



Prioritizing Supply Chain Risk for Flexibility and Resilience: A House of Risk Approach

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Received: September 4, 2026	Revised: September 10, 2026	Accepted: September 11, 2026	Online: October 7, 2026
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Abstract

Indonesia's inorganic chemical industry, a national priority sector, faces mounting supply chain uncertainty driven by its heavy reliance on imported raw materials. However, research combining empirical risk factor validation with measurable risk prioritization in this sector remains scarce. This study aims to identify and validate the risk factors contributing to this uncertainty and determine risk priorities, laying the foundation for mitigation strategies that strengthen Supply Chain Flexibility (SCF) and Resilience (SCRes). Based on judgments from five Supply Chain Management experts, the study uses a descriptive quantitative design that combines the Content Validity Index (CVI) to validate risk factors with House of Risk (HoR) Phase 1 for risk prioritization. Results show nine of 14 initial risk factors were valid, with Strategic, Supply, and Quality risk as the most conceptually relevant. However, ARP results revealed the opposite pattern: rather than these three, Demand risk in the planning process, particularly weak forecasting and limited demand information sharing, emerged as the highest-contributing risk agent, followed by logistics and raw material inventory risk. Eighteen of 34 risk agents contributed to 80,91% of total risk, consistent with the Pareto principle. These findings confirm that a risk's conceptual relevance does not always reflect its quantitative urgency, indicating mitigation should prioritize forecasting systems, information visibility, and supply diversification as a foundation for balanced SCF and SCRes improvement in the inorganic chemical industry.

Keywords *Content Validity Index, House of Risk, Inorganic Chemical Industry, Supply Chain Flexibility, Supply Chain Resilience*

INTRODUCTION

Global supply chain uncertainty has increasingly intensified due to geopolitical disruptions, energy crises, and pandemics (Bednarski et al., 2023). In Indonesia, this impact is reflected in the rising need for non-oil and gas imports, as well as raw and auxiliary materials, from 2023 to 2024 (BPS, 2024). This aligns with Indonesia's decline in the Logistics Performance Index (LPI) ranking to 63 out of 139 countries in 2023 (The World Bank, 2023).

The chemical industry sector, particularly inorganic chemicals, recorded import growth far higher than that of organic chemicals, indicating a significant level of import dependence (Kementrian Perdagangan PDSI, 2025). This is crucial because the chemical sector has been designated as one of the national priority sectors by Sekretariat Negara Republik Indonesia (2025), making stronger supply chain flexibility and resilience a strategic necessity to maintain the continuity of domestic production.

Supply Chain Flexibility (SCF) refers to a company's ability to adapt to environmental changes (Siagian et al., 2021), while Supply Chain Resilience (SCRes) refers to the ability to withstand, adapt to, and recover from disruptions (Hosseini et al., 2022). Previous studies on SCF and SCRes stop at identifying risk factors through systematic reviews, without moving further into

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validation or quantitative prioritization of mitigation. Combining the Content Validity Index (CVI) to validate these factors with the House of Risk (HoR) to prioritize them offers one way to close that gap.

This study is urgent because disruptions in the Plan, Source, and Deliver stages remain the main sources of risk in the inorganic chemical industry's supply chain, yet a more in-depth quantitative analysis to measure uncertainty and set mitigation priorities is still lacking.

Although previous studies have identified various risk factors influencing SCF and SCRes, studies on the Indonesian inorganic chemical industry sector, which has the highest import dependence among basic chemical subsectors and holds the status of a national priority sector, remain limited, particularly those integrating empirical validation of risk factors with measurable risk prioritization.

Based on this, this study aims to identify and validate the risk factors of supply chain uncertainty in the Indonesian inorganic chemical industry sector and determine risk priorities using the HoR phase 1 method as a basis for formulating a mitigation strategy to enhance SCF and SCRes. Through this approach, the study examines the extent to which sources of uncertainty long considered most pressing align with the root causes that most significantly affect supply chain performance.

