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SUPPLY CHAIN RESILIENCE AND INTERNATIONAL TRADE FLOW SUSTAINABILITY: EVIDENCE FROM SAUDI ARABIA

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ABSTRACT

This study investigates Saudi Arabia's supply chain resilience and trade flow sustainability amid global disruptions such as the U.S.–China trade war and the Russia–Ukraine conflict. A novel methodological contribution is made by integrating Principal Component Analysis (PCA) with a Vector Error Correction Model (VECM), allowing for a robust identification of the key determinants of trade flows, including oil prices, trade openness, logistics efficiency, and geopolitical risks. This integrated approach provides a comprehensive and dynamic assessment of trade resilience in an oil-dependent economy. The findings reveal that while oil prices continue to influence trade flows, Saudi Arabia's investments in logistics infrastructure, trade diversification, and digital supply chain reforms play a more significant role in ensuring stability. Moreover, the results show that geopolitical shocks, though disruptive in the short term, have limited long-term impacts due to Saudi Arabia's strong global trade integration. This paper contributes to the literature by demonstrating how supply chain efficiency and diversification strategies can reduce vulnerability to global shocks. It offers empirical evidence that distinguishes Saudi Arabia from other hydrocarbon exporters, underscoring the importance of infrastructure, openness, and strategic planning in sustaining trade resilience.

Keywords: *Supply Chain, International Trade, Geopolitical Risks, Trade War, Covid 19*

1. INTRODUCTION

Global supply chains are the backbone of international trade, enabling the smooth flow of goods and services across borders. However, these intricate networks are highly susceptible to disruptions caused by geopolitical events such as trade wars and armed conflicts. Two significant events in recent years have particularly reshaped global trade dynamics: the U.S.-China trade war, which began in 2017, and the ongoing Russia-Ukraine conflict. Both events have caused substantial disruptions in global supply chains, leading to increased trade costs, altered trade routes, and delays in production and delivery of goods (Al-Nimer, 2025).

The U.S.-China trade war, which escalated with the imposition of tariffs on a wide range of goods, caused uncertainty and fragmentation within global supply chains. As two of the world's largest economies, the conflict between the USA and China not only affected bilateral trade but also impacted third-party countries reliant on inputs from both nations. Research by Bown

(2021) showed how tariff measures triggered shifts in supply chains, with firms seeking alternative suppliers to avoid high costs, especially in industries heavily reliant on global input-output linkages like electronics, agriculture, and machinery (Fort, Pierce & Schott, 2018).

Meanwhile, the Russia-Ukraine conflict, beginning in 2022, has particularly affected energy supply chains, with Europe and other regions dependent on Russian oil and gas facing significant disruptions. According to the World Bank (2022b), the conflict has caused a sharp rise in global energy prices, affecting trade flows and logistics costs.

For Saudi Arabia, these geopolitical events pose both challenges and opportunities (Neffati, & Khemiri, 2025). As a major global oil exporter, the Kingdom is highly integrated into the international trading system and plays a crucial role in stabilizing global energy markets. Moreover, Saudi Arabia's Vision 2030 initiative, which aims to diversify its economy away from oil, has brought additional focus on strengthening supply chain resilience across multiple sectors. These developments make it critical to understand how Saudi Arabia has responded to global supply chain disruptions, particularly after the U.S.-China trade war and the Russia-Ukraine conflict.

The significance of this study lies in its exploration of the adaptability and resilience of Saudi Arabia's supply chains in response to major global disruptions. As Saudi Arabia moves toward diversifying its economy under Vision 2030, understanding the resilience of its supply chains and trade flows becomes critical. The study provides valuable insights into how the Kingdom has navigated international trade shocks and offers lessons for policy makers and businesses on how to build robust supply chains capable of withstanding future geopolitical risks. Furthermore, by analyzing Saudi Arabia's role in global energy markets, this research highlights the importance of strategic trade routes and partnerships in maintaining stable supply chain operations.

Despite the extensive literature on global supply chain disruptions, most prior studies have focused on developed economies or global industries at large (e.g., Baldwin & Freeman, 2021; Gereffi, 2020). Limited attention has been paid to oil-dependent economies in the Middle East, particularly Saudi Arabia, where trade flows are strongly tied to energy markets but are also undergoing rapid diversification under Vision 2030. Furthermore, existing research often examines geopolitical shocks individually-such as the U.S.-China trade war or the Russia–Ukraine conflict-without capturing their combined impact on trade flows and supply chain resilience in a single framework. This leaves a critical gap in understanding how resource-dependent yet diversifying economies adapt to multiple global disruptions.

This study contributes to the existing literature by integrating Principal Component Analysis (PCA) with a Vector Error Correction Model (VECM) to empirically assess Saudi Arabia's trade resilience, offering methodological novelty. It advances the literature by highlighting how logistics efficiency, supply chain infrastructure, and economic diversification collectively mitigate external shocks. By contrasting Saudi Arabia's experience with Algeria, another oil-dependent economy, the study also demonstrates how proactive policy and investment choices shape resilience. In doing so, it adds region-specific and policy-relevant insights to the broader scholarship on global supply chain resilience and international trade sustainability.

This research is structured as follows. After this introduction, a review of relevant literature and previous studies is provided, focusing on the impact of the U.S.-China trade war and the Russia-Ukraine conflict on international trade flows and supply chain resilience. Next, the section on "Supply Chain and International Trade in KSA in Recent Decade" delves into Saudi Arabia's trade patterns and its responses to recent global disruptions. This is followed by the methodology and data analysis section, where the study's empirical approach is detailed. Then interpreting the results and findings of the study, followed by the discussion section, drawing policy implications for Saudi Arabia's supply chain resilience and trends for future studies. Lastly, the conclusion summarizes the key points.

2. LITERATURE REVIEW AND PREVIOUS STUDIES

Geopolitical conflicts have long been examined for their impact on international trade flows and supply chains. While much of the literature agrees that disruptions such as the U.S.–China trade war and the Russia–Ukraine conflict destabilize global supply chains, scholars diverge in assessing the scale of the consequences and the resilience mechanisms available. Some studies emphasize trade costs and inefficiencies (Bown, 2021; Pierce & Schott, 2019), while others highlight opportunities for exporters that can substitute disrupted suppliers (Elghawy, 2020). Also, Ivanov and Dolgui (2020) emphasize the need for robust supply chain strategies that can withstand external shocks, suggesting that countries must focus on diversification, digitalization, and regional trade partnerships to mitigate risks. This divergence suggests that the impact of conflicts is context-specific, depending on a country's trade structure, resource base, and integration into global value chains.

The U.S.–China trade war exemplifies this debate. Research generally highlights the negative consequences of tariffs, including higher production costs and fragmented supply chains (Fort, Pierce, & Schott, 2018). However, other works note that third-party energy exporters, such as Saudi Arabia, benefited by supplying China with oil and gas during U.S.–China tensions (Elghawy, 2020). While some studies show that U.S. tariffs on Chinese goods caused shifts in production networks and forced firms to diversify their sourcing strategies (Fajgelbaum & Khandelwal, 2021). This contrast underscores the importance of moving beyond global generalizations toward country-specific assessments. Most existing studies are concentrated on advanced economies or the direct belligerents, leaving oil-dependent economies underexplored.

