

# Assessing The Supply Chain Risks of an Indonesian Electricity Company

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## Abstract

Energy is a crucial necessity for human societies, and access to electrical energy plays a significant role in economic development. A state-owned enterprise (SOE) is entrusted with the provision of electrical energy across Indonesia. The objective of this study is to identify and assess risk factors within the supply chain of primary distribution materials at SOE. The identification of risk factors was based on a comprehensive review of literature across various industrial sectors, further validated through consultations with senior managers at the company. For the assessment of these risks, the study employed the modified Decision Matrix Risk Assessment methodology, which involves evaluating risks based on their likelihood and impact. This evaluation was conducted through surveys distributed to 66 respondents, including planning managers, distribution managers, and commercial managers across all regional and distribution main units in Indonesia. Two risk categories with five sub-categories and a total of 27 risk factors were identified. Supply-related risks are the most significant compared to the other four sub-categories. Scarcity of raw materials, lack of capacity flexibility, and failure to make delivery requirements are in the top three rankings. This research can enrich the supply chain risk literature and provide valuable insights for utility managers in understanding supply chain risks.

*Keywords:* Risk assessment, risk identification, risk matrix, supply chain risk.

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## 1. Introduction

Energy is an indispensable human need after food, water, and shelter (United Nation, 2021). Its role in enhancing the quality of human life has become crucial as standards of living improve globally. Affordable and accessible electricity is essential for socioeconomic development, impacting both household well-being and broader developmental goals. Globally, the electrification ratio as of 2021 is 91.2%, where the African continent is the lowest electrification ratio with an average of 45% (World Bank, 2023). Indonesia's electrification ratio in 2022 reaching 97.63%, the country still aims to achieve a 100% electrification ratio by 2024, a target set by the Ministry of Energy and Mineral Resources. Based on data from the World Bank, Australia's electrification ratio has been 100% since 1990. When compared with Indonesia, there are differences in electricity management. In Australia, electricity is not completely controlled by the state but also by private companies (Energy Networks Australia, 2019). In Indonesia, based on electricity act, the supply of electricity is carried out by state-owned enterprises (SOE) (Undang-Undang Nomor 30, 2009)

An SOE is legally entrusted with the provision of electricity nationwide. As of the end of 2022, the company operates an extensive power generation, transmission, and distribution network, serving millions of customers. A strategic focus has been the acceleration of new residential customer connections, a downstream process in the electricity distribution system that directly influences service provision and customer satisfaction (RUPTL, 2021).

Supply chain plays a pivotal role in supporting the achievement of company goals, underscoring the importance of effective management and optimization for enhancing decision-making and developing optimal infrastructures (Lee, 2004). Given the critical nature of addressing uncertainties within the supply chain, there's a pressing need to focus on supply chain optimization to ensure resilience and efficiency (Papageorgiou, 2009). Coordination and integration of material distribution is very influential in improving overall supply chain performance (H. Hou et al., 2017). In 2022, 14.5% of electricity service delays will be due to material unavailability (internal data processed by the author, 2023). This is particularly relevant when addressing challenges such as achieving targeted electrification ratios, where a

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thorough examination of the Primary Distribution Materials (PDM) supply chain becomes essential. The PDM supply chain is fundamental not only in maintaining service levels but also in ensuring a rapid response to customer needs.

With this background, this research will conduct a comprehensive study on the primary distribution material supply chain. This study aims to answer two questions:

RQ1. What are the main risk factors in the primary distribution materials supply chain?

RQ2. Which risk factors have a more significant influence on the primary distribution material supply chain process?

Supply chains are becoming more exposed to a wide array of disruptions (Chen et al., 2024). Risks and disruptions are inevitable for any industry, and any disturbances in the operation of a supply chain is likely to pose catastrophic threats to a product's value-adding process. This is also supported by (Barbosa-Póvoa & Pinto, 2023) with the emergence of global pandemics and increasing geopolitical instability, it became evident that to ensure reliable products and services, there is a need for supply chains that guarantee efficiently and effectively the management of information and material flows. Robust supply chain and contingency plans also has significant effects of shortages (Alshibli et al., 2024).

The primary stages of risk management align with those of conventional risk management processes and encompass the following key phases: risk identification, assessment, analysis, treatment, and monitoring (Fan & Stevenson, 2018). Various methodologies exist for identifying risks, including tools like risk mapping and checklists, which aid in pinpointing potential threats. These risks are subsequently evaluated and assessed by considering their likelihood and impact on supply chain performance. (Zsidisin et al., 2004). Risk analysis is commonly regarded as a pivotal phase within the risk management process, given its critical role in comprehensively evaluating and understanding potential hazards and their associated impacts. (Hallikas et al., 2004). For companies to effectively address risks, it is imperative that they grasp the underlying causes of these risks and comprehend the potential repercussions should these risks materialize. This understanding enables them to select the most suitable mitigation strategies and actions. (Giannakis & Papadopoulos, 2016).