LITERATURE REVIEW

Supply chain uncertainty is unpredictable and uncontrollable, originating from three areas: internal company uncertainty, supply chain uncertainty (demand, supply, forecasting), and external influences (natural disasters, policies, competitors) ([Fatin et al., 2022](#)).

Supply Chain Flexibility (SCF) is the capacity of a supply chain to adapt to environmental uncertainty without incurring excessive cost or disruption, encompassing five dimensions: production flexibility, product development flexibility, logistics flexibility, supplier flexibility, and supply base flexibility. Supply Chain Resilience (SCRes) refers to a supply chain's ability to adapt, react, and recover from unexpected disruptions, reflected in four dimensions: readiness, resourcefulness, recovery, and evaluation ([Kamalahmadi et al., 2022](#)).

Supply Chain Risk Management (SCRM) is a systematic approach to identifying, evaluating, ranking, and monitoring potential supply chain disruptions, with risks classified as internal or external ([Um & Han, 2021](#)). Conventional risk evaluation generally uses a probability-impact matrix to classify risks as low, medium, or high, but this approach is limited to a two-dimensional assessment and does not consider interrelationships among risk sources.

The Content Validity Index (CVI) measures the relevance of each risk indicator item to the construct being assessed before the item is used in subsequent analysis. CVI includes the item-level (I-CVI), which assesses each item's relevance based on expert judgment ([Wang & Sahid, 2024](#)). A panel of at least three to five experts is considered adequate to produce stable content validity, provided that the experts possess competence and experience relevant to the field of study ([Zawani et al., 2020](#)).

House of Risk (HoR), which was developed from the FMEA and QFD methods, extends conventional risk evaluation by prioritizing risk agents through the Aggregate Risk Potential (ARP) value, which takes into account the probability of occurrence, the severity of impact, and the correlation between risk agents and risk events ([Partiwi et al., 2023](#)). This approach allows early identification of dominant risk agents and directs them toward the most effective and realistic mitigation strategy priorities.

Previous studies show that multi-dimensional supply chain flexibility contributes significantly to supply chain resilience, with external risk exerting a strong moderating effect, and that supply chain resilience capability serves as an important mediator between global supply chain

risk and mitigation strategy (Piprani et al., 2022). Applying HoR across various manufacturing sectors has proven effective in identifying dominant risk agents and formulating priority mitigation strategies based on the Effectiveness-to-Difficulty Ratio, confirming the method's relevance as an industrial engineering approach to risk-based decision-making (Irawan & Iskandar, 2022). Similarly, applying CVI across various industrial supply chain contexts shows the method's consistency in validating risk assessment instruments across sectors.

Nevertheless, most of these studies have been applied to sectors other than basic chemicals, so the combined application of CVI and HoR in the Indonesian inorganic chemical industry, which depends heavily on imported raw materials, has not been widely explored. Combining CVI to empirically validate risk factors with HoR to prioritize risks and mitigation strategies is relevant to address this gap.

RESEARCH METHOD

To address this gap, the study applies the following methodology to validate the identified risk factors and prioritize the associated risks. This study takes a descriptive quantitative approach grounded in expert judgment, drawing on CVI to validate risk factors and HoR to prioritize the resulting risks. The study focuses on companies in the Indonesian basic inorganic chemical industry sector with internationally scaled raw material supply chains.

The study begins with a systematic literature review using Publish or Perish and Google Scholar with the keywords supply chain flexibility, resilience, inorganic chemical industry, and risk management, to compile an initial list of internal and external risk factors. This list is then validated through a first questionnaire administered to the expert panel, followed by a second questionnaire to assess the severity, occurrence, and correlation of each risk agent and risk event as the basis for the HoR phase 1 calculation, and concluded with the formulation of mitigation options based on the resulting priority risk agents.

The expert panel consists of five Supply Chain Management practitioners with at least five years of professional experience in basic chemical B2B companies, holding managerial or supervisory positions involved in SCM decision-making (Kellerhuis et al., 2025). A panel of three to five experts is considered adequate to produce stable assessments, with the focus placed on the suitability of expertise rather than the number of respondents (Wang & Sahid, 2024).

