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Perceived business risks and observed impacts of the Russian-Ukraine war among small- and medium-sized agri-food value chain enterprises in Egypt

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ABSTRACT

We examine the perceived business risks and impacts on performance associated with the Russian aggression in Ukraine in February 2022 among 450 Egyptian small and medium-sized agrifood enterprises. Our analysis identifies six distinct clusters of enterprises based on their perceived risks and three clusters based on the observed impacts of the war. We find a strong association between perceived business risks and observed impacts, suggesting that the risks identified by agrifood SMEs significantly influence their actual business performance. This underscores the importance of understanding and effectively managing perceived risks to mitigate the negative impacts of external shocks, enhance operational resilience, and improve overall performance. Moreover, the results indicate that the consequences of the war extend beyond direct effects on agrifood enterprises, affecting various stages of the agrifood chain. This implies that, in times of crisis, the absence of a well-functioning agrifood SME sector may threaten the sustainability of the entire agrifood value chain. These insights contribute to a more comprehensive understanding of the experiences of agrifood SMEs during the early stages of the war, helping policymakers and enterprises prioritize risk management strategies and allocate resources effectively to enhance performance and competitiveness in times of crisis.

1. Introduction

Russia's aggression in Ukraine has, since its onset on 24 February 2022, emerged as an additional shock that intensified the pressures on already-fragile agrifood value chains in Low- and Middle-Income Countries (LMICs) (Abu Hatab, 2022). Especially, this is because the aggression erupted when these countries were still grappling with the consequences of the COVID-19 pandemic, which had already strained various elements of food supply chains from production to consumption (FAO, 2022a). While Russia and Ukraine are key players in the international market for agrifood commodities, collectively accounting for around 12 % of traded calories worldwide, many LMICs, particularly in the Middle East, rely heavily on agrifood imports from the two countries to meet the demands of their domestic markets (FAO, 2022b). Russia's significant role as a major exporter of energy products has also resulted in a surge in oil prices that triggered ripple effects on various activities across agrifood value chains in LMICs, including the cost of fuel consumption for agricultural machinery and operation of production facilities, electricity uses in irrigation, and energy requirements for downstream processes such as cooling, processing, transportation, and distribution of food products. In addition, the active fighting has inflicted damage on inland transport infrastructure, seaports, and storage and processing facilities in Ukraine, which disrupted commercial shipping operations in their ports, leading to increased costs for transportation and higher insurance premiums for vessels sailing into the Black Sea (Abu Hatab, 2022). Hence, the effects of the Russia-Ukraine war have pushed food production costs in LMICs significantly higher, causing inflation in food prices and fluctuations in consumer demand, and posing significant threats to food security and poverty levels (Barrett, 2020; FAO, 2022b).

Previous studies in LMICs' agrifood value chains show that downstream stages of the agrifood chain have been more severely impacted by the effects of recent shocks (e.g. the COVID-19 pandemic) compared to the upstream stages (Lu et al., 2020; Abu Hatab et al., 2023). In this regard, small- and medium-sized agrifood enterprises (agrifood SMEs) are particularly susceptible to the risks presented by external shocks, affecting not only their day-to-day operations but also endangering their organizational survival (Fei et al., 2020). Lu et al. (2020) attribute such

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heightened vulnerability to agrifood SMEs' size, lower productivity, weaker financial structure, and reduced profitability. Furthermore, the informality of many of their businesses often leads to their exclusion from government stimulus plans aimed at supporting enterprises during times of crisis (Jola-Sanchez, 2020).

The global repercussions of Russia's war on Ukraine have brought the resilience of agrifood supply chains into focus, raising important questions about their ability to recover and improve in the face of crises (Monsalve Suárez & Dreger, 2022). There is growing interest in understanding how agrifood value chains can be transformed to promote crisis prevention and response, adapt to new challenges, and ensure sustainable access to nutritious food in the long run (Hall, 2023). Studies that explored the impact of the Russian aggression in Ukraine on agrifood value have focused on the effects of the war on agricultural inputs and food production (e.g. Shahini et al., 2022), regional agrifood trade (e.g. Feng et al., 2023), as well as on food security and consumption patterns (Lin et al., 2023; Behnassi & El Haiba, 2022). However, there remains a dearth of research examining the specific effects of the war on various downstream stages and actors within agrifood value chains, with a particular gap in understanding the consequences for agrifood SMEs. Especially in the context of LMICs, no study – to the best of our knowledge- has yet been conducted to investigate the business risks arising from the war and the actual impacts experienced by agrifood SMEs due to this conflict. Such research is important considering the crucial role of agrifood SMEs in the socioeconomic fabric of LMICs, fostering economic growth, accounting for more than 90 % of business, facilitating agricultural trade, generating up to 60 % of employment, and contributing to livelihoods and food security in these countries (World Bank, 2023).

