Supply chain resilience as a mitigating factor for the impact of the Sudan Crisis on the performance of food manufacturing enterprises in Egypt
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Keywords: Sudanese Crisis, Egyptian food industry, supply chain resilience, multigroup analysis, risk mitigation.
Abstract: This research investigates the Sudan Crisis 's impact on the performance of food industry enterprises in Egypt. It focuses on the moderating role of supply chain resilience (SCR) capabilities in mitigating these effects and their direct influence on enterprises' performance. Employing the quantitative approach, a questionnaire survey was used to examine the hypotheses and theoretical framework. Data were collected from 365 Egyptian food industry enterprises, and partial least squares structural equation modelling (PLS-SEM) with multigroup analysis (MGA) was used to analyse the data. The results show that the Sudanese Crisis has a negative impact on the performance of enterprises, with a path coefficient (-0.111) for both grouping sectors, indicating that these effects are not statistically significant (p-values > 0.05). Also, the results indicate a significant and positive relationship between supply chain resilience (SCR) capabilities and enterprises' performance across the animal-based industry and 0.616 for the plant-based industry groups of food industries. The path coefficients for the SCR impact on ECP are 0.596 and 0.616 for the two industries, respectively. However, supply chain resilience capabilities demonstrate a significant moderating effect in the plant-based industry, p-value of 0.029. underscoring the importance of resilience measures in mitigating disruptions. The research concludes that fitted resilience strategies are essential for enhancing supply chain adaptability and protecting firm performance, particularly in industries exposed to regional conflicts. Recommendations include investments in diversified supply chains, enhanced logistical strategies, and policy support to strengthen SCR capabilities within the food industry.

1   Introduction

Political, environmental, or economic crises significantly impact supply chains across various industries worldwide, disrupting the continuous flow of goods, raw materials, and information, leading to delays, increased costs, and challenges in meeting consumer demand. For instance, political armed conflicts can result in the closure of trade routes, border restrictions, and increased uncertainty, which affects industries dependent on supply chains. The increasing effect of these disruptions can affect industry competitiveness, reduce profitability, and force enterprises to adapt by expanding their supplier bases, reconfiguring logistics strategies, and investing in alternative transport routes. The resilience and adaptability of enterprises' supply chains in various industries during political, environmental, or economic crises have become critical factors for maintaining performance stability and growth. The ongoing political and economic turmoil that erupted in Sudan in April 2023 is a clear example of how quickly disruptions can spread beyond national borders to affect neighbouring economies. The conflict in Sudan has disrupted vital trade routes and impacted agricultural output, threatening the stability of supply chains and presenting risks that introduced significant challenges for supplying neighbouring countries, particularly Egypt, which depends partially on input imports from Sudan for its main food industries. Sudan takes second place in Nile basin countries' imports to Egypt with a value of $504.4 million in 2022, compared to $336.7 million in 2021, an increase of 30.8%. The food industry in Egypt is likely facing substantial challenges in sustaining its food industry performance amid such crisis. This research explores how risks emerging from the Sudanese Crisis directly influence food enterprises performance in Egypt, highlighting the impact of supply chain resilience on enterprises' performance within food industries in Egypt and the role of supply chain resilience (SCR) as a potential mitigating factor against these disruptions by investigating how adaptive and resilient supply chain practices can buffer food industry enterprises Egypt from external shocks.

While previous studies have broadly examined the impacts of crises across various sectors, there still needs to be a significant gap in understanding their specific effects on food industry operations, supply chains, and performance metrics. This study seeks to address this gap by analysing the nuanced implications of the Sudanese Crisis on Egypt's food industry enterprises, focusing on supply chain resilience as a mitigating mechanism. By concentrating on the food sector, this research offers a granular perspective on managing industry-specific vulnerabilities amidst regional instability, providing actionable insights into conflict-induced challenges and strategic responses tailored to mitigate these impacts.

The structure of this research is as follows: the next section provides a review of relevant literature, followed by an outline of the research design and methodology; subsequently, the data analysis and results are presented. The findings are then discussed, emphasizing the practical implications. The paper concludes with practical

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recommendations, a discussion of the research's limitations, and suggestions for future research.

2 Literature review

2.1 Supply chain resilience

Supply chain resilience is vital for understanding how logistics networks survive and recover from unexpected disruptions. [1] stated that supply chain resilience is the ability of a supply chain to adapt, prepare to respond to, and recover from unexpected disruptions- geopolitical conflicts or natural disasters- while maintaining continuity of operations. [2] findings underscored that resilient supply chains are characterized by a combination of flexibility, agility, and the integration of technological advancements that enable real-time responses to disruptions. From this perspective, the key factors that enhance supply chain resilience include transparency in operations, collaboration among chain partners, and the ability to quickly adjust operations when needed [3]. These factors contribute to building a culture of prediction and preparedness, enabling organizations to respond effectively in challenging times [4]. [5] emphasized that Resilient supply chains also require proactive strategies, including continuous risk analysis, contingency planning, and developing diverse supplier networks. At the same time, reactive strategies involve quick decision-making, agile response mechanisms, and effective communication [6]. [7] suggested that organizations adopt a holistic view of risks, integrate advanced data analytics, and build resilient structures that can adapt to unexpected challenges. The Dynamic Capabilities Theory, as developed by [8] highlights an organization's ability to renew and adapt its resources and capabilities to respond to rapidly changing environments and maintain competitiveness. Developing these capabilities required significant investments in organizational learning, strategic decision-making, and the alignment of various resources and processes to effectively respond to and exploit environmental changes [9].

2.2 Supply chain resilience and firm performance

[10] stated in their study the role of supply chain flexibility as a moderating factor in mitigation risks which cause uncertainty in supply chains and these risks arising from factors such as demand variability, supply disruptions, and external shocks. These risks can disrupt the flow of goods, increase costs, and negatively impact firm performance. [11] in their study on supply chain resilience and absorptive capacity during the COVID-19 pandemic, highlighted that firms with robust resilience strategies and the ability to absorb external shocks effectively mitigate risks and sustain performance during crises. Also, they emphasize that resilience supports firms in quickly adapting to disruptions. [12] reveal that supply chain resilience (SCR) capabilities positively affect firm performance and competitive advantage within the Sri Lankan apparel industry, especially re-engineering, agility

and collaboration. [13] demonstrated that firms with higher levels of resilience are better equipped to manage disruptions, ensuring continuity and operational efficiency, which leads to enhanced financial and operational outcomes.