Previous studies have explored risk identification, including, (Truong & Hara, 2018) who compared the impact of various risks on the performance of manufacturing-oriented and service-oriented companies from a supply chain perspective using structural equation modeling and multiple group analysis, (Rostamzadeh et al., 2018) developed a framework for sustainable supply chain risk management using an integrated fuzzy TOPSIS-CRITIC approach, (Sharma et al., 2024) assessed supply chain risk factors in the Indian pharmaceutical industry using the fuzzy synthetic evaluation (FSE) method, (Vafadarnikjoo et al., 2023) analyzed mitigation strategies to address various risks in the agri-food supply chain context using an integrated modified risk mitigation matrix with grey multi-objective binary linear programming, (Abdel-Basset & Mohamed, 2020) estimated sustainable supply chain risk management in a Telecommunications Equipment Company using a plithogenic multi-criteria decision-making approach based on the Technique in Order of Preference by Similarity to Ideal Solution (TOPSIS) and the Criteria Importance Through Inter-criteria Correlation (CRITIC) method, dan (J. Hou & Zhao, 2020) developed a framework for identifying and evaluating supply chain risk management using system theory. None of these studies, however, have addressed risk identification in the utility industry, specifically in the electricity sector where companies are state-owned.

This research is confined to the supply chain processes of utility state-owned company, with a particular emphasis on the risks associated with the distribution materials. The findings will not only guide the company in optimizing its supply chain risk management but also contribute to academic discourse on supply chain risk management practices within state-owned utility industries.

The remainder of this paper is organized as follows. Section 2 consists of a review of the literature concerning the definition and classification of supply chain risks. Section 3 introduces research methods used in this study for the identification, measurement, validation of risk factors and its materials. Section 4 explains the results of risk measurements which have calculated the impact and probability, arranged based on ranking, visualized into a 5x5 risk matrix and discussion. Section 5 provides brief conclusion of this research.

## **2. Literature Review**

The concept of supply chain risks has garnered considerable attention in scholarly literature, given its critical implications for supply chain management and organizational resilience. This paper seeks to elucidate the various definitions of supply chain risk provided by seminal authors in the field, thereby laying a foundation for understanding its multifaceted nature.

### 2.1. *Supply chain risks definitions and management*

The foundation of managing supply chain risk lies in its definition. March & Shapira, (1987) were among the first to articulate a definition of supply chain risk as “variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective values.” This early definition underscores the inherent uncertainties in supply chain operations and their impacts on outcomes. Building on this foundation, Zsidisin (2003) expanded the definition by linking the occurrence of an incident with the affected companies' inability to cope with the consequences, thereby highlighting the operational implications of supply chain risks. Similarly, Yu & Goh (2014) regarded supply chain risks are defined as the likelihood of an unfavorable event transpiring within a specified timeframe, coupled with its resultant impacts on supply chain performance. Jüttner et al. (2003) approached the definition from the perspective of supply and demand mismatches, emphasizing the operational and performance implications. Aven (2016) further broadened the definition by considering the potential losses in terms of efficiency and effectiveness due to uncertain developments triggered by specific events.

Identifying and assessing risks is pivotal in managing supply chain vulnerabilities. Heckmann et al. (2015) emphasized risk identification as the starting point for categorizing triggering events that could potentially disrupt supply chain operations. This process is crucial for understanding the specific risks a supply chain faces and the underlying causes of these risks. Upon identifying and assessing the risks, developing and implementing appropriate risk management strategies is essential. Manuj & Mentzer (2008) outlined a five-step process for supply chain risk management: risk identification, risk assessment and evaluation, selection of appropriate risk management strategies, implementation of these strategies, and finally, mitigation of supply chain risks.

### 2.2. *Supply chain risks categorization*

Prior research on supply chain risk has examined the diverse risks present in supply chains with numerous dimensions and endeavored to classify several risk categories based on various factors. Duong et al. (2023) classify risks in the supply chain into two main types: internal risks and disruption risks. These include five subcategories: supply risk, operational risk, demand risk, man-made risk, and natural risk. On the other hand, Pradhan & Routroy (2014) using FMEA approach to identify risks, it is classified into three categories according to domains; supplier, manufacturer and customer. Using both quantitative and qualitative analysis Chang et al. (2015) developed a model of supply chain risk by prioritizing risks based on their association with three key flows: information, physical, and payment flows.