Risk factors refer to broad risk categories identified from the literature review. Each validated risk factor was further specified into risk events and their underlying risk agents based on the industry's operating characteristics. The second expert questionnaire then confirmed these risk events and agents. Risk factor validation is calculated quantitatively using the Item-level Content Validity Index (I-CVI) with the following formula:

$$I-CVI = \frac{\text{Total number of experts in agreement}}{\text{Total number of experts}}$$

Relevance was rated on a 4-point scale, 1 = not relevant and 4 = highly relevant. Only risk factors with a high validity value proceed to the HoR analysis stage.

Risk factors that pass validation are subsequently processed in HoR. The Aggregate Risk Potential (ARP) value for each risk agent is calculated using the following formula:

$$ARP_j = O_j \sum S_i R_{ij}$$

Where:

O_j is the probability of occurrence of risk agent j ,

S_i is the severity of impact of risk event i ,

R_{ij} is the correlation between risk agent j and risk event i .

Severity (S_i) is rated on a 1-5 scale from no effect to catastrophic impact, and occurrence (O_j) on a 1-5 scale from very low (0-25% likelihood) to very high (76-100% likelihood), while correlation (R_{ij}) follows a 0-1-3-9 scale representing no, weak, moderate, and strong correlation. Risk agents are ranked by the highest ARP value, and priority is then determined using the Pareto principle, focusing on the top 80% of contributing causes to concentrate the analysis on the most dominant sources of risk.

A literature review identified fourteen risk factors that may cause supply chain uncertainty, briefly described below with their associated SCM process and risk source.

Table 1. Risk Factors for Supply Chain Uncertainty

Risk Factor	Description	SCM Process	Source
Strategic risk	Strategic decisions misaligned with SC needs (Malik et al., 2022)	Plan	Internal & External
Supply risk	Supplier delay/failure (Katsaliaki et al., 2022)	Plan, Source	External
Demand risk	Demand fluctuation and inaccurate forecasting (Wang & Jie, 2020)	Plan, Make	External
Financial risk	Exchange rate fluctuation and imported material cost (Aljabhan, 2023)	Source	Internal & External
Operational risk	Production process/facility failure (Wang & Jie, 2020)	Source	Internal
Quality risk	Inconsistent raw material/product quality (Piprani et al., 2022)	Make, Return	Internal & External
Raw Material Inventory risk	Raw material stock imbalance (Katsaliaki et al., 2022)	Source	Internal
Logistics risk	Logistics provider delay and limitations (Katsaliaki et al., 2022)	Deliver	External
Customer Delivery risk	Failure to deliver on time/in the correct quantity (Aman et al., 2023)	Deliver	Internal & External
Technological risk	IT infrastructure failure and weak system integration (Etemadi et al., 2021)	Source, Make	Internal & External
Informational risk	Biased, inaccurate, or outdated information among partners (Hsu et al., 2022)	All processes	External
Disruption risk	Major disruption from disasters, pandemics, or environmental incidents (Bednarski et al., 2023)	Source, Deliver	External
Geopolitical risk	Cross-border trade wars, conflicts, or sanctions (Bednarski et al., 2023)	Source, Deliver	External

Risk Factor	Description	SCM Process	Source
Political risk	Domestic political instability and policy changes (Kassem, 2022)	Make, Deliver	External

A panel of five experts subsequently evaluated these risk factors, whose profiles are summarized in Table 2.

Table 2. Expert Data for Validation Process

Expert	Job Position	Inorganic Industry Segment	Working Time
Expert 1	Manager	Mineral raw materials	11 years
Expert 2	Supervisor	Pigment and additives	6 years
Expert 3	Supervisor	Ceramic raw materials	7 years
Expert 4	Manager	Ceramic raw materials	9 years
Expert 5	Supervisor	Coating and glaze materials	6 years

Based on this expert evaluation, we prioritized risk factors and risk agents using CVI and HoR phase 1, forming the basis for the mitigation strategy directions discussed in the following section.

