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Research Paper

Identifying the Threshold of the Effect of Systematic and Unsystematic Risks on the Supply Chain of the Oil-Petrochemical and Chemical Industries (Hybrid Fuzzy Delphi Models Type 3 Threshold Panels)[1]

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INTRODUCTION

The oil and gas industry are considered one of the high-risk industries (Fabiano et al; 2017), as its operations entail significant levels of risk (Abrahamsen et al; 2018). High-risk industries must identify related risks comprehensively and systematically (Moore, 2013). The petrochemical and chemical industry serves as the critical link between the oil industry and other sectors. It faces a growing flow of risks, and any disruption in its supply chain can result in shortages of essential raw materials, leading to cascading disruptions in related industries (Van de Putte et al; 2012).

A key concern for these industries is the threatening risks posed by their complex and unpredictable supply chains. Complexity and unpredictability inherently increase risk (Atashsooz et al; 2016). Consequently, any deviation in this value chain due to risk can cause crises in these industries (Iqbal et al; 2020).

While several studies, such as Abduljabbar & Breesam (2022), Moshesh et al. (2018), Fazli et al. (2015), Shafie Nategh et al. (2023), Ahmadi et al. (2020), Benshasteh et al. (2020), and Atashsooz et al. (2016), have examined supply chain risk management in the petroleum and petrochemical sectors, none have employed the third-

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type fuzzy Delphi approach. This gap presents an opportunity to enhance the accuracy and depth of existing research. Therefore, to address this theoretical gap and advance the topic's theoretical foundation, this study seeks to answer the following research questions using a hybrid approach of the third-type fuzzy Delphi method, Principal Component Analysis (PCA), and Panel Smoothness Transition Regression (PSTR):

1. What risks affect the supply chain management of oil-petrochemical and chemical industries?
2. At what thresholds do external and internal risks disrupt the supply chain of the oil-petrochemical and chemical industries?

METHODOLOGY

This study adopts an applied and analytical (correlational) approach. We use information from the Central Bank to identify systematic factors and data from the Comprehensive Database of All Listed Companies (CODAL) to extract non-systematic factors affecting the supply chain.

Sampling

- First Sample: Petrochemical and chemical industry experts. Indicators were identified based on interviews using snowball sampling.
- Second Sample: Petrochemical and chemical firms. Variables were collected from their financial statements using purposeful sampling.

Procedure

1. Using library research, we identified 99 risks affecting the petroleum-petrochemical and chemical supply chain, categorized into:
   - Non-systematic risks: 77 indicators.
   - Systematic risks: 22 indicators.
2. Employing expert opinions through the third-type fuzzy Delphi approach, we refined and identified key systematic and non-systematic risks.
3. Using PCA and PSTR, we determined the disruption thresholds for these risks in the supply chains of the studied industries.

FINDINGS

To identify risks affecting the supply chain, we applied two indicators: Kendall's coefficient and Delphi analysis.

1. Kendall's Coefficient: By removing unrelated indices, Kendall's coefficient improved from 0.51 to 0.82, indicating increased reliability.
2. Delphi Analysis: Based on the average difference index between the first and second Delphi rounds:
   - 23 risks were selected from the 77 non-systematic risks.
   - 13 risks were selected from the 22 systematic risks.

These refined factors are summarized in the following table:

Selected factors of unsystematic risk		Selected factors of systematic risk
1. Asset intensity	13. Operating profit to total assets	1. Oil income
2. Staff intensity		2. Fluctuation of oil income
3. Total debts intensity	14. Net profit to equity	3. Budget deficit
4. Average sales growth	15. Acid-test ratio	4. Fluctuation of economic growth