### 2.3. *Risk identification*

Risks cannot be assessed or managed until they are identified and described in an understandable way. Risk identification is an organized thorough approach to seek out the real risks associated with the program. Expert interviews, analogy comparisons, and the evaluation of the program plans are techniques that are especially strong in the risk identification segment (Defence System Management College, 1989). de Oliveira et al. (2022) state that brainstorming and interview are classified as strongly applicable for risk identification. Review of previous studies, data and documents to identify risk is a common method used in risk analysis studies (Chang et al. 2015)

### 2.4. *Risk analysis.*

In general, the risk filtering and ranking process are used to provide priorities for risk analysis (J. Hou & Zhao, 2020). Chapman (2001) dividing risk analysis of project risk management into two sub-stages: a qualitative analysis sub-stage that focuses on identification together with the assessment of risk, estimation with probability and impact is use for estimation, and a quantitative analysis sub-stage that focuses on the evaluation of risk with four analysis technique: sensitivity analysis, probabilistic analysis, influence diagrams and decision trees. Reniers et al. (2005) comparing 7 risk analysis techniques, checklist, safety audit, fault tree analysis, HAZOP, what-If analysis, risk matrix, and Kinney and fine with risk matrix is the most applied risk ranking method and it is well known. Domínguez et al. (2019) delineate risk analysis and assessment methodologies into three primary categories. Qualitative methodologies rely on both analytical estimation processes and the competence of safety management engineers. Examples include checklists, What-If Analysis, safety audits, task analysis, the STEP technique, and HAZOP. Quantitative methodologies treat risk as a measurable quantity that can be calculated and represented mathematically using data from actual accidents at work sites. Techniques include the Proportional Risk Assessment (PRAT), the Decision Matrix Risk-Assessment (DMRA), measures of societal risk (SRE), Quantitative Risk-Assessment (QRA), Quantitative Assessment of Domino Scenarios

(QADS), Clinical Risk and Error Analysis (CREA), Predictive, Epistemic Approach (PEA), and Weighted Risk Analysis (WRA). Hybrid techniques combine elements of qualitative, quantitative, and semi-quantitative methods and may involve significant complexity. Examples of such techniques are Human Error Analysis Techniques (HEAT), Human Factor Event Analysis (HFEA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA), and Risk-based Maintenance (RBM).

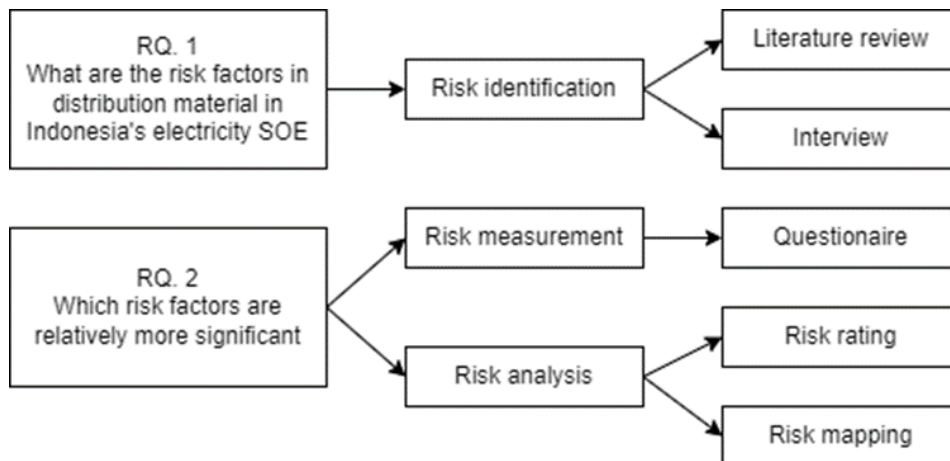
### 3. Research Method and Materials.

This study employs a quantitative approach using a case study method. The quantitative approach was selected to quantify the perspectives and experiences of experts and management teams involved in the supply chain business process. Creswell & Creswell (2018) state that the quantitative approach emphasizes precise measurement of a series of variables to address theoretical research questions. In the quantitative approach, one of the techniques used is through surveys. Surveys provide a quantitative or numerical overview of trends, attitudes, or opinions of a population by studying a sample from that population. From a temporal dimension perspective, questionnaires, and structured interviews in data collection with the aim of generalizing from the sample to the population fall into the cross-sectional category.