2.3 Supply chains and conflicts

The smooth operation of supply chains, which link production, distribution, and consumption across geographies and industries, is crucial to the global economy. Nonetheless, supply networks are highly susceptible to interruptions brought on by several causes, the most important of which is violence. Conflict, whether armed, political instability, or economic sanctions, seriously threatens the movement of products, services, and raw resources [14].

In this essence, the Russia-Ukraine conflict has significantly impacted global supply chains, disrupting existing networks and posing significant challenges for sectors dependent on essential goods. [15] emphasize that the conflict has significantly affected the global food supply chain, given that Russia and Ukraine are prominent exporters of essential products, including wheat, maize, and sunflower oil. This disruption has resulted in considerable price increases, supply deficiencies, and logistical difficulties reverberating across international markets, intensifying pre-existing weaknesses revealed during the COVID-19 pandemic. [16] assert that these disruptions have exacerbated risks to supply chains by impacting not only food but also essential commodities and energy sources, highlighting the interdependent nature of global trade networks. Their analysis demonstrates how these disruptions generate cascade consequences that affect other industries, including manufacturing and transportation, and influence global economic stability.

[17] assert that the combined impacts of the Russia-Ukraine conflict and the pandemic have engendered a double crisis, impacting supply chains beyond food to energy and vital raw resources. This led numerous nations to address systemic vulnerabilities, hastening the shift to alternative energy sources and highlighting inequalities in global supply chain robustness.

2.4 The Sudan Crisis and Egypt's economy

Sudan, the third-largest country in Africa, spans 1,886,068 square kilometres and shares borders with seven neighbouring countries: South Sudan, Ethiopia, Eritrea, Egypt, Libya, Chad, and the Central African Republic [18]. Sudan has enormous agricultural and animal resources, with about 200 million acres of arable land, suitable climate, water sources, and renewable energy. The agricultural sector, with its agricultural and livestock sections, plays a crucial role in Sudan's economy, serving as the primary livelihood for most of its population and accounting for approximately 30% of its GDP. Sudan's agricultural landscape is diverse, encompassing crops such as cereals, horticultural products and valuable cash crops like sesame, ground nuts and gum Arabic, as well as

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livestock, which is one of the largest in the Arab world and Africa, with 103 million heads of cows, sheep, goats and camels, in addition to 45 million poultry and a fish wealth estimated at annual catch of 100 thousand tons. Agriculture employs over 50% of the labour force, especially in rural areas. Additionally, agricultural exports are a critical source of foreign currency, with gum Arabic contributing to about 80% of the global annual production and substantially supporting Sudan's export economy [19]. Data for 2021 indicate that Sudanese exports were concentrated by 90.5% in certain major markets, including the United Arab Emirates, China, Egypt, and Saudi Arabia ,as shown in Table 1.

Table 1 Major markets for Sudanese exports in the years 2020 and 2021 (USD Million)

Country	Export Value 2020	Export Value 2021	Key Export Commodities
United Arab Emirates	1,637.5	2,203.1	Sesame, Gold
China	752.3	614.5	Sesame, Peanuts
Egypt	363.8	496.4	Live Animals, Sesame
Saudi Arabia	284.9	365.3	Live Animals, Leather

Source: Central Bank of Sudan - Annual Trade and Financial Report for 2021 [20].

The Sudanese Crisis has destroyed the agricultural infrastructure, a situation exacerbated by the disputes over the agricultural resources, particularly land, leading to a significant decline in agricultural production as many farmers have lost their means of production or had to flee their lands; meanwhile the decline in state support for essential inputs, such as diesel and fertilizers, has also prompted the farmers to reduce their agricultural areas [21] thus exacerbating the food production crisis and increasing costs of basic commodities in Sudan, as shown in Figure 1, and driving higher costs for the exported agricultural products to the neighbouring countries [22].
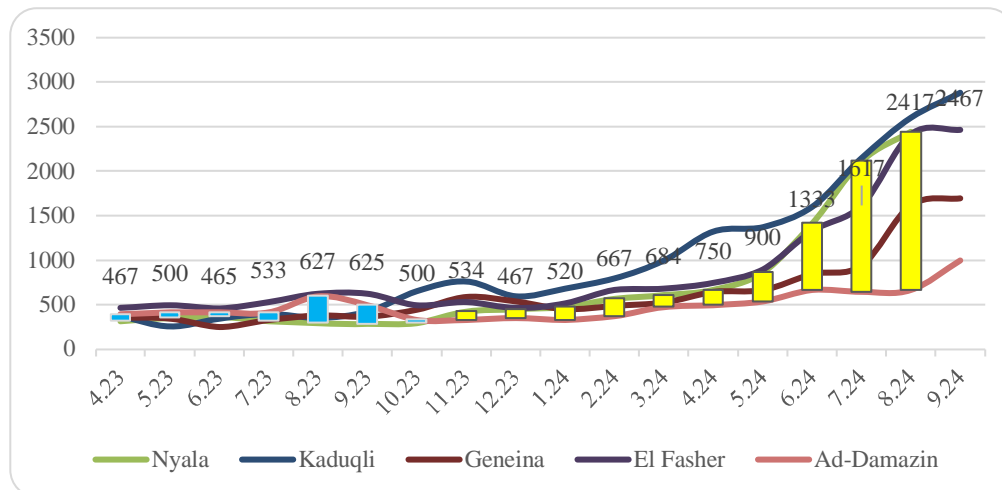

Figure 1 Sorghum retail prices April 2023-September 2024 (Sudanese pound /kilogram)
Source: FEWS NET Food Security Outlook, October 2024 [23].

The Sudanese Crisis has significant spillover effects on neighbouring economies, particularly in food production and supply chains. Sudan's position as a major regional supplier of agricultural products, livestock, and essential goods means that the disruption of its industries has reverberated across borders. Countries like Egypt, Saudi Arabia, South Sudan, Chad, and Ethiopia, which rely on imports of food, livestock, and other commodities from Sudan, have seen reduced trade flows. The closure of key trade routes and infrastructure collapse have further exacerbated the challenges of trade and supply chains. The disruptions in the supply chains, particularly in transportation and logistics, have made it difficult for these countries to secure their stable food imports from Sudan. This regional impact underscores the interconnectedness of Sudan's economy with its neighbours, especially in critical sectors like food production and supply chain resilience [24].