FINDINGS AND DISCUSSION

Risk Factor Identification and Validation

The literature review identified 14 risk factors as potential drivers of supply chain uncertainty in the inorganic chemical industry, spread across five supply chain processes and spanning both internal and external sources. Nine of the 14 risk factors cleared the I-CVI threshold ($\geq 0,8$) through validation by five experts, as shown in Table 3; the other five (Technological, Informational, Disruption, Geopolitical, and Political risk) fell short (I-CVI 0,4–0,6), since their effect on day-to-day operations tends to be indirect and filtered through logistics and supply.

Table 3. Validated Risk Factors (I-CVI $\geq 0,8$)

Risk Factor	I-CVI
Strategic risk	1,0
Supply risk	1,0
Quality risk	1,0
Demand risk	0,8
Financial risk	0,8
Operational risk	0,8
Raw Material Inventory risk	0,8
Logistics risk	0,8
Customer Delivery risk	0,8

Risk factors concentrated in the Source, Make, and Deliver processes point to the industry's heavy reliance on imported raw materials. Strategic, Supply, and Quality risk, the three highest-scoring factors, all trace back to procurement reliability and the quality of materials sourced from abroad.

General manufacturing research usually points to operational or logistics risk as the dominant concern (Katsaliaki et al., 2022). Strategic and supply risk carry more weight than risks originating

purely inside the company, underscoring why mitigation efforts in this sector should focus on procurement strategy and supply diversification. Together, these nine validated factors form the foundation for the risk agent analysis under HoR that follows.

House of Risk: Risk Aggregation and Pareto Prioritization

These risk factors were then broken down into the risk events and risk agents detailed in Figure 1.