In light of this context, the present study aims to examine the factors that influence the perception of business risks associated with the Russia-Ukraine war among agrifood SMEs in LMICs, as well as to examine how the perceived business risks relate to experienced impacts on their business performance. The empirical analysis draws on a sample of 450 Egyptian agrifood SMEs, employing fewer than 100 workers and being officially registered and authorized to operate in both domestic and international agrifood markets. The main contribution of this study lies in its unique approach to analyzing perceived business risks and connecting them to observed impacts, which distinguishes it from other studies that have typically concentrated solely on either: risk perception (e.g., Abu Hatab et al., 2021; Poon and Tung, 2023); observed business impacts and mitigation strategies (e.g. Chowdhury et al., 2020; Nordhagen et al., 2021; Xie et al., 2023), or have addressed both of them separately in independent analyses (e.g. Abu Hatab et al., 2023). In this study, we first cluster the surveyed agrifood SMEs according to their perceived business risks. We then examine the conditional relationship between these perceived risks' clusters and agrifood SMEs' firm and market characteristics. Following that, we segment the surveyed enterprises based on the business impacts resulting from the war. Finally, we investigate the relationship between the clustering of experienced business impacts and the clustering of perceived business risks. By bridging the "risk-impact" gap, the study contributes to a more comprehensive understanding of the experiences of agrifood SMEs during the early stages of the war, which can enable these enterprises to better prioritize risk management strategies and allocate resources effectively to mitigate risks, minimize negative impacts, and seize opportunities, thereby enhancing their overall performance and competitiveness in dynamic and uncertain environments.

Second, the study adds to the growing body of research on food supply chain resilience in LMICs, particularly in light of the increasing frequency and severity of exogenous shocks faced by these countries. The Russian aggression in Ukraine offers a distinctive case of an exogenous shock and an unforeseen event that was not instigated in an LMIC marketor or driven by agrifood market dynamics, yet substantially impacting agrifood value chains in LMICs (Miklian & Hoelscher, 2022). Additionally, the geopolitical nature of the conflict brought about unique uncertainty and unpredictability for agrifood SMEs, setting it apart from other shocks (e.g. the COVID-19 pandemic or climate shocks). This has rendered it difficult for agrifood SMEs to anticipate, absorb, and adapt to the changes that the war posed to agrifood SMEs' business environment and market conditions. For instance, while climate-related shocks typically affect specific regions or crops, the invasion has widespread and immediate consequences across multiple regions and food supply chains. Furthermore, unlike the COVID-19 pandemic, which primarily disrupted supply chains through lockdown measures and labor shortages, the invasion of Ukraine led to trade sanctions, export restrictions, infrastructure damage, and disruptions in trade routes. Therefore, the Russia-Ukraine conflict presents a unique and complex shock to agrifood SMEs and associated actors in LMICs' food supply chains, underscoring the importance of understanding how agrifood SMEs perceive business risks and experience business impacts to inform evidence-based decision-making and the design of targeted interventions and support mechanisms to enhance the resilience and sustainability of agrifood SMEs. The failure of LMICs' agrifood SMEs to absorb and effectively respond to the consequences of this shock not only threatens their own performance but also carries the potential for economy-wide ramifications, including disruptions in agricultural product flow, food price inflation, food insecurity, and even sociopolitical unrest (IFPRI, 2023).