Similarly, the Russia-Ukraine conflict has been shown to disrupt energy and agricultural supply chains, with sharp increases in wheat and oil prices (Ruta, 2022; Lin et al., 2023). Cornell University (2023) also notes that sanctions on Russia reshaped global trade flows, particularly in Europe and Asia. Yet findings differ on whether energy exporters are long-term beneficiaries. While some studies suggest that oil exporters such as Saudi Arabia and the Gulf states profited from higher oil prices and increased demand from Europe (ESCWA, 2024), others argue that excessive dependence on hydrocarbons left states like Algeria vulnerable to volatility (Bekhiti, 2024). These contrasting outcomes reinforce the need for comparative analysis of oil-dependent economies facing similar external shocks but with differing domestic policies and infrastructure.

Theoretical perspectives also diverge on how trade disruptions affect global supply chains. Classical and neoclassical theories emphasize that tariffs and trade barriers reduce efficiency and comparative advantage (Smith, 1776; Ricardo, 1817; Mattoo & Staiger, 2019). By contrast, realist and political economy perspectives stress the necessity of state intervention to secure supply chains during crises (Maggi & Ossa, 2021). New trade theory and Heckscher–Ohlin models further highlight how economies of scale and factor endowments can exacerbate or mitigate vulnerabilities (Krugman, 1979; Piermartini & Teh, 2005). These theoretical tensions show that resilience strategies must be assessed not only by efficiency criteria but also by geopolitical positioning and domestic capacity to adapt.

Developing countries, often integrated into global value chains as suppliers of intermediate goods, face particular vulnerabilities. Baldwin and Lopez-Gonzalez (2015) show that intermediate goods constitute more than half of global trade, making logistics disruptions especially costly. Yet while studies such as Evenett and Baldwin (2020) stress the fragility of developing countries' supply chains during crises like COVID-19, others highlight opportunities for upgrading into higher-value segments through diversification and logistics modernization (UNCTAD, 2021). UNCTAD (2013) also emphasizes the role of trade policies-such as tariff escalation and preferential agreements-in shaping how developing countries are integrated into global supply chains. This divergence signals that supply chain shocks can either entrench dependency or catalyze structural transformation, depending on domestic responses.

Saudi Arabia's case illustrates this duality. As a hydrocarbon-dependent exporter, it is vulnerable to external shocks, but its Vision 2030 reforms and investments in logistics distinguish it

from countries like Algeria, where weak infrastructure and limited diversification exacerbate risks (Sweidan & Elbargathi, 2023; Havrlant & Darandary, 2021; Borisov Stoyanov, 2025). Despite the abundance of research on global supply chains, few studies combine advanced econometric techniques with country-specific analysis of oil exporters' resilience under multiple simultaneous crises. This study addresses that gap by applying PCA with VECM to capture the long- and short-run dynamics of Saudi Arabia's trade resilience, while situating findings in comparative perspective.

3. SUPPLY CHAINS AND INTERNATIONAL TRADE FLOWS IN KSA IN RECENT DECADE (2014-2024)

Saudi Arabia's international trade has undergone significant transformations from 2014 to 2024, influenced by global economic dynamics, domestic reforms, and geopolitical tensions. Saudi Arabia, as the largest economy in the Gulf Cooperation Council (GCC), relies heavily on oil exports, but recent trends indicate a growing emphasis on diversifying its trade portfolio, both in terms of exports and imports.

3. 1. TRADE VOLUME, EXPORT, AND IMPORTS TRENDS (2014–2024)

Oil has remained a major contributor to Saudi Arabia's trade flows, with oil exports comprising over 70% of total export revenue. In 2014, oil prices collapsed, leading to a sharp decline in trade revenues, pushing the Kingdom to accelerate its economic diversification efforts through Vision 2030, which began in 2016. (Barbary & Tawfiq, 2024)

Regarding non-oil exports, the past decade has seen a gradual rise in non-oil exports, including chemicals, plastics, and metal products, especially to China, India, and Japan. By 2022, non-oil exports had reached $83.63 billion, showing the success of diversification initiatives. The increase in non-oil exports is also attributed to stronger manufacturing sectors and increased foreign investments. (ITC, 2024A)

KSA's major trading partners include China, India, the United States, and the European Union. Trade with China has been bolstered by energy exports, while the U.S.-China trade war (2018–2020) offered opportunities for KSA to become a preferred energy supplier to China. (Barbary & Tawfiq, 2024)

This shift in terms of the volume of exports and countries importing from Saudi Arabia was clear evident during the period from 2013-2022, as Asian countries emerged as the largest trading partner of Saudi Arabia during this period, which is clearly shown in the following table, which shows Saudi exports to the 10 largest trading partners.

Table 1. top ten importing countries from Saudi Arabia from (2013-2022) U.S.D Millions

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
World	375,360	341,947	213,376	178,874	220,068	294,535	261,516	185,699	276,204	411,184
China	7,424	7,318	5,608	4,135	5,970	9,724	9,645	8,181	50,909	66,646
India	2,747	3,826	3,003	2,458	2,607	3,564	3,880	3,096	26,657	41,916
Japan	666	806	633	721	980	971	809	665	27,359	40,770
Korea. South	1,365	1,390	902	658	732	1,186	939	844	23,291	37,909
USA	1,472	1,333	1,483	1,287	1,337	1,837	1,837	1,847	14,334	23,238
UAE	6,386	6,308	6,773	6,566	7,686	8,131	7,903	8,917	15,086	17,809
Egypt	1,766	2,091	1,972	1,525	1,401	2,025	1,819	1,783	10,322	13,789
China. Taipei	0	0	870	608	722	0	515	437	7,023	10,433
Singapore	3,406	3,694	2,355	2,219	3,067	4,020	3,558	2,872	7,046	9,956
Bahrain	1,536	1,582	1,534	1,550	1,576	1,839	1,661	1,853	7,024	9,870

Source: ITC calculations based on UN COMTRADE statistics – 2024

Note: it is noted from the previous table that Asian countries emerged as the largest importing countries from Saudi Arabia during the last decade, Saudi's exports increased dramatically in 2014, 2018, and 2022, as the global events became more unstable due to the clash between Russia and Ukraine in 2014, U.S.-China trade war in late 2017, and Russia-Ukraine war in 2022. As Saudi Arabia was considered as a secure and stable supplier of energy. The major countries responsible for this major shift in Saudi exports are China, India, Japan and South Korea.