The Sudanese exports to Egypt (which are mainly raw materials) constitute essential inputs for some Egyptian food industries; the trend in the value of annual Sudanese exports to Egypt shows a significant increase in recent years (especially for groundnuts, livestock, sesame and cotton), but significant fluctuations have also been observed during this period. According to the Central Agency for Public Mobilization and Statistics in Egypt, the value of Egyptian imports from Sudan amounted to $386.9 million in 2023 compared to $505.4 million in 2022, a decrease of 23.4%. Meanwhile, the Egyptian exports to Sudan increased to record $979.9 million in 2023 compared to $954.3 million in 2022, an increase of 2.7% [25].

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When comparing Sudan's annual exports of agricultural products to Egypt's total import value of the same products, we find that Sudan's export contribution varies across the period of 2019 and 2021, as illustrated in Table 2. For instance, ground nuts showed a high export percentage in 2019 at 77.03%, making it the dominant export category for that year; however, there was a sharp decline in 2020 to 15%, while in 2021, the percentage partially recovered to 35.14%, suggesting fluctuation in demand, or competitive factors. The value of Sudan's traded cotton to Egypt was relatively steady in 2019 and 2020, at 13.71% and 13.52%, respectively, while a noticeable increase in 2021 was depicted, with cotton exports reaching 25.16% of Egypt's imports, indicating a positive shift in this trade category that can be attributed to the expansion of cotton cultivation while the spinning and weaving industry in Sudan is witnessing several structural and economic constraints that are reflected as a general local reduction demand for cotton [26,27].

Table 2 Percentage of Sudan's exports for total Egypt's imports of some traded commodities

		2019	**2020**	**2021**
chickpea	Sudan exports to Egypt	9	9	2057
	Egypt total imports	15675	16952	21853
	Sudan exports per cent of Egypt's' total imports	0%	0%	9%
Ground Nuts	Sudan exports to Egypt	7973	7558	13994
	Egypt total imports	10350	49260	39820
	Sudan exports per cent of Egypt's' total imports	77%	15%	35%
Cotton	Sudan exports to Egypt	32468	22905	49985
	Egypt total imports	236903	169412	198670
	Sudan exports a per cent of Egypt's total imports	14%	14%	25%
Meat	Sudan exports to Egypt	24814	20921	26989
	Egypt total imports	1984369	1711231	1146391
	Sudan exports a per cent of Egypt's total imports	1%	1%	2%

Source: Calculated from the Arab Agricultural Statistics Yearbook -Vol 42 published by the Arab Organization for Agricultural Development [26], Annual Foreign Trade Digest published by Central Bank of Sudan2004-2022 [27].

The ongoing conflict will certainly affect trade between the two countries, Egypt and African countries, with a route in Sudan. In October 2024, the paramilitary Rapid Support Forces (RSF) of Sudan imposed an restriction on certain products (including cereals, oil crop seeds, livestock and other products, including gold) from areas under their control to areas controlled by the Sudanese Armed Forces (SAF), where exports are customarily routed to Egypt [28]. Implementing this decree will likely negatively impact on the exports, at least soon. The export decline would likely negatively affect commodity prices in Egypt, especially food and meat, given its reliance on Sudanese imports. [21] stated that as the conflict continued, most economic activities in Sudan stopped, leading to a significant decline in trade volume between the two countries.

The food industry sector in Egypt is considered one of the most prominent economic sectors, as it plays a vital role in meeting the needs of the local market and promoting exports. According to the General Authority for Export and Import Control, imports from the food industry sector recorded about $6.664 billion in 2021, occupying fifth place in Egyptian imports [29]. Sudan takes second place in Nile basin countries imports to Egypt with a value of $504.4 million in 2022, compared to $336.7 million in 2021, an increase of 30.8%, and the most essential items imported [25].

2.5 Literature gap and hypotheses

While research has generally examined the broader effects of crises on various sectors, there needs to be more exploration of how such disruptions affect food industry operations, supply chains, and performance metrics. This research aims to address this deficiency by investigating the nuanced effects of Crisis in Sudan on food industry enterprises in Egypt, emphasizing the role of supply chain resilience as a mitigating factor. By narrowing the scope to the food sector, this research provides more detailed insights into how industry-specific vulnerabilities can be managed amid regional instability, contributing to a more targeted understanding of Crisis impacts and strategic responses. Motivating the following hypothesis:

H1: *Sudanese Crisis Risks negatively impact firm performance in Egyptian food Industries.*

H2: *Supply chain resilience capabilities positively impact firm performance in Egyptian food Industries.*

H3: *Supply chain resilience capabilities moderate the impact of risk caused by the Sudan Crisis on firm performance.*

Figure 2 illustrates the conceptual framework of the research.

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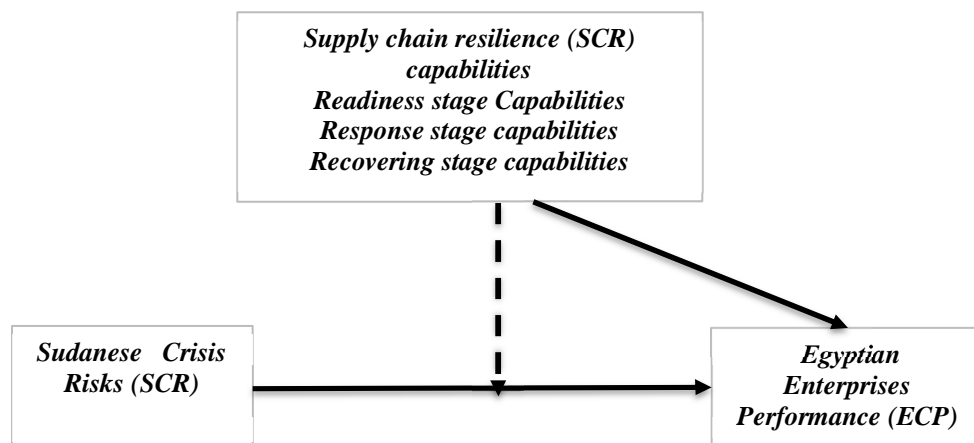Selma Abdelrahim

Figure 2 Research conceptual model

3 Methodology

The study population is represented by all enterprises operating in the food industry in the Arab Republic of Egypt. According to statistics published by the Central Agency for Public Mobilization and Statistics during the first quarter of 2024, the total number of enterprises operating in the food industry reached 7,219. The study sample size (n = 365) [30]. The calculated sample size was distributed according to the proportion of each industry in the target population. The tool for the current study was a questionnaire designed for managers of food industry enterprises, which were selected in a stratified simple random sample. The questionnaire was distributed from May to July 2024. Table 3 shows the distribution of the target population and the stratified simple random sample of each stratum.