2. Egyptian agrifood SMEs under exogenous shocks and study approach

The Egyptian agrifood SMEs' sector mirrors many of the challenges encountered by many other LMICs when dealing with exogenous shocks, due to several factors. First, akin to most LMICs, agrifood SMEs form a significant portion of the agricultural economy in Egypt: comprising nearly 90 % of agrifood production and export firms, generating over 90 % of employment in the food system, and exporting around three-quarters of the country's agrifood commodities (EAAE (Egyptian Association of Agricultural Economics), 2020). Second, similar to many other LMICs, Egypt's agrifood SMEs often operate within fragile economic environments marked by limited access to capital, inadequate infrastructure, and regulatory complexities, making them particularly vulnerable to external shocks (Abu Hatab et al., 2021). For instance, evidence from the recent COVID-19 pandemic indicates that Egyptian agrifood SMEs were notably more susceptible to the impacts of the pandemic compared to other enterprise categories, due to their low productivity, constrained financial resources, fragile financial structure, the small-scale of their businesses, and the informality of many of their activities (Zaazou and Salman Abdou, 2022; El-Naggar & El-Sayed, 2023). Third, the business performance and survival of Egyptian agrifood SMEs greatly depends on several external factors, such as global market prices, trade agreements, and geopolitical events, which can significantly impact their stability and resilience. In connection with this, Egypt's geographical location in North Africa positions it as a gateway between Africa, the Middle East, and Europe, exposing its agrifood sector to a wide range of geopolitical and economic influences. Therefore, the risks posed by the Russia-Ukraine war on Egyptian agrifood SMEs are anticipated to reverberate, potentially affecting the livelihoods and food security of the poor, whose well-being relies largely on the functioning of agrifood value chains. Furthermore, Egypt's large population and growing demand for food imports place additional pressure on its agrifood SME sector, which is responsible for around 60 % of agrifood trade in- and out-flows, to adapt and respond to external shocks effectively. Hence, the Egyptian agrifood SMEs' sector provides a representative case of other LMICs' agrifood SMEs, and thus the results of this study provide valuable insights applicable to other LMICs facing comparable challenges.

Turning to the study approach, while uncertainty is inherent in any supply chain, the perception and management of risks have been extensively discussed in organizational theory and agribusiness

literature, backed by a history of theoretical frameworks and empirical studies (e.g. Barry, 1984; Cummings & Wilson, 2003; Hardaker et al., 2015). In general, the existing literature highlights that agrifood SMEs in LMICs confront various exogenous shocks, including risks posed by economic crises, natural disasters, climate change and environmental degradation, pest and disease outbreaks, and armed conflicts (Hamilton et al., 2020; Shiferaw & Apfalter, 2022). Their vulnerabilities to these risks are further compounded by structural weaknesses and limited frameworks that support their effective response to such shocks (ILO, 2021). Although risk perception and management has been a frequent topic in organizational theory, there have been few empirical investigations into how SMEs in the context of LMICs perceive and manage risks from exogenous shocks and extreme events, and the underlying mechanisms that contribute to SMEs' resilience (Bhamra et al., 2011, Sopha et al., 2020).

Risk identification and perception represent the first step in formulating effective strategies for supply chain resilience (Koh et al., 2006). Previous research has provided insights into the factors that influence how agrifood SMEs respond to immediate and foreseen changes in the face of various disruptions, which include organizational characteristics, risk-averse infrastructure, resource reconfiguration capabilities, proactive risk management, and enterprise networks (Abu Hatab et al., 2021; Parker & Ameen, 2018). Furthermore, Miklian & Hoelscher (2022) emphasize that the vulnerability and impact of shocks on SMEs are contingent upon business attributes (size, age, management capabilities, organization, experience, and sector), crisis nature (political, financial, social, conflict, disaster, and pandemic), and response nature (reactive, proactive, strategic, instinctive, pivoting, and networking).

In the present study, we adopt a resource-based perspective to examine the perceived business risks and observed impacts of the Russia-Ukraine conflict on the business activities and performance of the surveyed agrifood SMEs. Specifically, we focus on their financial, physical, human, and organizational assets, which may determine their perceived risks and observed impacts arising from the conflict. Drawing on Helfat & Lieberman (2002), a resource-based approach proves valuable in analyzing risk perception and observed impacts, as the organizational capacity of agrifood SMEs to mobilize resources and mitigate risks relies on their resource base, which, in turn, influences their capacity to implement proactive and effective responses to risks while capitalizing on emerging opportunities.