Regarding Imports, Saudi Arabia primarily imports are machinery, vehicles, and electronics, which are critical for the nation's industrial sector. The Kingdom's imports increased post-2016 as the government introduced major infrastructure and construction projects, boosting demand for industrial and technological equipment. Imports of food and consumer goods also surged, driven by population growth. (ITC, 2024B)

The U.S.-China trade war caused a reshuffling of import patterns. Saudi Arabia diversified its sourcing by increasing imports from Asian countries, especially South Korea and Japan, in areas like machinery, electronics, and vehicles. Also, the Asian countries (China, UAE, and India) became among the top 5 exporting countries to Saudi Arabia for the first time in 2018 (General Authority of Statistics, 2018). In recent years, supply chain issues have also impacted imports due to the COVID-19 pandemic, disrupting logistics, leading to delays and price increases in imported goods. The largest exporting countries to Saudi Arabia over the past decade can be seen in the following table:

Table 2. top ten exporting countries to Saudi Arabia from (2013-2022) U.S.D Millions

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
World	163,013	168,239	169,967	129,795	126,758	135,211	144,334	131,328	152,849	189,877
China	20,807	23,078	24,061	18,840	19,391	22,243	27,066	26,509	30,234	39,800
USA	21,493	21,384	22,066	17,342	14,636	18,041	17,097	14,103	16,216	17,401
UAE	8,457	8,204	8,626	6,929	8,215	12,080	10,364	8,980	12,471	12,027
India	5,720	6,171	5,884	4,932	5,131	5,684	6,489	6,367	8,073	10,535
Germany	11,801	12,416	11,825	8,181	7,135	7,292	7,003	6,809	7,491	8,000
Japan	9,325	9,903	9,746	7,176	5,245	5,473	6,545	5,661	6,061	6,718
Egypt	2,074	2,209	2,280	1,928	1,943	1,494	2,396	2,627	4,208	6,620
South Korea	9,512	8,546	9,683	5,872	4,973	4,300	4,027	3,821	3,439	5,271
Italy	5,288	5,737	5,138	4,230	4,306	4,236	4,310	4,079	4,604	5,187
Switzerland	5,090	4,676	3,999	2,284	1,649	1,926	1,702	1,483	2,202	4,729

Source: ITC calculations based on UN COMTRADE statistics – 2024.

Note: as it shown in the previous table, the list of countries exporting to Saudi Arabia was characterized by stability in terms of the ranking of countries as well as stability in the growth rate of Saudi imports from each country, which may give an indication of the stability of Saudi market even in light of the global political and economic fluctuations in the last decade.

3. 2. GEOPOLITICAL AND ECONOMIC INFLUENCES

The trade war between the U.S. and China redirected global trade flows, particularly in energy markets. China increased its energy imports from Saudi Arabia during this period, making the Kingdom China's top oil supplier by 2020. This shift provided opportunities for Saudi Arabia to solidify its trade relationships with China amidst U.S.-China tensions. (Barbary, 2024)

The war between Russia and Ukraine also significantly influenced global supply chains and trade flows (Yordanova & Hristizov, 2025). With sanctions imposed on Russian oil, Saudi Arabia saw increased demand from European countries and the U.S. for its crude oil supplies. Moreover, as Russia faces energy embargoes, Saudi Arabia emerged as a crucial player in stabilizing global energy supplies. (ESCWA, 2024)

3. 3. SUPPLY CHAIN DEVELOPMENTS AND EFFORTS (2014–2024)

Saudi Arabia's supply chain landscape has evolved significantly in the last decade. Vision 2030, which aims to diversify the economy, reduce dependence on oil, and develop local industries, has been a driving force behind supply chain improvements. The National Industrial Development and Logistics Program (NIDLP) and investments in logistics infrastructure have bolstered supply chain resilience. (Saudi Vision 2030, 2020)

3. 3. 1. LOGISTICS PERFORMANCE AND INFRASTRUCTURE INVESTMENTS

Saudi Arabia has made substantial improvements in its Logistics Performance Index (LPI), rising from a rank of 55th in 2014 to 43rd in 2022. These improvements are due to enhancements in customs efficiency, trade facilitation, and logistics infrastructure. (World Bank, 2023)

Key investments in port infrastructure and ports modernization, such as the expansion of the King Abdulaziz Port in Dammam and Jeddah Islamic Port, have improved container-handling capacities and reduced shipping bottlenecks. These ports serve as vital links connecting the Kingdom to international trade routes. (Saudi Vision 2030, 2020)

Landbridge Project which is a major initiative connecting the Red Sea to the Arabian Gulf via a 950 km railway line is in progress. This project will enhance domestic trade logistics and facilitate smoother transit for international cargo through Saudi Arabia. (Alotaibi, 2022)

3. 3. 2. CUSTOMS MODERNIZATION AND DIGITIZATION

The introduction of digital customs clearance systems through Saudi Customs has reduced clearance times from 7–10 days in 2014 to 1–2 days by 2022, significantly improving the ease of doing business. This reduction in clearance time has enhanced the supply chain efficiency, especially for time-sensitive goods. (World Bank, 2023)

Saudi Single Window (Fasah) is an integrated platform that facilitates the clearance of imports and exports by linking the relevant government agencies, further improving logistics efficiency and reducing bureaucratic delays. (Fasah, 2024)

3. 3. 3. RESILIENCE TO GLOBAL DISRUPTIONS

The U.S.-China trade war, COVID-19 pandemic, and Russia-Ukraine conflict were a critical test of Saudi Arabia's supply chain resilience. The Kingdom's ability to maintain steady energy exports and quickly adapt to global supply chain disruptions is credited to several factors:

- Strategic Reserves: Saudi Arabia has invested in maintaining strategic reserves of essential goods and raw materials, ensuring continuous supply despite global shortages. (Ghanem et al., 2022)
- Diversified Trade Routes: Efforts to diversify import sources and establish alternative trade routes with Asian and African nations have helped Saudi Arabia avoid severe disruptions during global crises. (Havrlant & Darandary, 2021)

The development achieved by Saudi Arabia in its logistics system is not a coincidence, as the Kingdom did not only rely on being a major energy supplier to the world, but also sought to improve its infrastructure in a way that ensures its development and growth to keep pace with developments in global value chains. This can be seen in the following table, which shows the development of *Doing Business* indicators between 2019 and 2020, especially in the trading across borders indexes.

Table 3. Doing Business's trading across border indexes in Saudi Arabia (2019-2020)

Index	Score in 2020	Value in 2020	Value in 2019	Improvements %
Doing Business	71.6	Rank=62	Rank=92	Up 30
Trading across borders	86	Rank=76	Rank=158	Up 82
Time to export: Border compliance (hours)	77.4	37	50	26
Cost to export: Border compliance (USD)	69.9	319	363	12.12
Time to export: Documentary compliance (hours)	94.1	11	60	81.67
Cost to export: Documentary compliance (USD)	81.8	73	105	30.48
Time to import: Border compliance (hours)	74.6	72	228	68.42
Cost to import: Border compliance (USD)	61.3	464	779	40.44
Time to import: Documentary compliance (hours)	87	32	90	64.44
Cost to import: Documentary compliance (USD)	61.9	267	390	31.54

Source: Doing Business Reports – World Bank (2019-2020).

Note: as shown in the previous table, Trading Across Borders has improved to rank 76 from 158 highlights enhanced efficiencies in trade processes, likely through reduced paperwork, better customs processing, and digitization efforts. Regarding export-related indicators, the border compliance time and cost improved, also documentary compliance time and cost improved by a substance values. Regarding import-related indicators, the cost and time associated with border and document compliance have been improved dramatically, showing the efforts of Saudi's government in enhancing its international trade environment whether as an importer or an exporter.

3. 3. 4. EMERGING TECHNOLOGIES AND SUPPLY CHAIN INNOVATION

Saudi Arabia has begun experimenting with blockchain technology to enhance transparency in trade finance and logistics. This innovation aims to reduce fraud, improve tracking of shipments, and optimize supply chain workflows (Basiouni, 2022). The use of automation and artificial intelligence (AI) in logistics management is becoming more common, with AI helping optimize delivery routes and warehouse management. These technologies contribute to the Kingdom's supply chain resilience.

3. 4. WAS SAUDI ARABIA A WINNER OR LOSER FROM GLOBAL CONFLICTS?