Selected factors of unsystematic risk		Selected factors of systematic risk
5. Intellectual capital	16. Total debt to total assets	5. Official exchange rate
6. Decrease in sales at t-1	17. Sales to total assets	6. Fluctuation of unofficial exchange rate
7. Firm life cycle	18. Inventory turnover	7. Fluctuation of inflation
8. Commercial credit	19. Firm size	8. Taxes
9. CEO vision	20. Soft assets ratio	9. Liquidity
10. Avoid earnings decreases	21. Earnings to price	10. Physical capital
11. Restriction of domestic financing	22. Firm financial crisis	11. Human capital
12. Income tax paid to operating profit	23. Institutional shareholders	12. Foreign direct investment
		13. Sanctions

To index the systematic and unsystematic risks identified from the above variables, we utilized Principal Component Analysis (PCA) in EViews 12 software. The systematic and unsystematic risk indices were calculated as the weighted sum of each variable multiplied by its respective weight (i.e; a weighted average) for each period.

Following the extraction of systematic and unsystematic risk components, the Panel Smooth Transition Regression (PSTR) method was applied to identify the threshold effects of these risks on the supply chain index. The findings, including the thresholds and their impacts, are summarized in the table below:

	Systematic		Unsystematic	
	Coeff	T-Stat	Coeff	T-Stat
RUS	-	-	-0.647***	-6.26
RS	-0.428***	-4.02***	-	-
CR*g(q_{it}, Y, c)	-0.353	-4.03***	Zero regime (upper the threshold)	
	0.218	-8.31***	one regime (lower the threshold)	
LR*g(q_{it}, Y, c)	Zero regime (upper the threshold)		-0.4138***	-4.36
	one regime (lower the threshold)		0.2375***	
C	-	-	4.961***	50.08
F	F(21, 322) ***	14.09	F(21, 322) ***	12.42

The results of the PSTR model, as shown in the table, reveal that the relationship between the supply chain and both systematic and unsystematic risks exhibits threshold behavior. The optimal thresholds are identified as -0.428% for systematic risk and -0.647% for unsystematic risk.

Systematic Risk:

- Above the threshold (-0.428%): Systematic risk exerts a negative effect of 0.353% on the supply chain.
- Below the threshold: Systematic risk has a positive effect of 0.218% on the supply chain.

Unsystematic Risk:

- Above the threshold (-0.647%): Unsystematic risk exerts a negative effect of 0.413% on the supply chain.

- Below the threshold: Unsystematic risk has a positive effect of 0.237% on the supply chain.

The positive impact of risk below the threshold suggests that risk is an inherent and integral component of the production process, fostering adaptability and resilience within the supply chain. However, when risks exceed their respective thresholds, their effects become detrimental, causing disruptions and reducing supply chain performance. This highlights the importance of monitoring and managing risks to ensure stability and efficiency in the supply chain.

CONCLUSION

Based on expert opinions in the petroleum, petrochemical, and chemical industries, 23 non-systematic risk indicators and 13 systematic risk indicators were identified using the third-type fuzzy Delphi approach. These indicators include financial factors, firm size, and life cycle as non-systematic risks, and economic factors as systematic risks, all of which play a significant role in the supply chain of these industries.

Given the strategic importance of the oil supply chain, which impacts upstream, midstream, and downstream activities, it is crucial to predict, identify, and manage such risks in a timely manner. Failure to address these risks may lead to disruptions in the supply chains of oil, petrochemical, and chemical companies. Therefore, when formulating strategies and operational plans for supply chain risk management in the oil industry, focusing on the risks identified in this study—including the 23 non-systematic risks and 13 systematic risks—can maximize value creation, enhance productivity, reduce costs, and improve communication with vendors and suppliers. The results of the PSTR model further emphasize that systematic and non-systematic risks in the petroleum, petrochemical, and chemical supply chains exhibit thresholds. These thresholds highlight that risk is an inherent part of the production process and warrants careful consideration. Both types of risk, from the lowest levels to the thresholds, can progressively reduce efficiency and create challenges within the supply chain. This underscores the necessity of comprehensive risk management to maintain stability and operational effectiveness.

Keywords: Systematic Risk, Unsystematic Risk, Supply Chain, Oil, Petrochemical and Chemical.

JEL Classification: G32.