3. Data

3.1. Participants and data collection

The 450 enterprises included in our survey were randomly selected from agrifood SMEs that are registered in Egypt, have fewer than 100 workers, and operate in both domestic and international agrifood markets. A statistical power analysis showed that this sample size is robust enough to provide reliable insights and detect meaningful effects and relationships within the data and support generalizable conclusions. In comparison to similar studies conducted with Egyptian agrifood enterprises (e.g., Abu Hatab et al., 2019; Hassan, 2016; Abu Hatab et al., 2021), the sample size used in this study is significantly larger.

While there is no universally agreed-upon definition of agrifood SMEs in Egypt, we utilized sampling criteria that have been applied in several recent studies, including those by Abu Hatab et al. (2021) and Zaazou and Salman Abdou (2022). These criteria offer a practical framework for identifying and classifying agrifood SMEs, thereby ensuring consistency and comparability across studies within the field (Abu Hatab et al. 2023). Previous research on agrifood SMEs in Egypt has shown that the perception of risks, as well as their management strategies, can significantly differ across geographic locations of the agrifood SMEs (e.g. Abu Hatab et al., 2021; Zaazou and Salman Abdou, 2022). Therefore, the sampling was done with one group consisting of enterprises located in "old lands" along the Nile Delta, which follow conventional farming practices and tend to have lower export-to-total sales ratios. The second group comprises enterprises situated in "new lands" reclaimed in the desert, which are more focused on exports, and hold certifications for food quality standards. To capture this variation, we conducted our survey in six areas, including three areas in the "old lands" (Sharkia, Dakahlia, and Beni Suief) and three areas in the "new lands" (Fayoum, Nubaria, and Behaira), with an equal representation of 75 enterprises in each area, to ensure adequate representation of the target population and mitigate sample selection bias.

While our selection of "formally" registered agrifood SMEs excludes "informal" enterprises, this approach was intentional to ensure data reliability and comparability. Additionally, the dynamics, regulations, and challenges faced by the formal agrifood SMEs sector in Egypt are distinct and therefore require targeted analysis to provide relevant and actionable recommendations to stakeholders and policymakers. Furthermore, our sampling approach was designed to capture the heterogeneity of the Egyptian agrifood SME sector by including a variety of enterprise profiles, such as different sub-sectors (e.g., production, processing, and trade), geographic locations, and sizes. To validate the representativeness of our sample, we compared the characteristics of our sampled agrifood enterprises with national agricultural census data and reports from relevant Egyptian authorities, such as the Central Agency for Public Mobilization and Statistics (CAPMAS). Our findings indicate that our sample closely mirrors the broader distribution of SMEs in the agricultural sector in terms of size, sub-sector distribution, and regional presence.

Data collection was based on a questionnaire developed by the research team, which was translated into Arabic and reviewed by local experts from academia, export organizations, and branches of the Ministry of Agriculture and Land Reclamation in the designated areas. A pretest of the questionnaire was administered to three selected agrifood SMEs in each area to assess question appropriateness, logical flow, and respondent comprehension. The pilot study influenced the refinement of the final questionnaire, which comprised both structured and open-ended questions (Supplementary Material). The final questionnaire was divided into three main sections. The first section focused on gathering background information about the agrifood SMEs and their operators. The second section aimed to capture the perceived risks of the Russia-Ukraine war on the agrifood SMEs' business operations. The third section collected information on the observed impacts of the war on the business performance of agrifood SMEs.

The field survey took place between July and August 2022. Each interview lasted between 30 and 45 min. Before starting the interviews, respondents were provided with a brief introduction to the study objectives and asked for their consent to participate. Face-to-face interviews were conducted by skilled enumerators from partner universities in Egypt with founders, managers, or key staff who held decision-making positions within the surveyed agrifood SMEs. The majority of respondents (76 %) were male, and approximately half of them fell within the age range of 40 to 50 years. Around 60 % of the participants had held their current management positions for more than 5 years. A half of the respondents had completed secondary education, 28 % had finished middle school, 19 % had obtained university or postgraduate degrees, and the remaining 2 % had completed primary education.

3.2. Characteristics of the sample agrifood SMEs

The surveyed enterprises demonstrate a diverse range of roles and positions within both the domestic and export value chains of agrifood commodities. These positions are influenced by factors related to their background characteristics, value-adding activities, and market and product specialization. Table A1 in the Appendix A provides summary statistics of the main characteristics of the surveyed enterprises.