Table 3 Target population distribution and the sample distribution

Industry (Enterprises')	Population	%	Sample size
Meat, poultry and fish industry	732	10%	37
Manufacture of vegetable oils and fats	1088	15%	55
Dairy products industry	1226	17%	62
Vegetable and fruit industry	2156	30%	109
Manufacture of juices, drinks and water	1661	23%	84
Sugar, candy and chocolate industry	356	5%	18
Total	7219	100%	365

3.1 Multigroup Analysis (MGA)

Multigroup Analysis (MGA) is a statistical method employed to ascertain the presence of significant differences among established groups within a dataset. This method is frequently utilized in structural equation modelling (SEM) and other multivariate analytical techniques to assess the influence of factors across several subpopulations or groupings. The aim is to evaluate if the connections among variables vary significantly between groups, enabling researchers to investigate potential moderating effects and verify the stability of their models across varied samples [31].

3.2 Data analysis and results

The data was analyzed using Partial Least Squares (PLS) path modelling with the SmartPLS software. Smart PLS version 4, developed by Ringle et al. in 2024. It employs a component-based approach to structural equation modelling, making it highly suitable for exploratory research and applicable for confirmatory research [32]. The model has two variables: exogenous latent variables, which explain other constructs, and endogenous latent variables, which are the investigated constructs [33].

3.2.1 Measurement model

The analysis of the measurement model, as presented in Table 4, demonstrates robust reliability and validity across all constructs: Occupational health and safety, Organizational Resilience, Staff Engagement, and Staff Resilience.

The reliability and validity analysis of the constructions for both animal-based and plant-based products and the complete model shows internal solid consistency and measurement accuracy. Cronbach's Alpha values for all constructs across the three models are above the threshold of 0.7, indicating high internal consistency reliability. For the Egyptian enterprises' performance, the Alpha values for animal-based products, plant-based products, and the complete model are 0.864, 0.795, and 0.813, respectively. Similarly, the Alpha values are consistently above the threshold in the Sudanese crisis risk and supply chain

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resilience constructs, reflecting reliable scales across different categories.

Table 4 The reliability and validity

Items	Animal-based product			Plant-based product			Complete		
	ALPHA	CR	AVE	ALPHA	CR	AVE	ALPHA	CR	AVE
Egyptian Enterprises' Performance	0.864	0.902	0.649	0.795	0.855	0.541	0.813	0.868	0.567
Sudanese Crisis Risk	0.854	0.881	0.600	0.776	0.802	0.458	0.813	0.863	0.559
Supply Chain Resilience	0.799	0.855	0.501	0.848	0.888	0.569	0.837	0.880	0.551

Moreover, Composite Reliability (CR) values for all constructs exceed the critical value of 0.7, which further supports the high reliability of these constructions. For example, the CR for the Egyptian enterprises' performance ranges from 0.855 to 0.902, while the Sudanese crisis risk ranges from 0.802 to 0.881, and supply chain resilience shows a CR between 0.855 and 0.888. These values confirm that the respective items accurately measure the constructions.

All constructs' Average Variance Extracted (AVE) values also exceed 0.5, confirming convergent validity. For instance, the AVE for Egyptian enterprises' performance is 0.649 for animal-based products and 0.541 for plant-based products, while supply chain resilience exhibits AVE values ranging from 0.501 to 0.569. These AVE values demonstrate that the latent constructs capture a substantial portion of the variance in the observed variables, ensuring good validity. Thus, the reliability and validity of the constructions are well-supported across all models.

3.2.2 Discriminate validity

Discriminant validity was assessed using the Fornell-Larcker criterion, which evaluates whether each construct shares more variance with its indicators than with other constructs. According to the Fornell-Larcker criterion, the square root of the Average Variance Extracted (AVE) of each construct should be greater than the highest correlation it has with any other construct. The results are presented in Table 5 below.

Table 5 Discriminant validity

Fornell-Larcker criterion	Egyptian Enterprises' Performance	Sudanese Crisis Risk	Supply Chain Resilience
Egyptian Enterprises' Performance	**0.753**		
Sudanese Crisis Risk	-0.115	**0.748**	
Supply Chain Resilience	0.685	-0.057	**0.742**

For the Egyptian enterprises' performance, the square root of the AVE is 0.753, which is higher than its correlations with Sudanese crisis risk (-0.115) and supply chain resilience (0.685). Similarly, for the Sudanese crisis risk, the square root of its AVE is 0.748, which exceeds its correlation with Egyptian enterprises' performance and supply chain resilience (-0.057). Lastly, supply chain resilience has a square root of AVE of 0.742, greater than its correlation with the other two constructs. These results indicate that each construct shares more variance with its indicators than others, confirming discriminant validity. This means that Egyptian enterprises' performance, Sudanese crisis risk, and supply chain resilience are distinct and well-differentiated within the model. The results align with the Fornell-Larcker criterion, further supporting the measurement model's validity and ensuring that the constructs accurately represent different aspects of the phenomenon under study.

3.2.3 Structural model measurement

The structural model analysis focuses on assessing the overall explanatory power, path coefficients (β), and significance levels to evaluate the relationships between the constructs. The explanatory power is measured using the R^2 value, which indicates the proportion of variance in the dependent variable explained by the independent variables. High R^2 values suggest a strong explanatory power of the model. Path coefficients (β) represent the strength and direction of the relationships between constructs, while significance levels determine the statistical significance of these relationships as shown in Figures 3 and 4, respectively.

All of these are well below the critical threshold of 5, indicating that multicollinearity is not an issue and that the estimates of the path coefficients are reliable.