No	Risk factor	Risk Event	Event Code	Risk Agent	Agent Code
1	Strategic risk	Inefficiency of the allocation of resources in the procurement of inorganic chemicals due to supply fluctuations or export-import regulations.	E1	Lack of data-driven strategic planning systems, including analysis of demand projections, regulations and global conditions	A20
		Reduced company innovation so that innovative products and processes in inorganic chemistry left behind competitors.	E2	Lack of investment support in research and development of new products or technologies.	A22
		The complexity of global supply chain coordination of inorganic chemicals that have different regulations across countries, causing delays in the supply chain.	E3	Companies are not able or ready to face more complex cross-border regulations	A27
2	Supply risk	Delays in the supply of key inorganic chemical raw materials with specific compositions that interfere with the continuity of the production process	E4	The company only uses a <i>single supplier</i> system for certain materials	A28
		Suppliers fail to fulfill demand for inorganic chemicals with specific specifications (e.g. purity, particle size, or content levels)	E5	Suppliers do not have production capabilities or backup facilities to meet demand fluctuations.	A23
		Limited flexibility of supplier capacity in adjusting order quantities of inorganic chemicals	E6	Mismatch of demand and supply in the supplier's production line to meet regular needs (<i>high volume</i>) without considering the priority of supplier needs	A13
		Changes in hazardous chemicals regulations that increase <i>lead time</i> and procurement costs.	E7	Inconsistent chemical export-import policies between countries and the inability of companies to follow the global certification system of chemicals.	A3
3	Demand risk	Uncertainty of demand pattern in industrial customer demand patterns due to project dynamics, regulatory shifts, or global economic fluctuations.	E8	Lack of data-driven strategic planning systems, including analysis of demand projections, regulations and global conditions	A20
		The inability of the supply chain to handle <i>non-standard orders</i> quickly, especially on chemical products with customer-specific formulas.	E9	Lack of coordination between production parts and demand planning leads to delays in adjusting chemical formulations to the needs of industrial customers.	A15
		Sudden customer demand <i>cancellation</i> which causes chemical stocks to become idle and increases storage costs.	E10	There is no real-time customer order monitoring system and flexible regulations with customers to anticipate sudden changes in demand.	A33
		Inaccuracy of demand forecasting	E11	The demand forecasting system has not taken into account seasonal data and fluctuations in user sector demand, so production planning is not adaptive.	A31
		There is a distortion of demand due to promotions, incentives, or lack of supply chain visibility that leads to overestimation of demand.	E12	The company does not implement a user sector forecast sharing system.	A21
4	Financial risk	Disruptions in cash flow and delays in funding for inorganic chemical raw materials disrupt supply continuity and production flexibility.	E13	There are fluctuations in the cost of inorganic chemicals, currency exchange rates or late payments from customers.	A1
		Sudden increase in currency exchange rates causes margin pressure	E14	High dependence on overseas suppliers without long-term contracts or hedging mechanisms.	A10
		Failure to calculate the feasibility of investing in new facilities (e.g. kilns, reactors) leads to low-capacity utilization.	E15	Investment planning does not take into account the high energy needs and utility costs of the inorganic chemical production process, so the project's economic projections are unrealistic.	A25
5	Operational risk	Production process shutdowns due to failure of facilities such as boilers, <i>reactors</i> , or chemical cooling systems that require special treatment (e.g. temperature or stable pressure), resulting in material degradation and loss of production batches.	E16	There is no <i>preventive/predictive maintenance</i> system on critical equipment such as mixing tanks, high-pressure pipes, or gas ventilation systems.	A34
		Low utilization of production facilities leads to waste of resources and decreased process efficiency	E17	The lack of a production capacity evaluation system based on actual chemical consumption data per batch leads to energy overload and idle reactors.	A19
		The sudden surge in demand for key ingredients has led to raw material shortages and production delays	E18	Lack of real-time data integration coordination between production, planning, and logistics departments in managing batch or formula capacity.	A16
6	Quality risk	Inorganic chemicals from suppliers do not meet the required specifications (e.g. metal content, moisture, or viscosity), thus degrading the quality of the finish and triggering rework in the formulation process.	E19	Inconsistency in supplier quality standards due to lack of quality supervision of imported raw materials and the absence of regular supplier audits.	A11
		There is a discrepancy or variation in the final product results with customer standards which has an impact on quality claims and lowers customer confidence.	E20	<i>Large quality allowance</i> so that tolerance is still given to pass	A4