Fig. 1 (right) shows that the European Union (EU) serves as the main destination for agrifood commodities exported by the surveyed

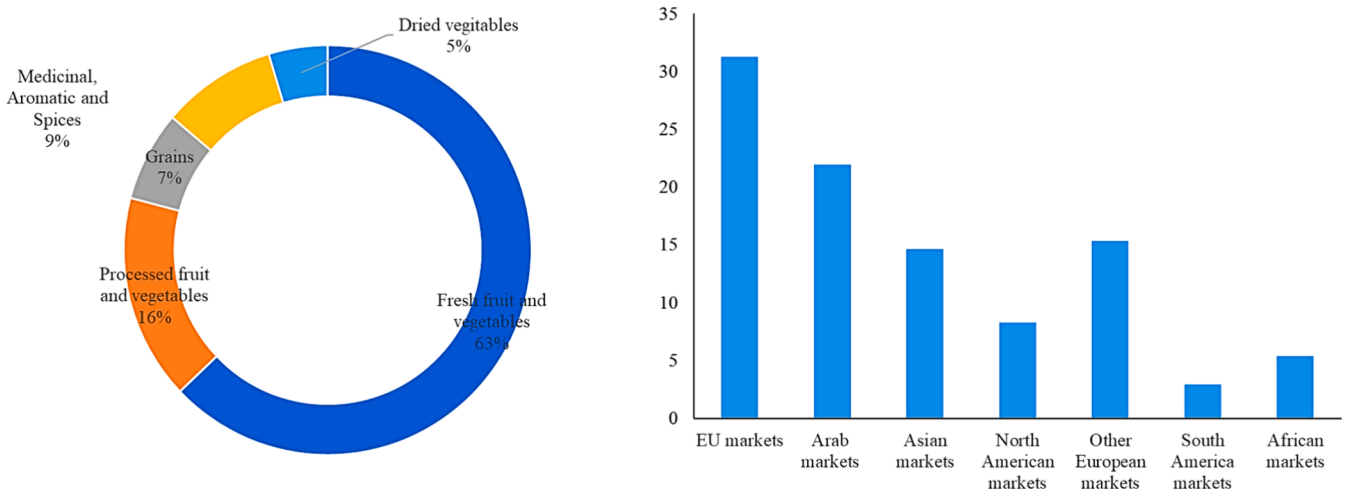

Fig. 1. Product and market specialization of the surveyed agrifood SMEs (% of the sample).

enterprises, with around a third of the sample enterprises shipping their exports to EU markets. Approximately 20 % of the surveyed enterprises reported Arab countries, particularly Saudi Arabia and the United Arab Emirates, as their main export market. Around 15 % identified other European countries outside the EU as their primary export destination, making Europe the main destination for 46 % of the sample enterprises.

Notably, approximately 60 % of the surveyed agrifood SMEs export to Russia and/or Ukraine, with around 30 % considering either Russia or Ukraine as a main export destination. About 30 % of the surveyed enterprises export to other destinations in Asia, the Americas, and Africa. While the majority of the surveyed enterprises are export-oriented, directing around 70 % of their total sales to export markets, a third of them also allocate a portion of their sales to the domestic market. While the Russia-Ukraine conflict has led to significant disruptions in global agrifood supply chains, impacting all agrifood enterprises regardless of their specific export orientation or import markets, the market distribution of our surveyed agrifood SMEs is expected to effectively capture the diverse ways in which the conflict has affected these businesses. For instance, enterprises that do not export directly to Russia, Ukraine, or even the EU are still affected by the conflict through indirect channels, such as shifts in global demand and supply chains, increased competition in other markets, and changes in trade policies. In addition, enterprises not directly exporting to Russia or Ukraine face challenges related to increased shipping costs, transportation delays, and uncertainties in global markets.

The surveyed enterprises specialize in various agricultural or food products, with a focus on producing high-quality commodities to meet the specific market demands and consumer preferences in importing markets (Fig. 1, left). This explains the importance they place on obtaining quality certifications to comply with food safety and quality standards, which represent a key determinant of their competitiveness in the international agrifood commodity markets. Around 90 % of the surveyed enterprises reported being certified for one or more certification standards, primarily GlobalGAP, HACCAP, ISO9001, or ISO22000. Approximately 37 % of the enterprises practice vertical integration, engaging in both the production and sale of their own agrifood commodities either domestically or internationally or both. This allows them to have greater control over the supply chain, ensuring quality, efficiency, and potentially capturing a larger share of the value chain. Around 32 % of the surveyed enterprises practice external integration by sourcing agrifood commodities from external suppliers, such as other agrifood SMEs or farmers, and exporting them to the global market. The remaining third of the sample practices extended supply chain integration, which combines both external and vertical integration activities.