The entity used in the unit of analysis for the case study is an organization, namely PT XYZ, as SOE in electricity focusing on cases or issues about the primary distribution material supply chain

#### 3.1. Research methodology

This study adopts a case study methodology, concentrating on the risk analysis of the primary distribution material supply chain within a particular company. The research methodology included conducting interviews with experts and distributing surveys to professionals with relevant expertise. The findings from these surveys will be synthesized into a detailed risk matrix, which will facilitate the development of a risk ranking. This research process is divided into three main phases: risk identification, risk quantification, and risk analysis. A comprehensive literature review was carried out to identify all risk factors documented in previous studies. This was followed by an interview survey to confirm the results from the literature review and to discover additional risk factors. For risk quantification, a questionnaire employing a five-point Likert scale was utilized. The risk analysis phase involves ranking each risk factor according to its scale and mapping them to determine their relative importance.



**Figure 1.** The structure of methodology

Source: adapted from Chang et al. (2015)

The initial phase of the research entailed conducting a thorough literature review to catalog all risk factors previously identified in studies concerning operational risks in supply chains. This review was broadened to encompass general studies on operational risks within supply chains. To ascertain the relevance of the documented risks to the specific supply chain under study and to uncover potential risks not previously mentioned in the literature but present in practice, the study utilized face-to-face interviews. These interviews involved four Vice Presidents overseeing different divisions—distribution, supply chain, risk management, and procurement—and a Senior Manager from Pusertif (Certification Center). The interview format employed open-ended questions, allowing respondents to provide feedback

on the pre-identified list of risk factors and elements. Additionally, respondents were encouraged to suggest any risk factors that were absent from the initial list.

To determine and assess the likelihood and consequences of the risks encountered, this study implemented a questionnaire survey employing a five-point Likert scale. The survey was distributed among all planning managers, distribution managers, and commercial managers across each main distribution unit and main regional unit. Given that there are 22 main distribution and regional units, the total potential effective population size for the survey amounted to 66.

The study utilizes five abstract categories to describe the probability of an event occurring, which are: very low, low, medium, high, and very high. Correspondingly, a Likert scale ranging from 1 to 5 is employed to quantify these likelihood values, with 1 representing “very low” probability and 5 representing “very high” probability.

**Table 1.** Likelihood scale

Likelihood	Scale	Definition
Very low	1	Highly improbable
Low	2	Improbable occurrence
Medium	3	Equally probable to occur or not occur
High	4	Highly likely to occur
Very high	5	Virtually certain to occur

Source: Company internal criteria

The level of risk impact in this study uses a scale of “insignificant,” “minor,” “moderate,” “major,” “catastrophic,” each represented by numbers 1 through 5, used to describe the level of risk consequences.

Consequences	Scale	Definition
Insignificant	1	Causes minor disruptions or delays without significantly affecting company operations.
Minor	2	Disrupts operations but can be managed with minimal impact on customer service.
Moderate	3	Causes significant operational disruptions with a substantial impact on customer service.
Mayor	4	Leads to serious disruptions, or occasionally failures, with severe impacts on operations across several units.
Catastrophic	5	Disrupts company activities on a national scale.

**Figure 2.** Consequence scale

Source: Company internal criteria

In this article the risk assessment will be carried out using a modified DMRA. The risk calculation using the DMRA method is Risk (R) = Severity (S) × Likelihood (P). To accommodate calculations with multiple respondents, Chang et al. (2015) calculated risk value as an Average Risk Scale (ARS) so that the formula becomes:

$$ARS_R = \frac{1}{N} \sum_{i=1}^N (l_{ri} \times c_{ri}) \tag{1}$$

The ARS method calculates risk by multiplying each respondent's perceived likelihood of a risk with its consequences, then averaging these values across all respondents. A drawback of ARS is its inability to distinguish between the specific likelihood and consequences of risk. To overcome this, the current study utilizes the shortest distance method. This approach maps risk on a two-dimensional state space, with the x-axis indicating risk likelihood and the y-axis depicting risk consequences. In this space, each respondent's risk perception is represented as a distinct point. The distance between two points  $(x_1, y_1)$  and  $(x_2, y_2)$  is obtained from:

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{2}$$

The objective is to identify the optimal pairing of likelihood and consequences, such that their product matches the ARS value, and the corresponding point in the state space is closest in total distance to all respondent points. If  $\hat{l}_r$  is the estimated likelihood of risk and  $\hat{c}_r$  is the estimated impact level of risk. For a particular risk factor  $r$ , the total distance between  $(\hat{l}_r, \hat{c}_r)$  and  $(\hat{l}_{ri}, \hat{c}_{ri})$  for  $1 \leq i \leq N$  can be formulated as follows:

$$D_r = \sum_{i=1}^N \sqrt{(\hat{l}_r - l_{ri})^2 + (\hat{c}_r - c_{ri})^2} \quad 1 \leq r \leq M \quad (3)$$