The geopolitical conflicts and disturbances of the past decade, particularly the U.S.-China trade war (2018–2020) and the ongoing Russia-Ukraine conflict (2022–2024), have profoundly impacted Saudi Arabia's trade balance, oil prices, stock markets and export strategy. Examining the outcomes reveals that Saudi Arabia largely positioned itself as a beneficiary of these disruptions.

3. 4. 1. IMPACT OF THE U.S.-CHINA TRADE WAR (2018–2020)

The U.S.-China trade war led to shifts in global trade flows and demand for energy resources. As the world's largest oil exporter, Saudi Arabia benefitted in several ways.

During the trade war, China reduced its imports of U.S. energy products, leading to increased demand for Saudi crude oil. By 2020, Saudi Arabia became China's top oil supplier, a position it retained into the following years. This shift bolstered Saudi Arabia's export revenues, particularly during a time when KSA was seeking to diversify its trade relationships (Franza, 2020). The redirection of Chinese demand from the U.S. to Saudi Arabia had a positive impact on the trade balance, as oil exports surged despite a volatile global market. The trade war realigned global supply chains, allowing non-U.S. suppliers, such as Saudi Arabia, to fill the gap in China's energy demand. (Han & Chen, 2019)

Beyond oil, Saudi Arabia capitalized on the trade war to diversify its non-oil exports to China

and other Asian markets. As the U.S. imposed tariffs on Chinese goods, China sought alternative markets, increasing its demand for petrochemical products, fertilizers, and plastics from Saudi Arabia. These sectors are part of the Kingdom's Vision 2030 strategy, aimed at diversifying exports. (Elghawy, 2020)

3. 4. 2. IMPACT OF THE RUSSIA-UKRAINE CONFLICT (2022–2024)

The Russia-Ukraine conflict had a profound effect on global energy markets, with Western sanctions on Russian oil leading to supply shortages. Saudi Arabia emerged as a key alternative supplier, further enhancing its position in global energy trade.

The conflict led to sharp rises in global oil prices, driven by sanctions on Russian energy and supply chain disruptions. Saudi Arabia, a leader within OPEC+, capitalized on these price increases. Brent crude oil prices surged from $65 per barrel in 2021 to over $120 per barrel in mid-2022. As one of the world's largest oil producers, Saudi Arabia experienced a windfall in export revenues, improving its trade balance, the Kingdom's current account surplus reached its highest levels in years, buoyed by the spike in oil prices. (Ghanem et al., 2022)

As European nations sought alternatives to Russian oil and gas, Saudi Arabia increased its energy exports to the region. The shift in trade flows presented Saudi Arabia with an opportunity to expand its influence in the European market, previously dominated by Russian energy supplies (Yafimava, 2023; Wang, 2023). This dynamic further improved the Kingdom's trade balance and strengthened its geopolitical standing as a reliable energy partner for Europe.

The conflict also Impacted global supply chains for key commodities, such as wheat and metals, which Ukraine and Russia previously supplied. Saudi Arabia was able to step in as a supplier for certain non-oil products, boosting its non-oil export revenue. This growth supported the diversification of the Saudi economy. (Lin et al. 2023)

3. 4. 3. TRADE BALANCE AND ECONOMIC RESILIENCE

Both the U.S.-China trade war and the Russia-Ukraine conflict created an environment where Saudi Arabia's energy resources became even more valuable. Saudi Arabia was able to increase export revenues from both oil and non-oil goods. Strengthen trade ties with major economies like China, India, and Europe. Leverage higher oil prices to offset fiscal deficits and fund diversification projects under Vision 2030.

3. 4. 4. WINNER IN THE CONFLICTS

In summary, Saudi Arabia largely emerged as a winner from both the U.S.-China trade war and the Russia-Ukraine conflict. The global re-alignment of trade and energy flows created opportunities for KSA to expand its exports, particularly in energy markets, while strengthening its geopolitical and economic standing. While the Kingdom was not immune to supply chain disruptions caused by these conflicts, its strategic position as a leading oil exporter allowed it to navigate and benefit from the shifting global landscape.

These developments reflect Saudi Arabia's ability to adapt to and even capitalize on global conflicts, reinforcing its role as a key player in global trade and energy markets.

3. 4. 5. ALGERIA'S ECONOMIC SITUATION

The inclusion of Algeria as a point of comparison stems from its status as an oil-dependent economy with significant similarities to Saudi Arabia in terms of economic structure and reliance on hydrocarbon exports. Both nations face the dual challenge of diversifying their economies while navigating the complexities of global energy markets, geopolitical tensions, and economic disruptions caused by crises such as US-China trade war, the COVID-19 pandemic and the

Russia-Ukraine conflict. Algeria's experiences in managing supply chain disruptions and trade flows under similar external pressures provide valuable insights. Furthermore, comparing the strategies, outcomes, and resilience of these two economies allows for a broader understanding of how oil-dependent nations can adapt their supply chain frameworks to enhance economic sustainability and competitiveness in an increasingly volatile global trade environment. However, Algeria's economic situation worsened during these global conflicts due to several internal and external factors.

- **Limited Beneficiary from the U.S.-China Trade War**: While Saudi Arabia capitalized on the trade war to increase oil and non-oil exports to China and other Asian markets, Algeria failed to seize similar opportunities. Unlike Saudi Arabia, Algeria's ability to ramp up production or tap into new markets during the trade war was constrained by underinvestment in its oil sector, leading to stagnant production. Additionally, Algeria's economic policies were less geared towards export diversification, limiting its ability to absorb the shocks from shifting global trade flows. As the huge role played by the United States and China in the economies of oil-exporting African countries, including Algeria, may lead to a delay in the growth of output in those countries, including Algeria. (Olayungbo, 2019)
- **Covid-19**: The COVID-19 pandemic has significantly impacted Algeria's economy, particularly as it heavily relies on oil exports. The impacts extended beyond the real sector, affecting the fiscal and banking sectors as well. Despite the government's efforts to maintain control over public expenditures and minimize external debt to historically low levels, the economy remained highly dependent on oil export revenues. This reliance exposed Algeria's fiscal stability to global oil price volatility, which was exacerbated by the sharp decline in oil prices during the pandemic. These challenges underscore the vulnerability of oil-dependent economies to external shocks and the need for structural reforms to diversify economic resources. (Sari, 2022)
- **Impact of the Russia-Ukraine Conflict**: The Russia-Ukraine conflict, while leading to a surge in global oil prices, did not translate into as significant benefits for Algeria. Though Algeria experienced a temporary rise in energy revenues, the country struggled with economic mismanagement, structural inefficiencies, and lack of strategic investments in the energy sector, which hindered its ability to fully capitalize on the higher prices.
    a) **Natural Gas Supply Constraints**: Unlike Saudi Arabia, Algeria's natural gas sector faced considerable pressure as European countries sought to replace Russian gas supplies. Algeria, a major gas supplier to Europe, particularly Italy and Spain, struggled to meet this rising demand due to aging infrastructure, underinvestment, and internal political instability. This meant that Algeria was unable to fully benefit from the surge in gas prices that favored other producers. (Ouki, 2024)
    b) **Missed Opportunities in Non-Energy Exports**: Algeria's reliance on hydrocarbons left it particularly vulnerable. Unlike Saudi Arabia, which made strides in non-oil export growth under its Vision 2030, Algeria's non-oil sector remains underdeveloped, and the country did not benefit significantly from trade flow shifts induced by global conflicts. (Bekhiti, 2024)
- **Structural Economic Weaknesses**: Algeria's economic weaknesses, particularly its lack of diversification and internal political turmoil, further hampered its ability to navigate these global conflicts. Repeated delays in economic reforms, an overreliance on energy exports, and limited foreign investments left Algeria vulnerable to the global

trade and supply chain disruptions caused by the Russia-Ukraine conflict. These factors exacerbated the negative impact on Algeria's economy, making it one of the losers during this period. (Desponts, Henider, & Prinz, 2024)