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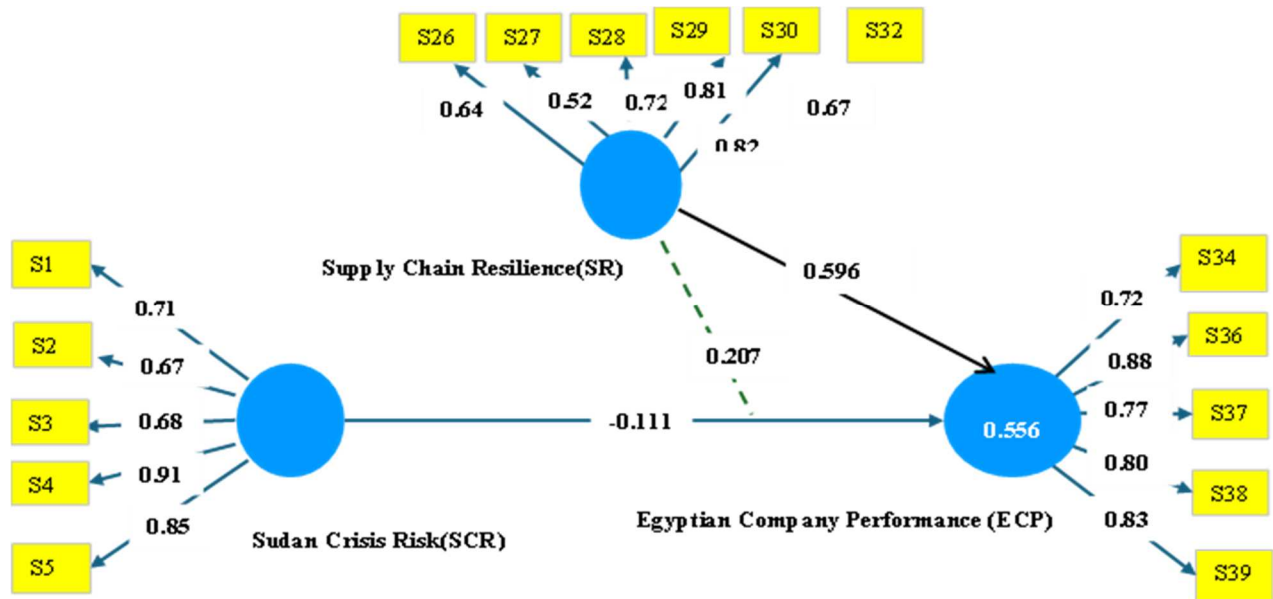Selma Abdelrahim

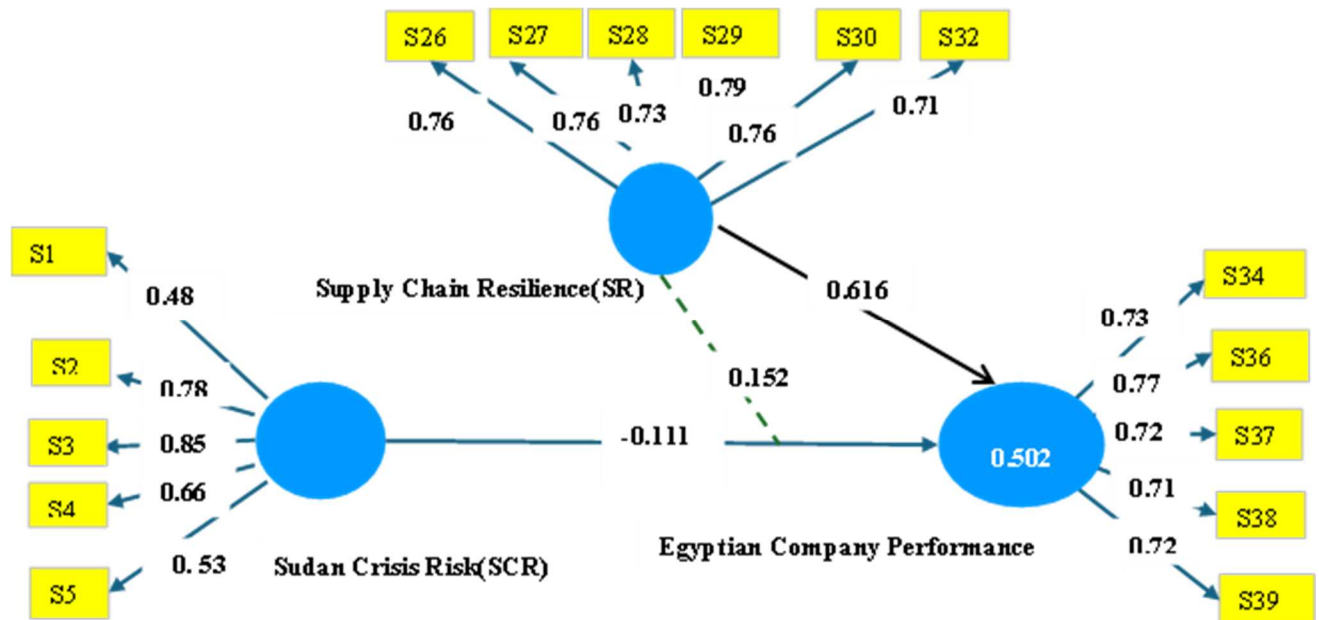*Figure 3 Structural model industry type (Animal-based)*

Figure 4 Structural model industry type (Plant-based)

Table 6 Collinearity statistics (VIF)

	VIF
Sudanese Crisis Risk -> Egyptian Enterprises' Performance	1.017
Supply Chain Resilience -> Egyptian Enterprises' Performance	1.305
Supply Chain Resilience x Sudanese Crisis Risk -> Egyptian Enterprises' Performance	1.308

The Variance Inflation Factor (VIF) is used to assess multicollinearity among predictor variables, with a general rule that VIF values below 5 indicate no significant multicollinearity issues. In this model, the VIF values for Sudanese crisis risk (1.017), supply chain resilience (1.305), and the interaction term between supply chain resilience and Sudanese crisis risk (1.308) all fall well below the threshold of 5, indicating that multicollinearity is not a concern as presented in Table 6. These low VIF values confirm that the predictor variables in the model are independent, allowing for robust and interpretable path coefficients. This reinforces the reliability of the structural model in analyzing the effects of supply chain resilience and Sudanese crisis risk on Egyptian enterprises'

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performance. As a result, the findings suggest that supply chain resilience and Sudanese crisis risk significantly impact enterprises' performance without being distorted by collinearity issues, highlighting their distinct and important roles in the model.

3.2.4 The Model's explanatory power

The model's explanatory power is evaluated using the R-squared and adjusted R-squared values, which indicate the proportion of variance in Egyptian Enterprises' Performance (ECP) explained by the independent variables in both the animal-based and plant-based industries. According to Table 7, the R-squared value for the animal-based industry, the is 0.56, and the adjusted R-squared is 0.54, indicating that the model explains 56% of the variance in ECP, demonstrating substantial explanatory power. In the plant-based industry, the R-squared and adjusted R-squared values are both 0.50, meaning the model accounts for 50% of the variance in ECP. These values suggest that the model has solid explanatory power in both industry groups, particularly for the animal-based industry, where a slightly higher proportion of variance is captured. This supports the model's robustness in predicting the performance of enterprises across different sectors, contributing valuable insights into the dynamics of these industries.