The objective is to find the optimal  $(\hat{l}_r, \hat{c}_r)$  for  $1 \leq r \leq M$  by solving the following constrained optimization problem:

$$\min D = \sum_{r=1}^M D_r = \sum_{r=1}^M \sum_{i=1}^N \sqrt{(\hat{l}_r - l_{ri})^2 + (\hat{c}_r - c_{ri})^2} \quad (4)$$

Where:

$$\hat{l}_r \times \hat{c}_r = ARS_r, \quad 1 \leq r \leq M \quad (5)$$

Based on the risk calculation results, identified risk factors will be classified into a risk matrix. This study uses a Risk Appetite Statement (RAS) to describe the likelihood level and impact level of a risk factor across all respondents. The risk matrix is divided into four zones: low-risk area (risk scale < 5), medium-risk area (5 < risk scale < 10), high-risk area (10 < risk scale < 15), and extreme risk area (risk scale > 15).

#### 4. Results and Discussion

This section comprises three stages: risks validated by experts, risk analysis, and finally, the risk matrix. The risks were categorized into two main categories: internal risks and disruption risks. Internal risks include supply risks, demand risks, and operational risks, while disruption risks encompass man-made risks and risks caused by natural events.

##### 4.1. Validated risk identification

The risks outlined in the literature review were corroborated through qualitative interviews with a cohort of Vice Presidents and Senior Managers. These interviews also sought to elicit any supplementary risks not previously identified. The findings indicate that all risk factors identified in the literature were substantiated by the interviewees. Furthermore, several novel risk factors were proposed during the interviews.

Data integrity emerged as a risk factor intertwined with operational risk. The manual recording of test results into forms presents avenues for personnel to approve materials improperly, potentially aligning with the manufacturer's interests. As articulated by one respondent:

“The possibility of data integrity issues arises when they fill out the test blanks. We have a specific form for these test blanks. So, they are the ones who record the results. Sometimes, employees are dispersed. It might happen that the Outsourced Personnel, knowing the calculations, could record something in the form to make sure the manufacturer's results are accepted. [...] It's mostly based on habit. If the voltage is so high that it doesn't fit, or if the current or temperature is off, they might lower the figures during recording. But this can be cross-checked later during temperature tests, which are recorded hourly; there are data loggers for that. If they tamper with the results, it will be evident from the discrepancies between what is recorded on the test blanks and what the devices show. [...] Unless, of course, there are individuals among the staff who are entering this data.”

Another risk factor suggested by the respondents is the limitation of raw materials. Its primary distribution materials for company still rely on imports due to unavailability domestically, which means that when raw materials are scarce, it can hinder the production process of manufacturers. The respondent explained:

“[...] In my opinion, most cases of delay are due to issues with raw materials, particularly those that are imported[...].”

Category	Sub-category	Risk factor	Source	Code	
Internal risk	Supply risk	Supplier opportunism	(Truong & Hara, 2018)	RS_1	
		Unstable quality of inputs	(Truong & Hara, 2018)	RS_2	
		Unstable quantity of inputs	(Truong & Hara, 2018)	RS_3	
		Price fluctuation	(Truong & Hara, 2018)	RS_4	
		Inability to handle volume demand and specification changes	(Rostamzadeh et al., 2018)	RS_5	
	Operational risk		Supplier bankruptcy	(Truong & Hara, 2018)	RS_6
			Supplier dependency	(Truong & Hara, 2018)	RS_7
			Failures to make delivery requirements	(A. Sharma et al., 2024)	RS_8
			Lack of capacity flexibility	(Vafadarnikjoo et al., 2023)	RS_9
			Scarcity of raw materials	Expert recommendation	RS_10
			Design changes	(Truong & Hara, 2018)	RO_1
			Technology changes	(Truong & Hara, 2018)	RO_2
			Poor planning and scheduling	(Rostamzadeh et al., 2018)	RO_3
			Accidents	(Truong & Hara, 2018)	RO_4
			Material asset management	Expert recommendation	RO_5
	Demand risk		Integrity of test result	Expert recommendation	RO_6
			Demand uncertainty	(Truong & Hara, 2018), (Abdel-Basset & Mohamed, 2020)	RD_1
			Inaccurate forecast	(Truong & Hara, 2018)	RD_2
			Lack of customer relationship management	(Truong & Hara, 2018)	RD_3
Customer fragmentation			(Truong & Hara, 2018), (Ho et al., 2015)	RD_4	
Disruption risk	<i>Man-made risk</i>	Recession	(Abdel-Basset & Mohamed, 2020), (Rostamzadeh et al., 2018)	RM_1	
		Social and cultural grievances	(Hou & Zhao, 2020)	RM_2	
		External legal issues	(Rostamzadeh et al., 2018)	RM_3	
		War and terrorism	(Rostamzadeh et al., 2018)	RM_4	
		Political instability	(Rostamzadeh et al., 2018), (Hou & Zhao, 2020)	RM_5	
	Natural risk		Pandemic	(Hou & Zhao, 2020)	RA_1
			Natural disaster	(Rostamzadeh et al., 2018), (Hou & Zhao, 2020)	RA_2