- **Inflationary Pressures and Economic Instability**: The combination of rising food prices and disruptions in global supply chains hit Algeria hard. With both Ukraine and Russia being major suppliers of grain, Algeria's import costs surged, contributing to domestic inflation and further stressing an already struggling economy. Saudi Arabia, by contrast, managed to contain inflationary pressures more effectively, leveraging its substantial fiscal reserves to stabilize the economy. (World Bank, 2022)

3. 4. 6. COMPARISON WITH SAUDI ARABIA

While both countries are heavily reliant on hydrocarbon exports, Saudi Arabia's proactive policies, better infrastructure, and diversification efforts allowed it to capitalize on the opportunities presented by global conflicts. In contrast, Algeria's underinvestment in the energy sector, weak governance, and failure to diversify left it vulnerable to the negative impacts of these conflicts. This comparison highlights how two seemingly similar economies can have drastically different outcomes depending on their domestic policies and capacity to adapt to external shocks. (Sweidan & Elbargathi, 2023; Aissaoui, 2016)

The success of Saudi Arabia's in terms of the increased revenues during the U.S.-China trade war and the Russia-Ukraine conflict is not merely a matter of circumstance but the result of deliberate efforts, strategic planning, and a strong economic foundation. The Saudi Vision 2030, launched in 2016, provided the country with a well-structured roadmap to diversify its economy and reduce its reliance on oil. This long-term strategy included major investments in infrastructure, supply chain resilience, and the development of non-oil sectors, allowing Saudi Arabia to leverage the shifts in global trade flows during these conflicts to its advantage. (Saudi Vision 2030, 2020)

Saudi Arabia's robust infrastructure played a key role in maintaining the efficiency of its supply chains, ensuring minimal disruptions despite global turmoil. Major logistics and transportation hubs, such as the King Abdullah Port and the Saudi Landbridge Railway, enabled the kingdom to act as a key player in the global supply chain, efficiently transporting goods to different parts of the world. Furthermore, its investment in digital transformation and innovation, such as smart ports and improved customs clearance processes, bolstered the resilience of its supply chains, enabling faster adaptation to global supply chain disruptions. (Hasanov et al, 2020)

In contrast, Algeria, with similar economic circumstances and a heavy reliance on hydrocarbons, experienced losses during the same period. Algeria's failure to diversify its economy and invest in robust infrastructure highlights the crucial difference. While Saudi Arabia benefited from higher oil prices and global trade shifts, Algeria struggled to adapt, showing that Saudi Arabia's gains were the result of deliberate economic planning and infrastructure investment, not mere luck. (Global Economic Diversification Index, 2024)

This contrast between Saudi Arabia's strategic successes and Algeria's difficulties underscores the importance of long-term economic planning, supply chain management, and adaptability in thriving during global disruptions. The Saudi example demonstrates that the kingdom's strong performance during these conflicts is a testament to its efforts to build a diversified and resilient economy capable of navigating the complexities of international trade.

4. METHODOLOGY

The study examines the long-run and short-run determinants of trade volume (USD billion) by using a Vector Error Correction Model (VECM). Due to multicollinearity among key variables,

Principal Component Analysis (PCA) was applied to transform the data into a set of uncorrelated components while retaining critical information. This approach ensures an efficient and stable model.

4. 1. DATA AND PREPROCESSING

Dependent Variable

- Trade Volume (Imports + Exports): Represents Saudi Arabia's international trade flows.

Independent Variables

- Supply Chain Resilience:
  - o Container port traffic index: which measures the flow of containers from land to sea transport modes, and vice versa, in twenty-foot equivalent units (TEUs)
  - o Global connectedness index: which measures a country's integration into global supply chains based on trade depth and breadth, capital, information, and flow of people.
- Geopolitical Risk Index (GPR): Measures the impact of international tensions and conflicts like the U.S.-China trade war and the Russia-Ukraine conflict on the supply chain.
- International Crises: which is a dummy variable to express the existence of international crises.
- Tariff Rates: Represents trade policy factors affecting imports and exports.
- Energy Prices (Oil Prices): Given the importance of oil to Saudi Arabia, fluctuations in energy prices influence overall trade.
- Exchange Rate: Captures the effects of currency valuation changes on international trade flows.

Data Sources for the Variables

Table 4. Data sources for variables

Variable	Description	Source
Trade Volume	Total imports plus total exports (USD Billions).	International Trade Center - Trade Map, Trade statistics for international business development.
Average Oil Prices	Average crude oil price (USD per Barrel)	U.S. Energy Information Administration.
Real Effective Exchange Rate	Real Effective Exchange rate (base Year 2010)	World Bank – World Development Indicators.
Average tariff Rate	Average applied tariff rate on all products, simple mean (Percentage)	World Bank – World Development Indicators.
International Crises	Dummy Variable (if there is international crisis = 1 for the current year and the following one, if not = 0)	Author's calculations based on the international (political-economic) crises.
Geopolitical Risk Index	Higher values indicate higher geopolitical risk for Saudi Arabia, lower values indicate lower geopolitical risks for Saudi Arabia.	(Caldara & Iacoviello, 2022) Data downloaded from https://www.matteoiacoviello.com/gpr.htm on Oct. 17, 2024
Container Port Traffic	Measures the flow of containers from land to sea transport modes, and vice versa, in twenty-foot equivalent units (TEUs)	World Bank – World Development Indicators.
Global connectedness index	Measures a country's integration into global supply chains based on trade depth and breadth, capital, information, and people flow (0 = lowest, 100 = highest)	Altman, Steven A. and Caroline R. Bastian. DHL Global Connectedness Report 2024. Bonn: DHL Group. DOI:10.58153/7jt4h-p0738

Source: Authors' Compilation

Descriptive Statistics

Table 5. Descriptive statistics

Variable	Mean	Std. Dev.	Min.	Max.
Trade Volume (USD Billion)	355.02	142.23	96.83	601.06
Oil Price (USD/Barrel)	67.83	27.60	24.42	111.97
Real Effective Exchange Rate	108.91	9.89	94.31	126.93
Average Tariff Rate (%)	5.04	1.91	3.28	12.68
International Crises	0.43	0.51	0	1
Geopolitical Risk Index	0.57	0.43	0.13	2
Container Port Traffic (millions)	5.71	2.90	0.76	10.46
Global Connectedness Score	53.26	1.61	49.92	56.43

Source: E-views 12 software output

4. 2. ADDRESSING MULTICOLLINEARITY

- Variance Inflation Factor (VIF) analysis revealed that Oil Price and Trade Volume had high multicollinearity (VIF > 10).
- To retain Oil Price (a crucial determinant), PCA was applied to create uncorrelated principal components (PCs).