Table 7 Coefficient of determination (R-Squared)

	R-square	R-square adjusted
Egyptian Enterprises' Performance (ECP)		
Group (1) Animal Based Industry	0.56	0.54
Group (2) Plant-Based Industry	0.50	0.50

3.2.5 Path coefficients and hypotheses testing

Based on the analysis in Table 8, the path coefficients and hypothesis testing provide critical insights into the relationships between Sudanese crisis risk (SCR), supply chain resilience (SR), and Egyptian enterprises' performance (ECP) across both animal-based and plant-based industries.

Table 8 Path coefficients and hypotheses testing

	Original (Group 1) ANIMAL BASED INDUSTRY	Original (Group 2) PLANT-BASED INDUSTRY	Mean (Group 1) ANIMAL BASED INDUSTRY	Mean (Group 2) PLANT-BASED INDUSTRY	STDEV (Group 1) ANIMAL BASED INDUSTRY	STDEV (Group 2) PLANT-BASED INDUSTRY	p-value (Group 1) ANIMAL BASED INDUSTRY	p-value (Group 2) PLANT BASED INDUSTRY
Sudan crisis risk (SCR) -> Egyptian Enterprises' Performance (ECP)	-0.111	-0.111	-0.116	-0.1	0.096	0.08	0.124	0.081
Supply chain resilience (SR) -> Egyptian Enterprises' Performance (ECP)	0.596	0.616	0.605	0.628	0.086	0.047	0	0
Supply chain resilience (SR) x Sudan crisis risk (SCR) -> Egyptian Enterprises' Performance (ECP)	0.207	0.152	0.18	0.122	0.141	0.08	0.07	0.029

Hypothesis (H1) Sudanese Crisis Risks negatively impact firm performance in Egyptian food industries. The analysis of the relationship between Sudan Crisis Risk (SCR) and Egyptian Enterprises' Performance (ECP) indicates a consistent negative effect across both the animal-based and plant-based industries, with an original sample (O) value of -0.111 for both groups. This suggests a small negative impact of the Sudanese Crisis on firm performance. The p-values of 0.124 (animal-based) and 0.081 (plant-based) are above the 0.05 significance level, meaning the results are not statistically significant. Therefore, H1 is not supported by the data, as the negative impact of the Sudan Crisis on firm performance, though present, needs to be strong to be considered statistically significant.

The analysis of H2, which examines the impact of Supply Chain Resilience (SR) on Egyptian Enterprises' Performance (ECP), shows a significant and positive relationship across both the animal-based and plant-based industries. The original sample values for SR -> ECP are 0.596 for the animal-based industry and 0.616 for the plant-based industry, indicating a consistent positive influence. The mean values (0.605 for animal-based and 0.628 for plant-based) reinforce this trend, highlighting that SR contributes to enhanced enterprises' performance in both sectors. The standard deviations (0.086 for animal-based

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and 0.047 for plant-based) Notably, the p-values are both 0, confirming that the relationship is highly significant and well below the standard 0.05 threshold, indicating strong evidence against the null hypothesis. This analysis suggests that enhancing supply chain resilience is critical for boosting enterprises' performance. It emphasizes that investments in robust and adaptable supply chains can yield substantial benefits for firms within the Egyptian food industry, regardless of their specific focus on animal- or plant-based products.

Hypothesis (H3) Supply chain resilience (SCR) capabilities moderate the impact of risk caused by the Sudan Crisis on firm performance. The interaction between supply chain resilience (SR) and Sudan Crisis Risk (SCR) was analyzed to determine its moderating effect on Egyptian enterprises' performance. For the animal-based industry, the original sample (O) value is 0.207, but the p-value of 0.07 is slightly above the common threshold of 0.05, indicating marginal significance. In the plant-based industry, however, the original sample (O) value of 0.152 with a p-value of 0.029 shows a statistically significant moderating effect of supply chain resilience. Supply chain resilience plays a more crucial role in mitigating the negative impact of the Sudanese Crisis on the plant-based industry. Therefore, H3 is partially supported as the moderating effect of supply chain resilience is significant in the plant-based industry but not in the animal-based industry.

4 Discussion

The literature presents the role of supply chain resilience in mitigating various disruptions caused by environmental, pandemics and conflict crises. However, most studies in conflict areas address the role on a macro level. The research explores the moderator role of supply chain resilience in Egypt's food sector during the Sudanese crisis. The analysis of the impact of the Sudanese Crisis Risk (SCR) on Egyptian Enterprises' Performance (ECP) demonstrates a negative relationship, though statistically insignificant, impact on firm performance in animal-based and plant-based industries. With an original sample value (O) of -0.111 for both industries, the results suggest a consistent negative effect. However, the t-values (1.153 for animal-based and 1.398 for plant-based) and p-values (0.124 and 0.081, respectively) indicate that these findings do not reach statistical significance, as they do not surpass the significance threshold of p-values at 0.05. This lack of significance implies that while the Sudanese Crisis may cause an obvious negative trend, its spillover effects must be wider and stronger to be definitively concluded as impactful on firm performance within the Egyptian food industry. This result aligns with findings from broader literature that emphasize the compounded nature of crisis impacts. For instance, [34,35] have shown that disruptions caused by crises like pandemics and regional conflicts can strain food security and supply chains but may manifest differently across sectors.

Similarly, [36] highlights that while such crises pose significant risks, the degree of impact often varies based on the affected sectors' resilience and adaptive capacity. These findings suggest that although the Sudanese crisis presents notable challenges, its impact on the performance of food industries in Egypt may be moderated by factors such as supply chain resilience and market adaptability, aspects explored in further research hypotheses. [37] stated that on a macro level, the economic spillover effects of Sudan's intrastate crisis did not significantly impact Egypt's overall economic growth. However, minor possible spillover effects can be detected through capital, labour and trade channels.

The analysis of H2, which demonstrates a significant and positive relationship between Supply Chain Resilience (SR) and Egyptian Enterprises' Performance (ECP) across both animal-based and plant-based industries, p-values (0) for both, aligns with the findings of [11]. Their study on supply chain resilience and absorptive capacity during the COVID-19 pandemic highlights that firms with robust resilience strategies and the ability to absorb external shocks effectively mitigate risks and sustain performance during crises. This complements the current analysis, where high original sample values (0.596 for animal-based and 0.616 for plant-based industries) and significant t-values indicate the strong influence of SR on firm performance. The highly significant p-values (both 0) further validate the importance of SR as a critical factor for maintaining operational success and competitive advantage in volatile environments. [11] emphasize that resilience supports firms in quickly adapting to disruptions; a finding echoed in the Egyptian food industry results shows that investments in adaptable and resilient supply chains can lead to substantial performance improvements. This underscores that SR is essential for crisis response, long-term competitive positioning, and operational stability. Additionally, [12] found that supply chain resilience (SCR) capabilities significantly positively affect firm performance and competitive advantage within the Sri Lankan apparel industry, especially re-engineering, agility and collaboration. [13] demonstrated that firms with higher levels of resilience are better equipped to manage disruptions, ensuring continuity and operational efficiency, which leads to enhanced financial and operational outcomes.