**Figure 3.** Validated risk factor

Asset management is also considered a risk factor. Poorly organized material layouts in warehouses can hinder the flow of materials, and there is also a possibility of materials being lost due to inadequate layout. The respondent described:

“[...] Warehouse issues as well, like after a contract ends. If the warehouse doesn't meet the proper safety standards, storage standards, or capacity, it will also impact the supply. For example, because the warehouse isn't large enough, we can only order a small amount of materials. Or the warehouse is big enough but not protected (an open warehouse without a roof). Currently, our warehouse has a lot of old materials stored inside, and the new materials, because they don't fit, end up outside, this situation intervenes the movement of material. Meanwhile, disposing of old materials requires lengthy approvals[...]”

Drawing from both the literature review and interview findings, this study delineates a comprehensive set of 27 risk factors spanning diverse subcategories such as supply risk, operational risk, demand risk, man-made risk, and natural risk.

The validation of risk factors by experts is summarized in Table 3. To condense the narrative, each risk factor is assigned a risk element code. Additional risk factors suggested by the interviewees are RS\_10, RO\_5, and RO\_6

#### 4.2. Risk analysis

The risk factors that have been identified are subsequently quantified on a risk scale before being incorporated into the risk matrix. Figure 4 displays detailed results from the calculations of the probability value, impact value, average risk scale value, standard deviation, and risk ranking.

Out of a total of 66 questionnaires distributed, 25 responses were received. Within the supply risk sub-category, six risks were identified in the high-risk zone, namely: “scarcity of raw materials” (RS\_10: 14.81), “lack of capacity flexibility” (RS\_9: 14.63), “failures to make delivery requirements” (RS\_8: 14.48), “inability to handle volume demand and specification changes” (RS\_5: 13.96), “price fluctuations” (RS\_4: 13.19), and “supplier dependency” (RS\_7: 12.96). Four risks were classified within the moderate risk zone: “unstable quality of input” (RS\_2: 12.44), “supplier opportunism” (RS\_1: 10.74), “unstable quantity of input” (RS\_3: 10.63), and “supplier bankruptcy” (RS\_6: 9.04). Among the five sub-categories of risk, supply risk was identified as the highest, with an average value of 12.69.

In the operational risk sub-category, only one risk falls into the high-risk zone, namely “poor planning and scheduling” (RO\_3: 13.52). The other five risks are categorized within the moderate risk zone, including “integrity of test results” (RO\_6: 10.04), “accidents” (RO\_4: 10.04), “material asset management” (RO\_5: 9.96), “technological changes” (RO\_2: 9.33), and “design changes” (RO\_1: 9.11). The operational risk sub-category is the lowest, with an average value of 10.33.

All risks within the demand risk sub-category are situated in the moderate risk zone, with an average risk value of 11.05. These risks include: “demand uncertainty” (RD\_1: 12.41), “inaccurate forecast” (RD\_2: 12.19), “customer relationship management” (RD\_3: 10.04), and “customer fragmentation” (RD\_4: 9.56).

In the man-made risk sub-category, “external legal issues” (RM\_3: 13.93) and “political instability” (RM\_5: 12.67) are positioned in the high-risk zone. “War and terrorism” (RM\_4: 12.56), “economic recession” (RM\_1: 12.56), and “social and cultural grievances” (RM\_2: 9.59) fall within the moderate risk zone. The average risk value for this sub-category is 12.26. The natural risk sub-category has an average risk value of 11.97, with the “pandemic: risk factor (RA\_1: 13.19) in the high-risk zone and the “natural disasters” risk factor (RA\_2: 10.75) in the moderate zone.