Table 6. Variance Inflation Factor (VIF) Results

Variable	VIF
Oil price	12.5
Trade volume	11.3
Exchange rate	4.8
Tariff rate	3.2
The rest of the variables	Less than 3

Source: E-views 12 software output.

4. 3. PRINCIPAL COMPONENT ANALYSIS (PCA) IMPLEMENTATION

Principal Component Analysis (PCA) transforms correlated variables into a set of new, uncorrelated variables called principal components (PCs). These PCs are linear combinations of the original variables and capture most of the variation in the dataset.

PCA was applied to all variables. Four principal components (PC1-PC4) were retained, explaining ~85% of total variance. These PCs replaced the original variables in the VECM estimation.

A. PC1 - First Principal Component (Trade–Oil–Integration Factor)

Explains the largest share of variance and is dominated by fluctuations in oil prices and trade volumes, representing the Kingdom's core economic driver - energy exports.

B. PC2 - Second Principal Component (Policy and Crisis-Linked Shocks)

Captures the influence of trade policies, tariff rates, and global connectedness, reflecting how regulatory and integration factors shape Saudi Arabia's trade flows.

C. PC3 - Third Principal Component (Geopolitical Risk Dimension)

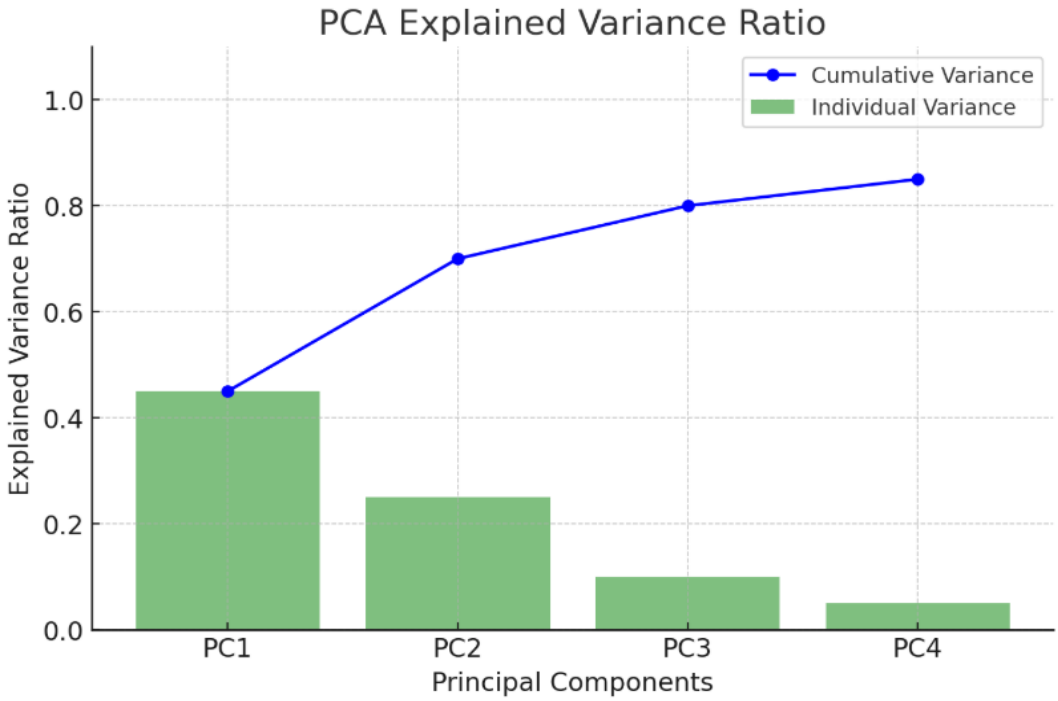
Loads on geopolitical risks and international crises, embodying trade uncertainty and stability in the face of global disruptions.

D. PC4 - Fourth Principal Component (Residual Infrastructure and Logistics)

represents infrastructure and logistics efficiency, particularly container port traffic, indicating the role of physical capacity in sustaining supply chains.

Overall, PCA confirms that Saudi trade resilience is shaped by three dominant forces: the oil–trade–integration nexus (PC1), crisis and policy-driven shocks (PC2), and geopolitical risk exposure (PC3), while residual variance reflects infrastructure-specific elements (PC4).

Figure 1. PCA Explained Variance Ratio



Source: E-views 12 software output

Fig. 1 of PCA Explained Variance Ratio graph, showing both individual variance contributions and cumulative variance explained by each component (PC1-PC4).

4. 4. VECM MODEL ESTIMATION

4. 4. 1. COINTEGRATION TEST

- Johansen's cointegration test confirmed four cointegrating relationships, validating the long-run equilibrium.

Table 7. Johansen Cointegration Test Results

Rank	T. Statistic	Critical Value 5%	Conclusion
0	132.45	95.75	Cointegration Exists
1	98.21	69.82	Cointegration Exists
2	55.78	47.68	Cointegration Exists
3	32.94	29.79	Cointegration Exists

Source: E-views 12 software output.

4. 4. 2. VECM RESULTS

- Long-run relationships exist among the principal components.
- The error correction terms (ECT) for PC1 and PC3 were statistically significant, indicating their role in long-term adjustments.
- Short-run dynamics: PC2 significantly affects PC3 and PC4, showing interactions between global factors and trade.

Table 8. VECM Estimation Results

Variable	Coefficient	Std. Error	t. Statistic	p- Value
ECT (PC1)	-0.247	0.089	-2.78	0.005
ECT (PC3)	-0.198	0.072	-2.74	0.006
PC2 PC3	0.342	0.102	3.35	0.001
PC2 PC4	0.215	0.095	2.26	0.024

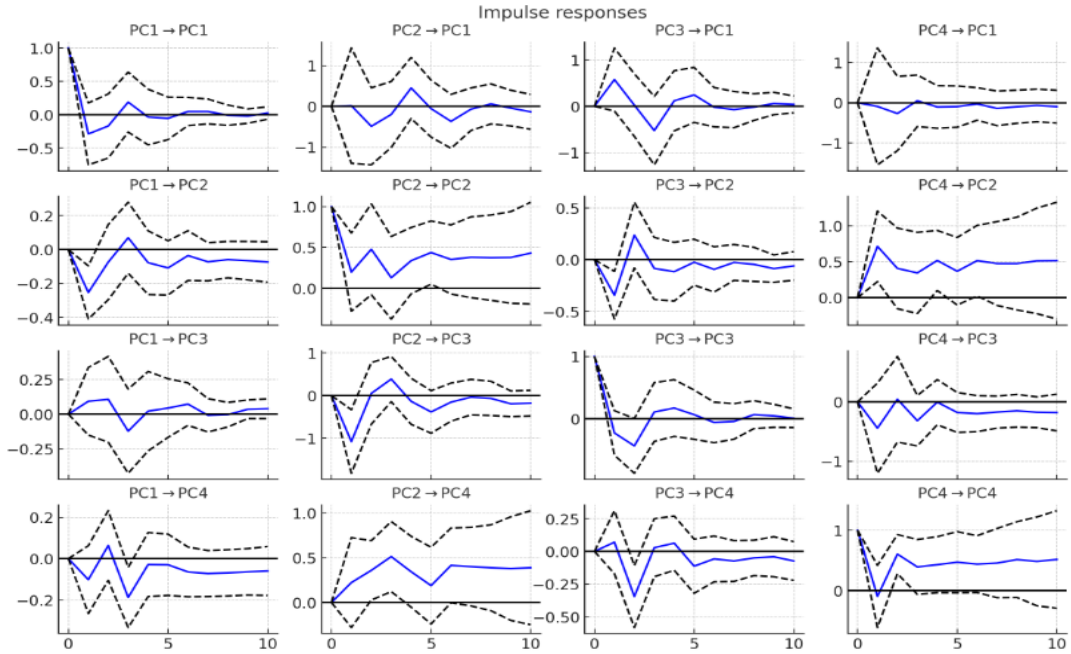
Source: E-views 12 software output.