The analysis of H3, which posits that supply chain resilience (SCR) moderates the impact of the Sudan Crisis Risk (SCR) on Egyptian enterprises' performance, reveals differentiated outcomes across industry types. In the animal-based industry, the original sample (O) value of 0.207 suggests an approach towards significance. However, a p-value of 0.07 falls just outside the conventional 0.05 threshold, indicating only marginal significance. This outcome implies that while supply chain resilience has some effect, it is not strong or consistent enough to be considered statistically significant for the animal-based sector. In contrast, the plant-based industry exhibits a more robust moderating effect, with an original

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sample (O) value of 0.152, a t-value of 1.896, and a p-value of 0.029, below the 0.05 significance level. This demonstrates a statistically significant interaction, affirming that supply chain resilience mitigates the adverse impact of the Sudanese Crisis in the plant-based industry. These findings align with insights from [34,35], who emphasize the importance of supply chain adaptability and resilience in safeguarding performance amid disruptions. Also, the findings of [38] highlight that supply chain resilience enables firms to absorb shocks, maintain operational continuity, and recover more effectively.

5 Conclusion

This research aimed to explore the impact of the Sudanese crisis risks on the performance of Egyptian food manufacturing enterprises and to study the impact of supply chain flexibility on the performance of these enterprises. The research results revealed a slight but statistically insignificant negative impact of the Sudanese crisis on the performance of Egyptian enterprises in both sectors, indicating that while the crisis poses challenges, its direct impact on performance alone is not strong. The results also demonstrated that the supply chain's resilience has a positive impact on the performance of enterprises operating in the Egyptian food industry market, particularly in the plant-based industry, thereby mitigating the negative effects of external crises. By examining these results, it was concluded that the Sudanese crisis, despite its negative impact on the performance of enterprises, has not had a tangible impact due to the continued flow of Sudanese exports to Egypt since the outbreak of the conflict in Sudan and due to the effectiveness and resilience of supply chains for enterprises operating in the food industry sector. The hypothesis about the impact of the Sudanese crisis on the performance of enterprises may be realized if it affects the flow of Sudanese exports that are difficult to obtain from other countries. The research recommends that food industry firms invest in building robust and adaptable supply chain resilience capabilities. This could include diversifying suppliers, enhancing logistics resilience, and adopting technologies that increase supply chain visibility and mobility. We encourage policymakers to bolster the food industry's resilience against external shocks by providing resources, incentives, and training. Future research should explore other potential drivers, such as government policy interventions and market adaptability, and assess the long-term impacts of resilience on firm performance across crises and industries.

References

[1] TUKAMUHABWA, B.R., STEVENSON, M., BUSBY, J., ZORZINI, M.: Supply chain resilience: definition, review and theoretical foundations for further study, *International Journal of Production Research*, Vol. 53, No. 18, pp. 5592-5623, 2015. https://doi.org/10.1080/00207543.2015.1037934

[2] FAGGIONI, F., ROSSI, M.V., SESTINO, A.: Conceptualizing supply chain resilience in exogenous crisis times: Toward a holistic definition, *Journal of the Knowledge Economy*, Vol. 15, pp. 17308-17332, 2024. https://doi.org/10.1007/s13132-024-01816-0

[3] CHOWDHURY, M.M.H., QUADDUS, M.: Supply chain readiness, response and recovery for resilience, *Supply Chain Management*, Vol. 21, No. 6, pp. 709-731, 2016. https://doi.org/10.1108/SCM-12-2015-0463

[4] PONOMAROV, S.Y., HOLCOMB, M.C.: Understanding the concept of supply chain resilience, *The International Journal of Logistics Management*, Vol. 20, No. 1, pp. 124-143, 2009. https://doi.org/10.1108/09574090910954873

[5] PONIS, S.T., KORONIS, E.: Supply chain resilience? Definition of concept and its formative elements, *The Journal of Applied Business Research*, Vol. 28, No. 5, pp. 921-935, 2012. https://doi.org/10.19030/jabr.v28i5.7234

[6] GAUDENZI, B., PELLEGRINO, R., CONFENTE, I.: Achieving supply chain resilience in an era of disruptions: A configuration approach of capacities and strategies, *Supply Chain Management: An International Journal*, Vol. 28, No. 7, pp. 97-111, 2023. http://dx.doi.org/10.1108/SCM-09-2022-0383

[7] MANNERS-BELL, J.: *Supply Chain Risk Management: Understanding Emerging Threats to Global Supply Chains*, London, Kogan Page Publishers, 2017.

[8] TEECE, D.J., PISANO, G., SHUEN, A.: Dynamic capabilities and strategic management, *Strategic Management Journal*, Vol. 18, No. 7, pp. 509-533, 1997.

[9] WINTER, S.G.: Understanding dynamic capabilities, *Strategic Management Journal*, Vol. 24, No. 10, pp. 991-995, 2003. https://doi.org/10.1002/smj.318

[10] SREEDEVI, R., SARANGA, H.: Uncertainty and supply chain risk: The moderating role of supply chain flexibility in risk mitigation, *International Journal of Production Economics*, Vol. 193, pp. 332-342, 2017. https://doi.org/10.1016/j.ijpe.2017.07.024

[11] STENTOFT, J., MIKKELSEN, O.S., WICKSTROM, K.A.: Supply chain resilience and absorptive capacity: Crisis mitigation and performance effects during Covid-19, *Supply Chain Management: An International Journal*, Vol. 28, No. 6, pp. 975-992, 2023. https://doi.org/10.1108/SCM-10-2022-0384

[12] ABEYSEKARA, N., WANG, H., KURUPPUARACHCHI, D.: Effect of supply-chain resilience on firm performance and competitive advantage: A study of the Sri Lankan apparel industry, *Business Process Management Journal*, Vol. 25, No. 7, pp. 1673-1695, 2019. https://doi.org/10.1108/BPMJ-09-2018-0241

[13] LIU, C.L., SHANG, K.C., LIRN, T.C., LAI, K.H., LUN, Y.V.: Supply chain resilience, firm performance, and management policies in the liner shipping industry, *Transportation Research Part A:*

Supply chain resilience as a mitigating factor for the impact of the Sudan Crisis on the performance of food manufacturing enterprises in Egypt
Selma Abdelrahim