#### 4.3. Risk matrix

The risk matrix illustrated in Figure 5 delineates risk levels into four distinct zones: a low-risk zone characterized by risk values less than 5, a moderate-risk zone with risk values ranging between 5 and 10, a high-risk zone spanning risk values between 10 and 15, and an extreme-risk zone encompassing risk values exceeding 15. Within the high-risk zone, 21 risk factors are identified, denoted as RS\_1, RS\_2, RS\_3, RS\_4, RS\_5, RS\_7, RS\_8, RS\_9, RS\_10, RO\_3, RO\_4, RO\_6, RD\_1, RD\_2, RD\_3, RM\_1, RM\_3, RM\_4, RM\_5, RA\_1, and RA\_2. However, it's noteworthy that certain risk factors within the high-risk zone, such as RS\_1, RS\_3, RO\_4, RO\_6, RD\_3, and RA\_2, closely border the threshold of the moderate-risk zone. Moreover, six risk factors fall within the moderate-risk zone, specifically RS\_6, RO\_1, RO\_2, RO\_5, RD\_4, and RM\_2.

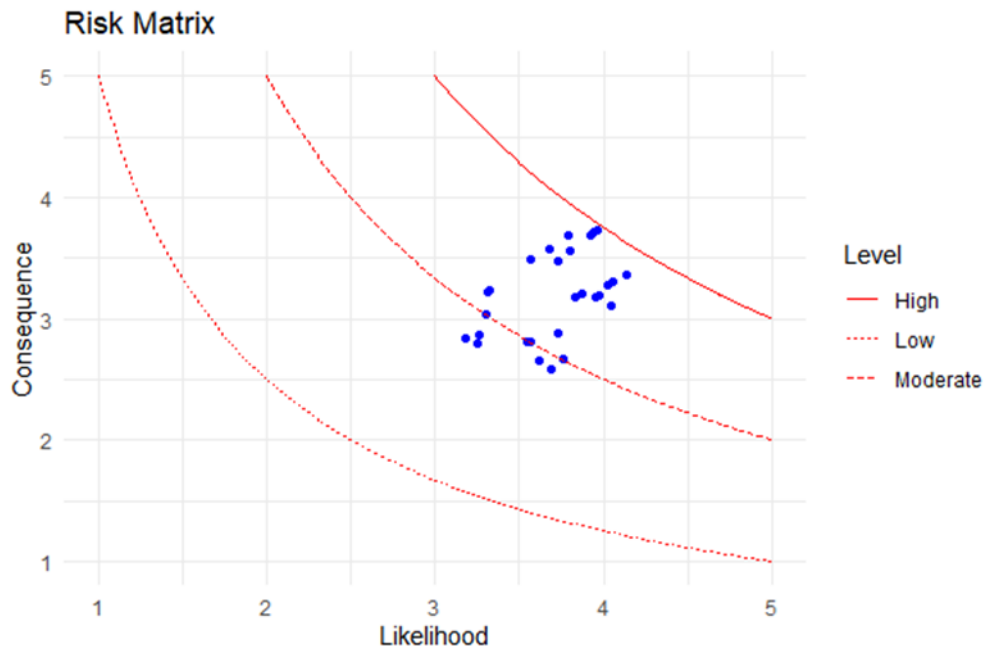
#### 4.4. Discussion

This study utilizes empirical data to scrutinize the risks confronted by state-owned electric companies, categorizing them into two distinct groups: internal risks and disruption risks. This classification endeavors to furnish a comprehensive outlook on the business process risks within the primary distribution material supply chain. The research inquiry has been effectively addressed, resulting in the identification and categorization of a total of 27 risk factors distributed across five sub-categories: supply risks, operational risks, demand risks, man-made risks, and natural risks. Notably, the evaluation of each risk factor's value has been undertaken. It is noteworthy that the supply risk category emerges with the highest value among the other risk sub-categories, thereby advocating for its prioritization in risk mitigation efforts. This discovery stands in contrast to earlier investigations cited in the introduction, where the pharmaceutical industry in India and the telecommunications equipment industry in China highlighted demand and financial risks as primary concerns, respectively, while ranking supply risks sixth in both sectors

Furthermore, this study enhances findings from previous research by systematically incorporating risk factors such as 'material asset management' and 'data integrity of test results,' even though these risk factors are ranked 22nd and 19th, respectively.