4. Methods

The empirical analysis of the perceived business risk and the observed impacts of the Russia-Ukraine war on the surveyed agrifood SMEs involved the following sequential steps:

4.1. Measuring perceived business risks

To assess perceived business risks by the surveyed agrifood SMEs, 28 items were included in the survey (Table A3 in the Appendix A). The 28 items were carefully selected based on a thorough review of the relevant literature on the impacts of the Ukraine-Russia war on agricultural sectors and agrifood SMEs in LMICs. The extant literature has identified supply chains organization and functioning, cost of production, sales and market demand, labor, and institutional and financial policies as the main sources of business risks (FAO, 2022a; FAO, 2022b; Abu Hatab, 2022; Feng et al., 2023; Gebeltová et al., 2023). Indeed, the extent of these risk-sources on a particular SME's is dependent on its role in the agribusiness value chain (Bacchetta et al., 2021; Abu Hatab et al., 2023). Consultations with local experts and stakeholders were conducted to ensure the relevance of the 28 items to the specific context of study (Egyptian agrifood SMEs) and that each item added unique value to the analysis. Furthermore, as part of the pre-analysis, we conducted a correlation analysis among the risk items to identify any significant correlations that might lead to redundancy or inflation of perceived risks. The results indicated that while some items exhibited moderate correlations, the majority were sufficiently distinct to warrant their inclusion as separate risk sources.

Perceived business risks were assessed by integrating a temporal dimension (*i.e.*, delay or immediacy of impact) into the traditional risk perception model (*i.e.*, severity and likelihood of exposure) (Lagerkvist et al., 2013; Abu Hatab et al., 2021). Respondents assessed 28 items from a tabular format (see the Supplementary Material). Specifically, they were asked: "*Review the following possible issues to your business in relation to the ongoing war and give your most honest opinion on their potential impacts on your farm business as well as on how likely you expect these issues are to occur in the short to long run*".

- Severity: "How severe is the impact of this issue on your enterprise's performance?" "minimal impact" (1), "small but noticeable" (2), "high" (3), "severe" (4), and "very severe" (5).
- Likelihood: "What do you think the likelihood is that your enterprise will be affected this issue?": "very unlikely" (1), "quite unlikely" (2), "neither likely or unlikely" (3), "quite likely" (4), "very likely" (5).

- Immediacy of impact: “in 1–2 years from now” (1), “in 6–12 months from now” (2), “in 3–6 months from now” (3), “now or soon (within 3 months)” (4).

For each item (i) and allowing for interaction among the three dimensions, the perceived risk was calculated as $r_i = (s_i \times l_i \times i_i)$ with a per-item risk score on the interval [1, 100].

4.2. Agrifood SMEs' segmentation based on perceived business risks

K-means clustering was used to identify clusters of agrifood SMEs sharing the maximal similarities in terms of perceived business risks within each cluster and with maximal dissimilarities between clusters. The clustering was performed using standardized data at each item (mean = 0, SD=1) because the underlying data were on the same measurement range. The analysis used the R package ‘factoextra v1.0.7′ in combination with the R package ‘cluster v2.1.4′ (Maechler et al., 2022) within the R network package (R Core Team, 2021). To determine the optimal numbers of clusters, we compared two approaches: (i) the number of clusters vs the total within sum of squares, and (ii) the number of cluster vs the gap statistic (Tibshirani et al., 2001). The calculation of the gap statistics was based on 50 Monte Carlo (bootstrap) samples.