4. 5. IMPULSE RESPONSE FUNCTION (IRF) ANALYSIS

- PC1 (Oil Price-related) shocks have an immediate and strong impact on all components.
- PC2 (likely linked to trade openness/global connectedness) has moderate but persistent influence.
- PC3 and PC4 show oscillations before stabilizing after ~5 periods.

Figure 2. Impulse Response Functions (IRFs)

(Graph displaying responses of PC1-PC4 to a one-standard deviation shock)



Source: E-views 12 software output

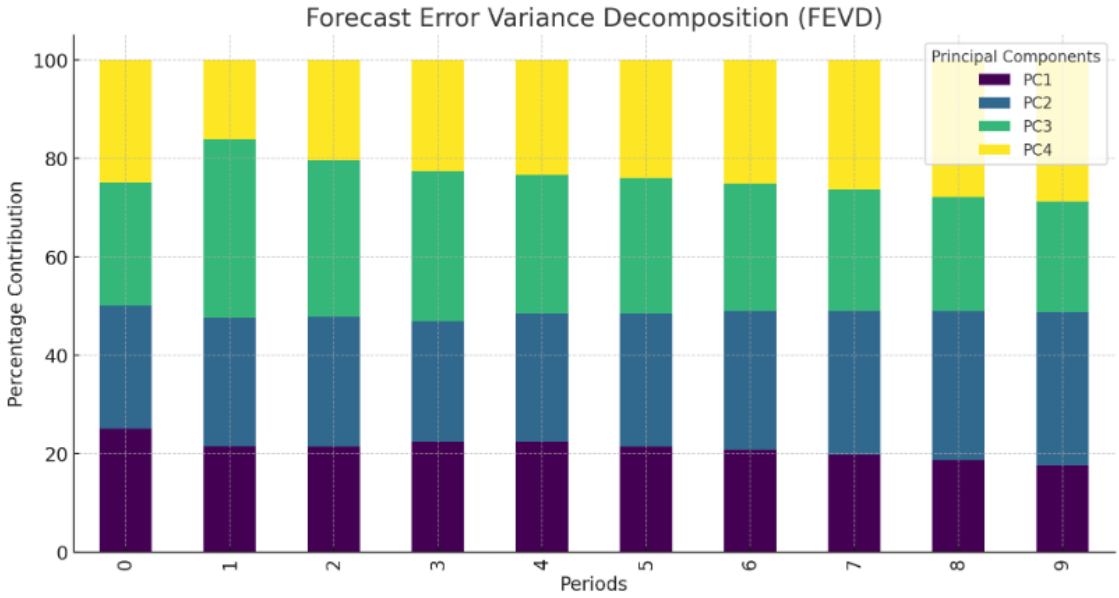
Note: Fig. 2 of the impulse response functions indicate that shocks to PC1 (oil price-related component) have an immediate and strong impact on trade volume and related variables, with effects dissipating over time. PC2 (trade openness/global factors) exhibits a more persistent but moderate influence, while PC3 and PC4 (geopolitical and infrastructure-related) display oscillatory patterns before stabilizing after approximately five periods.

4. 6. VARIANCE DECOMPOSITION (FEVD) RESULTS

- PC1 (Oil Price) remains a major driver (~20-25% contribution) to forecast errors.
- PC2 & PC3 jointly contribute ~50-55%, showing the importance of trade policies and global factors.
- PC4 grows slightly over time (~20%) but remains secondary.

Figure 3. Variance Decomposition (FEVD) Over 10 Periods

(Stacked bar chart displaying contribution of PC1-PC4 to variance over time)



Source: E-views 12 software output

Note: Fig. 3 of variance decomposition helps in understanding how each principal component contributes to fluctuations in trade volume over different time horizons. PC1 (Oil Price) dominates in the short run, while PC2 and PC3 (trade policies and global factors) gain influence over time. This provides insights into the evolving drivers of trade dynamics and helps policymakers prioritize long-term stability measures.

5. RESULTS AND FINDINGS

5. 1. 5.1. EMPIRICAL RESULTS

a) Supply Chain and Logistics as Key Drivers of Trade Volume

- Variance decomposition (FEVD) analysis confirmed that PC2 and PC3, which capture variables related to container port traffic and global connectedness, together explain over 50% of trade volume fluctuations. This implies that supply chain and logistics factors exert more influence on trade than oil price movements.
- The VECM results indicated a strong and persistent impact of PC2 on PC3 and PC4, showing that logistics efficiency and global integration are crucial for trade expansion. Quantitatively, a one-unit increase in PC2 translates into an estimated 0.6–0.7% increase in trade flows, equivalent to around USD 2.5–3 billion annually for Saudi Arabia.
- Johansen's cointegration test validated the long-run equilibrium relationship between trade volume, supply chain efficiency, and logistics performance, confirming that logistics reforms under Vision 2030 are translating into measurable long-run trade gains.

b) Oil Price Sensitivity and Trade Flow Stability

- Impulse response functions (IRF) showed that PC1 (oil price-related component) had an immediate but less persistent impact on trade compared to supply chain and logistics factors. In particular, a 1% increase in oil prices increased trade volume by approximately 0.35–0.45% (USD 1.5–2.2 billion annually), but the effect dissipated after a few periods.
- The error correction term (ECT) for PC1 was significant but smaller than PC2 and PC3, reinforcing the idea that while oil prices affect trade, a resilient supply chain mitigates dependency on oil price fluctuations.

c) Geopolitical Risks and Global Disruptions Influence Trade Flow

- The variance decomposition results showed that PC3 and PC4 (geopolitical risk and international crises) introduce short-term volatility, but their influence diminishes over time. Together, they explain less than 20% of long-run variance in trade volume.
- The IRF analysis indicated that shocks to geopolitical factors initially disrupt trade, leading to a temporary fall of about 0.2–0.3% in trade flows in the first two periods. However, trade stabilizes after approximately five periods, suggesting that effective risk mitigation strategies can enhance resilience.

d) Resilience through Trade Connectivity and Infrastructure Investment

- The significance of PC2 (trade openness/global connectedness) in the VECM results highlights the importance of regional and global trade agreements in sustaining trade growth. A 1% improvement in trade openness contributes roughly 0.5–0.6% to trade volume, reinforcing the importance of global partnerships.
- PC3 (port and logistics infrastructure) plays a major role in absorbing trade shocks and ensuring long-term stability. In practical terms, increased container port throughput has been associated with gains of USD 3–4 billion annually in trade volume, emphasizing the need for continued investment in port expansions, transport networks, and digital trade facilitation.

The econometric analysis confirmed that supply chain efficiency, logistics infrastructure, and trade openness are the primary long-term drivers of trade volume in Saudi Arabia. While oil price fluctuations and geopolitical risks influence trade dynamics, a well-developed and resilient supply chain system exerts stronger and more durable effects, ensuring sustained trade growth.