Risk	$\hat{I}_r$	$\hat{c}_r$	$ARS_r$	SD	Rank
RS_1	3,33	3,23	10,74	4,74	17
RS_2	3,57	3,49	12,44	5,76	13
RS_3	3,31	3,21	10,63	5,30	18
RS_4	3,68	3,58	13,19	6,21	7
RS_5	3,79	3,69	13,96	5,14	4
RS_6	3,18	2,84	9,04	4,98	27
RS_7	3,73	3,47	12,96	6,68	9
RS_8	3,93	3,69	14,48	5,65	3
RS_9	3,94	3,71	14,63	5,02	2
RS_10	3,97	3,74	14,81	6,25	1
Mean of supply risk			12,69		
RO_1	3,25	2,80	9,11	6,94	26
RO_2	3,26	2,86	9,33	5,37	25
RO_3	3,80	3,56	13,52	6,14	6
RO_4	3,31	3,04	10,04	5,71	21
RO_5	3,54	2,81	9,96	6,30	22
RO_6	3,57	2,81	10,04	4,94	19
Mean of operational risk			10,33		
RD_1	3,87	3,21	12,41	6,65	14
RD_2	3,83	3,18	12,19	5,74	15
RD_3	3,76	2,67	10,04	5,24	20
RD_4	3,69	2,59	9,56	6,33	24
Mean of demand risk			11,65		
RM_1	3,11	12,56	6,06	12	3,11
RM_2	2,65	9,59	6,64	23	2,65
RM_3	3,37	13,93	7,11	5	3,37
RM_4	3,17	12,56	6,59	11	3,17
RM_5	3,19	12,67	5,48	10	3,19
Mean of man-made risk			12,26		
RA_1	4,03	3,27	13,19	7,75	8
RA_2	3,73	2,88	10,75	5,52	16
Mean of natural risk			11,97		

Figure 4. Risk scale



**Figure 5.** Risk matrix

## 5. Conclusion

This research aims to assess the supply chain risks of an Indonesian electricity company by employing a modified Decision Matrix Risk Analysis with an average risk scale to accommodate risk scale calculations involving many respondents. Addressing the first research question regarding the main risks in the primary distribution material supply chain risks, based on the results of a literature study validated by experts, there are a total of 27 main risk factors which are divided into two categories with five sub-categories. First category is internal risk, consists of supply risk, operational risk and demand risk with the risk factors of supplier opportunism, unstable quality of inputs, unstable quantity of inputs, price fluctuation, inability to handle volume demand and specification changes, supplier bankruptcy, supplier dependency, failure to make delivery requirements, lack of capacity flexibility, scarcity of raw materials, design changes, technology changes, poor planning and scheduling, accidents, material asset management, integrity of test results, demand uncertainty, inaccurate forecast, lack of customer relationship management, customer fragmentation. The second category is disruption risk, consists of man-made risk and natural risk with the risk factors of recession, social and cultural grievances, external legal issues, war and terrorism, political instability, pandemic and natural disaster.

Furthermore, regarding the second research question, which risk factors have a significant influence on the primary distribution material supply chain risks, supply-related risks are the highest or most significant risks affecting the supply chain flow with an average value of 12.69 where four risk factors are at the top. namely “scarcity of raw material”, “lack of capacity flexibility”, “failure to make delivery requirements”, and “inability to handle volume demand and specification change”.

There are risk factors that were not found in previous research, namely “scarcity of raw materials”, “material asset management”, and “integrity of test results”. Where these three risk factors were suggested by experts through interviews.

A risk matrix has been developed to assess the significance of each risk factor. This matrix offers a clear and intuitive depiction of the levels of each risk factor, categorizing them into low, moderate, high, and extreme based on their likelihood and consequences.

The contribution of this research is twofold: Firstly, it offers an empirical contribution to the literature by addressing a notable gap in existing research. Specifically, prior studies have not delved into the intricacies of supply chain risks within state-managed utility companies. Secondly, this research provides a holistic and exhaustive analysis of the risks

inherent in electricity supply operations, focusing particularly on primary distribution materials. These materials are pivotal for ensuring the company's sustained ability to serve the community effectively.

In addition to identifying and cataloging all pertinent risks, this research delves deeper by scrutinizing the relative importance of each risk factor in terms of its potential consequences. This nuanced analysis yields valuable insights for utility company managers, enhancing their comprehension of operational risks and facilitating targeted risk mitigation strategies. A novel methodology is proposed to compute the magnitude of risk across multiple respondents, incorporating risk probability and associated consequences. This approach rectifies the limitations of conventional risk scale averaging methods, which may skew statistical outcomes by incorporating components derived from multiplying one respondent's probability with another respondent's consequences.

Limitations in this research include only using the opinions of practitioners within the institution without including the opinions of academics and other parties outside the institution such as material supply vendors, logistics vendors and installation vendors. Due to these limitations, the author suggests that in further research to add experts outside the institution, including academics and practitioners from providers of related goods and services.

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