Policy and Practice, Vol. 110, pp. 202-219, 2018. https://doi.org/10.1016/j.tra.2017.02.004

[14] TANG, C.S.: Perspectives in supply chain risk management, *International Journal of Production Economics*, Vol. 103, No. 2, pp. 451-488, 2006. https://doi.org/10.1016/j.ijpe.2005.12.006

[15] JAGTAP, S., TROLLMAN, H., TROLLMAN, F., GARCIA-GARCIA, G., PARRA-LÓPEZ, C., DUONG, L., MARTINDALE, W., MUNEKATA, P.E.S., LORENZO, J.M., HDAIFEH, A., HASSOUN, A., SALONITIS, K., AFY-SHARARAH, M.: The Russia-Ukraine conflict: Its implications for the global food supply chains, *Foods*, Vol. 11, No. 14, 2098, pp. 1-23, 2022. https://doi.org/10.3390/foods11142098

[16] NGOC, N.M., VIET, D.T., TIEN, N.H., HIEP, P.M., ANH, N.T., ANH, L.D.H., DUNG, V.T.P.: Russia-Ukraine war and risks to global supply chains, *International Journal of Mechanical Engineering*, Vol. 7, No. 6, pp. 633-640, 2022.

[17] ALLAM, Z., BIBRI, S.E., SHARPE, S.A.: The rising impacts of the COVID-19 pandemic and the Russia–Ukraine war: Energy transition, climate justice, global inequality, and supply chain disruption, *Resources*, Vol. 11, No. 11, 99, pp. 1-17, 2022. https://doi.org/10.3390/resources11110099

[18] World Atlas, (n.d.), Sudan geography, [Online], Available: https://www.worldatlas.com [10 Jan 2025], 2025.

[19] World Bank, Sudan agriculture value chain analysis, [Online], Available: https://documents1.worldbank.org/curated/en/731741593616746051/pdf/Sudan-Agriculture-Value-Chain-Analysis.pdf [10 Jan 2025], 2020.

[20] Central Bank of Sudan - Annual Trade and Financial Report for 2021, [Online], Available: https://cbos.gov.sd/en/periodicals-publications [11 Jan 2025], 2021.

[21] Pharos Studies: The repercussions of the war on the Sudanese economy and neighbouring countries, [Online], Available: https://pharosstudies.com [11 Jan 2025], 2023.

[22] Gulf Research Center: A year of conflict in Sudan: The impact on agricultural activity, [Online], Available: https://www.grc.net/documents/66323a29a3c49YearconflictSudan2.pd [11 Jan 2025], 2024.

[23] Famine Early Warning Systems Network: Sudan food security outlook: June 2024, [Online], Available: https://fews.net/east-africa/sudan/food-security-outlook/june-2024 [11 Jan 2025], 2024.

[24] SIDDIG, K., BASHEER, M.: We need to know the economic impacts of Sudan's ongoing conflict, *Nature Human Behaviour*, Vol. 8, pp. 1003-1004, 2024. https://doi.org/10.1038/s41562-024-01883-y

[25] Central Agency for Public Mobilization and Statistics: Trade exchange report between Egypt and the Nile Basin countries for 2022, [Online],

Available: https://www.capmas.gov.eg [11 Jan 2025], 2022.

[26] Arab Organization for Agricultural Development: Arab Agricultural Statistics Yearbook, Vol. 42, [Online], Available: https://www.aoad.org [11 Jan 2025], 2022.

[27] Central Bank of Sudan: Foreign Trade Statistical Digest (2004–2022), [Online], Available: https://cbos.gov.sd/en/periodicals-publications [11 Jan 2025], 2022.

[28] Sudan War Monitor: Sudan War Monitor Report, [Online], Available: https://sudanwarmonitor.com [11 Jan 2025], 2024.

[29] General organization for export and import control: Economic Bulletin of Egyptian Exports and Imports for 2021, [Online], Available: https://www.goeic.gov.eg/ar/news/default/view/id/728/title [12 Jan 2025], 2021.

[30] KREJCIE, R.V., MORGAN, D.W.: Determining sample size for research activities, *Educational and Psychological Measurement*, Vol. 30, pp. 607-610, 1970. https://doi.org/10.1177/001316447003000308

[31] HAIR, J.F., JR, HULT, G.M.T., RINGLE, C.M., SARSTEDT, M.: *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 2nd ed., SAGE Publications, 2017.

[32] HAIR, J.F., JR, SARSTEDT, M., HOPKINS, L., KUPPELWIESER, V.G.: Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research, *European Business Review*, Vol. 26, No. 2, pp. 106-121, 2014. http://dx.doi.org/10.1108/EBR-10-2013-0128

[33] SARSTEDT, M., RINGLE, C.M., HAIR, J.F.: A Primer on Partial Least Squares Structural Equation Modeling, In: Homburg, C., Klarmann, M., Vomberg, A. (eds) Handbook of Market Research, Springer, Cham., pp. 1-40, 2017. http://dx.doi.org/10.1007/978-3-319-05542-8_15-1

[34] XU, Z., ELOMRI, A., EL OMRI, A., KERBACHE, L., LIU, H.: The compounded effects of COVID-19 pandemic and desert locust outbreak on food security and food supply chain, *Sustainability*, Vol. 13, No. 3, 1063, pp. 1-17, 2021. https://doi.org/10.3390/su13031063

[35] BARAKAT, S., COCHRANE, L., VASEKHA, I.: The humanitarian-development-peace nexus for global food security: Responding to the climate crisis, conflict, and supply chain disruptions, *International Journal of Disaster Risk Reduction*, Vol. 98, 104106, 2023. https://doi.org/10.1016/j.ijdrr.2023.104106.

[36] AL-SAIDI, M., SAAD, S.A.G., ELAGIB, N.A.: COVID-19's perils for development and supply security in the Sahel, *Development and Sustainability*, Vol. 25, No. 7, pp. 6295-6318, 2023. https://doi.org/10.1007/s10668-022-02303-9

[37] WELANDER, J.O.: *Bad Neighbors, Conflict and Economic Growth: A qualitative analysis of the economic spillover effects of Sudan's intrastate*

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Selma Abdelrahim

conflict on Egypt's economic growth, Master's thesis, Lund University, School of Economics and Management, 2022.

[38] JÜTTNER, U., MAKLAN, S.: Supply chain resilience in the global financial crisis: An empirical study, *Supply Chain Management: An International Journal*, Vol. 16, No. 4, pp. 246-259, 2011. https://doi.org/10.1108/13598541111139062

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