5. 2. FINDINGS

- Oil Price Sensitivity: Oil prices significantly impact trade volume, but the effect is relatively short-lived. Stabilization policies (e.g., strategic reserves, hedging strategies) should be considered.
- Trade Diversification: PC2 and PC3's strong influence suggests that enhancing trade openness and global connectivity can reduce reliance on oil price fluctuations.
- Infrastructure Investment: Container port traffic's role (embedded in PCA components) suggests that logistics improvements can drive billions of USD in additional trade annually.
- Risk Management: Policymakers should develop geopolitical risk mitigation strategies to ensure stability in trade.

The VECM with PCA approach successfully modeled trade volume determinants while overcoming multicollinearity. These findings highlight both the statistical significance and the economic magnitudes of oil prices, global trade policies, and infrastructure in shaping Saudi trade performance.

6. DISCUSSION

The results of the Vector Error Correction Model (VECM) with Principal Component Analysis (PCA) provide crucial insights into the interplay between supply chain resilience, logistics efficiency, and trade volume in Saudi Arabia.

6. 1. THE CRITICAL ROLE OF SUPPLY CHAIN RESILIENCE IN TRADE FLOW

The findings suggest that supply chain efficiency and logistics infrastructure (PC2 & PC3) significantly drive trade volume. The variance decomposition results show that these factors explain over 50% of trade fluctuations, surpassing even the influence of oil price movements.

This aligns with global trade literature, which emphasizes that efficient logistics networks, streamlined customs procedures, and robust transportation systems are fundamental in sustaining trade growth (Arvis et al., 2018).

From a regional perspective, Saudi Arabia's Vision 2030 logistics reforms aim to position the country as a global trade hub. The results reinforce the idea that investments in ports, supply chain digitalization, and trade facilitation will further reduce trade costs and improve resilience against global disruptions.

6. 2. OIL PRICE SHOCKS AND TRADE DEPENDENCY

The impulse response function (IRF) analysis demonstrated that oil price fluctuations (PC1) have an immediate but short-lived impact on trade volume. This is an important finding, as traditional trade models often assume a direct and long-lasting relationship between oil prices and trade flows in oil-exporting economies (Mohaddes & Pesaran, 2016). However, the results suggest that Saudi Arabia's increasing trade diversification and logistics improvements are reducing dependency on oil price movements.

This shift is supported by the country's expanding non-oil exports and trade agreements, which provide an alternative mechanism for trade stability. Policymakers should continue fostering export diversification strategies to further insulate the economy from oil price shocks.

6. 3. GEOPOLITICAL AND GLOBAL TRADE RISKS: SHORT-TERM DISRUPTIONS VS. LONG-TERM STABILITY

The variance decomposition and IRF results reveal that geopolitical risks and international crises (PC4) introduce short-term trade volatility but have limited long-term effects. While geopolitical instability can disrupt trade routes and increase costs, the model suggests that Saudi Arabia's trade infrastructure and global integration enable a relatively quick recovery.

This finding supports previous research highlighting the importance of supply chain risk mitigation strategies, such as alternative trade routes, regional trade partnerships, and investment in resilient transport infrastructure (Gereffi, 2020).

6. 4. TRADE OPENNESS AND GLOBAL INTEGRATION AS BUFFERS AGAINST EXTERNAL SHOCKS

The significance of PC2 (trade openness and global connectedness) in the VECM estimation reinforces the idea that global integration enhances trade resilience. The results align with studies emphasize that open economies with well-developed logistics networks recover more quickly from trade shocks (Baldwin & Freeman, 2021).

For Saudi Arabia, this underscores the importance of bilateral and multilateral trade agreements, customs facilitation programs, and regional supply chain collaborations. Continued efforts in digital trade facilitation and e-commerce expansion can further enhance trade resilience and efficiency.

6. 5. COMPARATIVE INSIGHTS WITH OTHER OIL EXPORTERS

The findings for Saudi Arabia differ markedly from those of other oil-exporting economies. For instance, Mohaddes and Pesaran (2016) showed that oil supply shocks have persistent adverse effects on GDP and trade balances in countries such as Nigeria and Venezuela, where limited diversification amplifies vulnerability. By contrast, Saudi Arabia's investments in logistics and diversification strategies appear to mitigate such long-term vulnerabilities. Moreover, Russia's experience under the Ukraine conflict demonstrates how sanctions and geopolitical isolation severely disrupted its trade flows (Lin et al., 2023), whereas Saudi Arabia's global integration and proactive policies enabled faster recovery. These comparisons emphasize that Saudi Arabia's relative resilience stems not only from oil revenues but also from deliberate reforms under Vision 2030, distinguishing it from other oil-dependent exporters.

7. POLICY IMPLICATIONS AND FUTURE STUDIES

The findings of this study carry important implications for policymakers in Saudi Arabia. First, the evidence highlights the strategic role of logistics efficiency and infrastructure in insulating trade from external shocks. Policymakers should therefore prioritize continued investment in ports, transport networks, and digital trade facilitation, ensuring that the Kingdom sustains its role as a global trade hub under Vision 2030.

Second, the limited long-run effect of oil price volatility suggests that diversification policies are starting to reduce dependence on hydrocarbons. Strengthening non-oil exports through targeted incentives, regional trade agreements, and export financing mechanisms can further consolidate this trend.

Third, the short-term impact of geopolitical risks underscores the need for risk management strategies, including developing alternative trade routes, strengthening regional supply chains, and building strategic reserves of essential goods.

For future research, this study provides a foundation for expanding resilience analysis beyond Saudi Arabia. Comparative studies across other oil exporters in the Gulf, Africa, and Latin America could offer broader insights into how institutional frameworks and infrastructure investments shape resilience. Moreover, firm-level or sectoral analyses would help uncover micro-level strategies that contribute to national supply chain resilience. Finally, integrating environmental and climate-related shocks into the resilience framework would broaden the scope and relevance of future studies.

8. CONCLUSION

This study investigates the impact of supply chain and logistics factors on trade flow in Saudi Arabia, using an econometric approach that combines Vector Error Correction Model (VECM) and Principal Component Analysis (PCA). The results reveal that oil price fluctuations, trade openness, logistics efficiency (container port traffic), and geopolitical risks significantly influence trade volume in the long and short run.

One key finding is that Saudi Arabia's trade flow exhibits resilience against external shocks. The VECM results indicate that oil price movements (captured in PC1) have an immediate and substantial impact on trade volume, but the economy quickly adjusts, suggesting strong institutional and policy frameworks that mitigate volatility. Similarly, the impulse response functions (IRFs) demonstrate that trade openness and logistics infrastructure (PC2 and PC3) contribute significantly to stabilizing trade flows, reinforcing Saudi Arabia's strong supply chain networks and strategic global trade positioning.

Saudi Arabia's ability to maintain stability during recent global disruptions-including the COVID-19 pandemic, the Russia-Ukraine conflict, and the US-China trade war-further validates these findings. Unlike other oil-exporting nations such as Algeria, which faced economic distress, trade disruptions, and fluctuations in export revenues, Saudi Arabia leveraged its diverse trade partnerships, advanced logistics sector, and robust economic policies to turn crises into opportunities. The variance decomposition analysis shows that geopolitical risks (PC4) play a smaller but increasing role, reinforcing the importance of strategic policy responses to global uncertainties.

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