No	Risk factor	Risk Event	Event Code	Risk Agent	Agent Code
7	Raw Inventory risk	Build-up of volatile or corrosive inorganic chemicals that affect inventory volumes and potentially contaminate.	E21	The mismatch between the digital and actual inventory systems in the hazardous materials warehouse leads to stock miscalculations.	A12
		Decreased product value due to limited shelf life and changes in the chemical properties of inorganic materials when stored for too long.	E22		
		There is an increase in the storage cost of inorganic chemicals that require special treatment in stock management and rotation.	E23	Capacity planning and non-optimal rotation of inorganic chemicals stocks	A26
		Uncertainty in the supply and demand of inorganic chemicals due to variability in the consumption of user industries as well as global supply constraints of basic materials.	E24	Lack of integration of demand data between chemical manufacturers and industrial customers.	A14
		Leakage or spillage of inorganic chemicals leads to material loss, contamination and decreased storage capacity.	E25	Storage facilities do not meet standards	A2
8	Logistics risk	Delays in the delivery of inorganic chemicals due to limited licensed transportation facilities that comply with safety standards.	E26	Logistics providers do not have a permit or are certified for the transportation of special chemicals	A24
		Delays in the delivery of inorganic chemicals such as full transit port capacity, limited loading and unloading capacity or ship queues so that it requires re-routing and increased time.	E27	High dependence on major ports in the absence of alternative distribution channels for special chemicals.	A9
		Disruption to the logistics system has an impact on delays and instability of the logistics flow of chemicals.	E28	Absence of a logistical contingency plan such as <i>buffer stock</i> or alternative transportation routes	A32
		Disruption of distribution of inorganic chemicals to customers related to the export-import and licensing processes cross border.	E29	Chemical export-import procedures are inefficient due to policy and government regulations	A29
		The quality of logistics providers' services that do not match the needs of transporting hazardous chemicals causes disruptions	E30	The limited technological capabilities and innovations of logistics providers in handling specific chemicals have an impact on distribution efficiency.	A7
		Rising logistics costs for inorganic chemicals as well as import tariff regulations and limited hazardous materials transportation routes	E31	Dependence on a specific mode of transport without a specific logistical alternative for the transport of chemicals.	A8
		Cross-border administrative and documentation barriers that delay the smooth delivery of imported chemicals	E32	Lengthy cross-border bureaucratic processes and lack of technical documentation support in accordance with international regulations.	A30
		Delivery of chemicals not to specification	E33	Weaknesses in the verification or order tracking system that allow for chemical delivery errors.	A5
		Damage to chemical products during the shipping process	E34	Lack of training of logistics officers and warehouse operators in handling high-risk inorganic chemicals	A17
		Loss or inconsistency of delivery time of inorganic chemicals during the delivery process.	E35	Weaknesses in the verification or order tracking system that allow for chemical delivery errors.	A5
9	Customer Delivery risk	Disruption of the distribution of inorganic chemicals during the prohibition of the transport of chemicals on certain routes, road closures for national celebrations, or the implementation of emergency policies.	E36	Absence of logistical contingency plans such as <i>buffer stock</i> and alternative transportation routes	A32
		Excessive <i>handling</i> during a change of mode of transportation or cross-border that increases the potential of chemicals.	E37	Lack of supervision during transloading or absence of SOPs for handling chemicals	A18
		Delay in the fulfillment of chemicals in situations of inflexibility of distribution schedules.	E38	Limited ability of companies to adjust distribution schedules in the event of external disruptions.	A6

Figure 1. Risk Event and Risk Agent

This process identified 38 risk events and 34 risk agents; several agents tie back to more than one event because a single root cause can trigger multiple disruptions. The expert panel then scored each event and agent for probability of occurrence and severity of impact, and mapped the correlations between them to derive the Aggregate Risk Potential (ARP). Ranking these ARP values and plotting them on a Pareto diagram (Figure 2) showed that just 18 of the 34 risk agents account for 80,91% of total ARP, in line with the 80/20 Pareto principle.

