributors, regulatory agencies, and government bodies, should be strengthened to enhance supply chain coordination and responsiveness. Third, companies should develop focused product portfolios and targeted marketing strategies that align with market demand and organizational capabilities. Finally, robust financial management practices are essential for maintaining adequate cash flow and supporting long-term operational stability. These integrated approaches will enable pharmaceutical companies to build more resilient and sustainable supply chains that can withstand future disruptions.

### **Recommendations**

Pharmaceutical industry managers should prioritize cost optimization through lean manufacturing implementation, cultivate strategic partnerships with supply chain stakeholders, develop targeted market segmentation and penetration strategies, ensure stable cash flow management, and designate personnel responsible for regulatory compliance. This study's focus on risk factors within Indonesia's pharmaceutical supply chain provides a foundation for broader investigations. Future research could extend this framework to other industrial sectors to validate the applicability of the identified risk factors and mitigation strategies across different contexts. Expanding the sample size and standardizing respondent criteria would enhance the generalizability of the results and provide deeper insights into risk management practices. Additionally, future studies could investigate specific sustainability dimensions in greater depth, such as conducting focused studies on economic factors,

including raw material costs and production expenses. Other valuable research directions include examining raw material scarcity mitigation strategies, exploring mechanisms for maintaining regulatory compliance, and analyzing the interdependencies between individual risk factors. These targeted investigations would advance both the theoretical understanding and practical application of sustainable supply chain management in the pharmaceutical industry.

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