4.3. Examining the relationship between company characteristics and clustering by perceived business risks

A nonparametric recursive partitioning approach, based on ordinal regression (see Hothorn et al., 2006 for details), was used to examine the conditional relationship between the set of 18 company and market characteristics of the agrifood SMEs and the cluster membership associated with the perceived business risks. Appendix A Table A2 provides detailed information and summary statistics for the 18 variables used in this analysis. The company-related variables include the geographic distribution of enterprises, evenly split across six regions; the type of business, categorized by the source of exported commodities (own farms, a combination of own and other farms, or other farms); the level of experience in the agrifood business; the size of the firm, measured by the total number of employees; the total assets of the enterprise; certification status for quality standards; membership status in agrifood associations; the existence of a dedicated department for risk management; and the presence of an internal strategy for risk management. The market and sales-related variables include the total value of SME sales; the production or export system (conventional, organic, or mixed); the business's position in terms of downstream or upstream activities; the primary export markets of the enterprise (with three variables representing the top three markets); export status to Russia or Ukraine; primary export market status for Russia or Ukraine; and the product specialization of the enterprise (e.g., fresh fruit and vegetables, medicinal aromatics and spices, grains, dried vegetables, or other products, including processed fruit and vegetables).

In the ordinal regression model, following Hothorn et al. (2015), the ordinal response variables are measured at J levels and associated with score vectors $\xi \in \mathbb{R}$á¶. In contrast, the ordinal covariates are measured at K levels and associated with score vectors $\gamma \in \mathbb{R}$á·. Those scores represent the “distances” between the levels: If the variable is derived from an underlying continuous variable, the scores can be chosen as the midpoints of the intervals defining the levels. The linear statistic becomes a linear combination of the linear statistic Tâ ± ¼ of the form

$$MT_j(L_n, w) = vec\left(\sum_{i=1}^{n} wáµ¢\gamma^T g_j(X_{ji})\left(\xi^T h\left(Y_i, \left(Y^1, \cdots, Y_n\right)\right)\right)^T\right) \quad (1)$$

with $g_j(x) = e_K(x)$ and $h\left(Y_i, \left(Y^1, \cdots, Y_n\right)\right) = e_J(Y_i)$. If both response and covariate are ordinal, the matrix of coefficients is given by the Kronecker product of both score vectors $M = \xi \otimes \gamma \in \mathbb{R}^{1,KJ}$. In case the response is ordinal only, the matrix of coefficients M is a block matrix

$$M = \begin{pmatrix} \xi 1 & 0 \\ \ddots & \\ 0 & \xi 1 \end{pmatrix} |\cdots| \begin{pmatrix} \xi q & 0 \\ \ddots & \\ 0 & \xi q \end{pmatrix} \text{ or } .M = diag(\gamma)$$

when one covariate is ordered but the response is not. In this study, for both Y and X_j being ordinal, the corresponding test is known as linear-by-linear association test (Agresti 2002).

Aiming to detect sub-groups of agrifood SMEs by accounting for distributional properties for the explanatory variables, the partitioning of the space of explanatory variables proceed in three steps. First, for variable selection a global null hypothesis that there is no relationship between any of the explanatory variables and the dependent variable is tested through a permutation tests procedure using Bonferroni adjusted p-values to allow for an unbiased variable selection (the algorithm stops in case no violation is found). If the null hypothesis is not supported, the explanatory variable with the largest association with the dependent variable (lowest p-value) is chosen for a binary split. Second, the optimal cut point for the split is determined, again through permutation tests, and the sample is divided into two subgroups based on the exploratory variable selected in step 1). The algorithm then recursively repeats step 1 and step 2 until no further statistically significant splits can be identified. One advantage of this tree-based data-driven method is that it automatically performs variable selection, which means that some covariates may not be involved in any dataset split. Hereby, this method is unbiased in the identification of those explanatory variables with the highest relevance and the largest explanatory power in statistical terms. This approach has recently been utilized for applications in the business literature such as consumer branding (Schivinski, 2021) and technology transfer (Guerzoni et al., 2021), as well as in the agribusiness literature, such as examining risk perception among agrifood SMEs during the COVID-19 pandemic (Abu Hatab et al., 2021). To estimate the recursive partitioning model, we utilized the CTree module within the R package partykit v.1.2–16 (Hothorn & Zeileis, 2015), which was implemented in R (R Core Team, 2021). All significance tests were performed using a nominal significance level of 0.05.