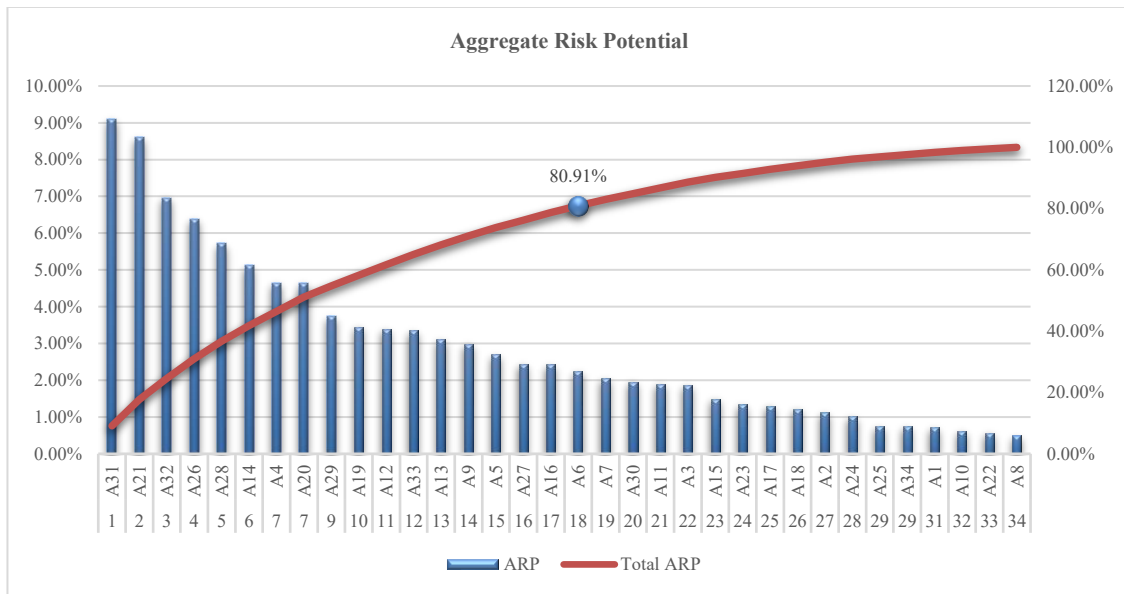


Figure 2. Pareto Diagram of ARP

Table 4 presents the five risk agents with the highest ARP contribution.

Table 4. Risk Agents with the Highest ARP

Code	Description	Risk Factor	SCM Process	ARP (%)
A31	Demand forecasting does not account for seasonality	Demand risk	Plan	9,10
A21	No forecast sharing system with downstream sectors	Demand risk	Plan	8,60
A32	No logistics contingency plan	Logistics risk	Deliver	6,95
A26	Suboptimal capacity planning and stock rotation	Raw Material Inventory risk	Make	6,37
A28	Dependence on a single supplier for certain materials	Supply risk	Source	5,71

Probability-Impact Matrix

The eighteen priority risk agents were subsequently mapped onto a probability-impact matrix to determine the mitigation urgency zones, as shown in Figure 3. Seven risk agents land in the red zone of Figure 3, all with high to very high probability and impact, and Demand risk in the Plan process (A31, A21) dominates there, not Strategic, Supply, or Quality risk despite their higher I-CVI scores. CVI and ARP measure different things. CVI asks how relevant a risk category is in general terms; ARP asks something narrower: which specific agents combine the steepest probability, impact, and correlation across events.

This distinction becomes clearer when considering how ARP is calculated. That correlation piece is really what separates HoR from a standard risk matrix. An agent does not need to top the charts on probability or impact alone; it just needs enough correlation across enough events, since ARP adds up effects rather than judging one risk on its own. That is how A31 and A21, both rooted in forecasting weaknesses, end up outranking something that reads as more severe on its face, like a single-supplier failure. Root causes with wide reach beat risks boxed into one process point, and that is arguably the more useful signal for where to put mitigation resources.

Likelihood Level	Very High					
	High		A12, A13, A9, A27	A4, A20	A32, A26, A28	A31, A21
	Medium		A19, A33, A5, A16, A6	A14, A29		
	Low					
	Very Low					
		1	2	3	4	5
		Very Low	Low	Medium	High	Very High
		Impact Level				

Figure 3. Risk Matrix

Figure 3 shows that A14 illustrates the limits of relying on either measure alone: its ARP exceeds two of the red-zone agents, yet it sits in the yellow zone because its probability and impact scores are only medium. Zone placement and ARP ranking capture different things, so read the two together rather than as substitutes. Practically, red-zone agents call for immediate action, yellow-zone agents need active monitoring and contingency planning, and green-zone agents can get by with periodic checks.

Beyond individual cases such as A14, the overall distribution of the risk agents provides a broader picture of the sector's risk profile. Thirteen risk agents span the red and yellow zones, and their spread suggests where this sector's risk really sits: most trace back to Plan and Make, so the pressure point is planning and production rather than delivery. Eight of them bear on Supply Chain Flexibility and five on Supply Chain Resilience. This suggests the company's main challenge is adapting to changes in demand and supply rather than recovering from major disruptions. Risk sources are relatively balanced between external and internal factors, indicating that mitigation requires both external risk management and improvements in internal governance and information systems (Um & Han, 2021).

The finding that Demand risk dominates as the risk agent with the highest ARP is also consistent with patterns in previous HoR studies in other manufacturing sectors, which likewise identified inaccurate demand forecasting as a primary risk agent (Partiwi et al., 2023). This reinforces the argument that this issue is systemic across manufacturing supply chains in general, while also being a particular concern for the inorganic chemical industry given that its demand characteristics are highly dependent on fluctuations in downstream user sector needs.

Referring to the priority risk agents identified in the red zone, a mitigation strategy approach can be formulated following two dominant risk groups. Demand risk in the Plan process (A31, A21) calls for better forecasting that accounts for seasonality, plus a channel to share demand data with downstream partners so production planning can react to what is happening rather than guessing. Logistics and Raw Material Inventory risk in the Deliver and Make processes (A32, A26, A28) shifts the priority to building a distribution contingency plan and diversifying supply sources to reduce reliance on a single supplier.

These priorities follow directly from the risk agents with the highest ARP contribution, keeping with HoR's logic of tying identification straight through to action rather than treating mitigation as a separate guess (Partiwi et al., 2023). That the fixes lean on information systems and coordination rather than added physical capacity says something about the root causes themselves: the weak points sit in planning and information exchange, not in raw resources.

The two mitigation directions address both Supply Chain Flexibility, through faster adaptation to demand changes, and Supply Chain Resilience, through improved preparedness for

logistics and material disruptions. Thus, an integrated strategy should address flexibility and resilience improvements rather than treating them separately (Piprani et al., 2022).

Nevertheless, quantitative prioritization and effectiveness assessment of each mitigation action, including implementation difficulty and its impact on supply chain performance, require further analysis beyond this study's scope. The proposed approach therefore emphasizes supply chain flexibility and resilience by improving readiness to anticipate and respond to changes in demand and supply before disruptions occur, rather than relying solely on the scale of available reserves or capacity.

CONCLUSIONS

Taken together, these findings provide an overall assessment of supply chain uncertainty in the Indonesian inorganic chemical industry. This study identifies and validates the risk factors of supply chain uncertainty in the Indonesian inorganic chemical industry, and determines risk priorities through the House of Risk phase 1 approach. Of the 14 initial risk factors, nine were declared relevant through Content Validity Index validation, with Strategic, Supply, and Quality risk as the most relevant factors. However, the Aggregate Risk Potential calculation results show that the risk agents with the highest risk contribution are instead dominated by Demand risk in the Plan process, particularly the weak demand forecasting system and limited information sharing with downstream user sectors, followed by Logistics risk and Raw Material Inventory risk in the Deliver and Make processes.

This finding indicates that a risk category's conceptual relevance does not always align with its quantitative urgency, so CVI validation and ARP analysis should be used side by side in supply chain risk mitigation decision-making. Based on these priority risk agents, a relevant mitigation strategy includes strengthening the demand forecasting system and information visibility, as well as developing a distribution contingency plan and diversifying supply sources, to improve Supply Chain Flexibility and Resilience in a balanced manner.

The main contribution of this study lies in the combined application of CVI and HoR phase 1 in the context of the Indonesian inorganic chemical industry, a sector with high import dependence that has not been widely examined through this approach, while also providing a risk identification and prioritization framework that can be replicated in similar manufacturing sectors.

LIMITATIONS & FURTHER RESEARCH

This study has limitations, particularly because the mitigation strategy approach remains conceptual and has not been quantitatively tested for effectiveness. Future work could take this further by quantifying mitigation priorities and testing their actual effect on supply chain performance, giving the proposed strategy the empirical backing it currently lacks. It would also be worth checking these HoR results against other risk-prioritization methods to see how consistent the findings hold up, and digging into why geopolitical and political risk factors failed validation here, since that gap in expert perception of macro-level risk deserves a closer look.

Data Availability

Supporting data are available at <https://doi.org/10.5281/zenodo.22282518>, comprising CVI and HoR calculation data; certain underlying data are withheld due to confidentiality.

Author Contributions

Fikri Kalbarqi: Conceptualization, writing-original draft, methodology, data collection, data analysis, and validation of results.

Rienna Oktarina: Conceptualization, Writing-Review, validation, and Supervision.

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