4.4. Agrifood SMEs' segmentation based on experienced business impacts

Seven statements were used to measure the extent of impact that the agrifood SMEs may have experienced as a result from the war. The statements covered: (1) total revenues, (2) cost and availability of raw materials and inputs (3) agrifood SMEs' operating costs, (4) incidents of delayed, or (5) rejected consignments, (6) cash flow coverage for sustaining the enterprise's operation, and (7) staff-layoffs implemented or under consideration (see Table A 4 in the Appendix A). These statements were set to capture changes between the data collection month (July 2022) and the same month one year prior (July 2021). Existing research has revealed that market shocks and extreme events are often channeled to agrifood SMEs through effects on supply chain organization, production and operation costs, consumer demand and sales, human resources, and financial capacity (e.g. Cowling et al., 2015; Apostolopoulos et al., 2021; Varum & Rocha, 2013). Previous studies have also attributed the realized extent of such shocks on agrifood SMEs to a suite of factors relating to organizational and firm-specific characteristics as well as management strategies, which collectively determine both observed impacts and post-crisis recovery (e.g. Sullivan-Taylor & Branicki, 2011; Sopha et al., 2020).

Following Ezugwu et al. (2022), hierarchical two-step clustering was used to identify clusters of agrifood SMEs sharing the maximal similarities in terms of business risks within each cluster and with maximal dissimilarities between clusters. Items responses were first recoded using a range distance transformation (z_i = [x-min(x)]/[max(x)-min(x)] (i = 1,….7) because the range of item scorings differed (Milligan & Cooper, 1988). The selection of numbers of clusters was based on the ratio of change in the Schwarz's Bayesian Criterion (BIC) and with the

ratio of distance measure. The model was estimated in IBM SPSS v.28.

4.5. Examining the sub-group relationship between experienced business impacts and the perceived business risks

As the final step in our analysis, we use the conditional inference approach (Hothorn et al., 2006) to examine the relationship between the clustering for experienced business impacts as response variable using the (indicator coded) clusters for perceived business risks as explanatory variables.

5. Results

5.1. Perceived business risks

Table A3 in the Appendix A presents average risk scores for each of the 28 items by the six clusters identified. The cluster analysis explained 53 % of the total variance. As shown in Table A3, agrifood enterprises belonging to Cluster 1, denoted *Cost-Driven Risk Cluster* (n = 45, 10 % of the sample), primarily perceived risks associated with increased costs in their business activities. These encompassed increased shipping charges due to the war, which rendered conventional shipping routes riskier or inaccessible (r3), heightened costs incurred by utilizing alternative modes of transportation (r5), and increased expenses related to transitioning exports to alternative or new markets, such as establishing fresh contracts and implementing marketing campaigns (r13). Another aspect of the perceived business risks relates to the reduced competitiveness of cluster members due to increased instability in foreign exchange rates, which leads to higher export prices compared to other exporters in the importing markets (r22).

Cluster 2 of the agrifood SMEs, labelled "*Market Dynamics-driven Risk Cluster*", comprises 96 enterprises, representing 21 % of the sample. Members of this cluster were characterized by the diverse nature of the perceived business risks, particularly those associated with changes in demand and access to importing markets. Agrifood SMEs in this cluster voiced concerns about the decline in foreign demand for their agrifood exports due to the anticipated impact of the conflict on their market access (r1 and r25). Notably, they also expressed concerns about the war's potential effect on global prices of products with complementary relationships to their own exports (e.g. cooking oil and potatoes), which could decrease foreign demand for their agrifood commodities (r16). Furthermore, these enterprises perceived significant risks arising from financial measures and trade sanctions imposed on and by Russia, posing a threat to the smooth flow of their agrifood exports to importing markets (r9). In connection with the geopolitical environment shaped by the war, members of Cluster 2 also highlighted risks related to the logistics and infrastructure, including the inability to deliver existing orders due to the blockage of shipping routes (r2 and r10), as well as the potential loss of commodities due to delays in ports lacking adequate cooling and storage facilities (r18).

When comparing Cluster 1and Cluster 2 to the clusters from Cluster 3 to Cluster 6, it is evident that agrifood SMEs in the latter clusters perceive fewer risks both in terms of the number and diversity. However, a distinctive feature of members in Cluster 3 (n = 102, 23 % of the sample) is that they perceive most of the risks related to Clusters 1 and 2, albeit to a lesser extent. Thus, this cluster can be labeled as the "*Cost- and Market Dynamics-driven Risk Cluster*".

Moving on to Cluster 4 (n = 42, 9 % of the sample), the results indicate that members of this cluster perceive higher risks resulting from the interplay between the risks posed by the Russia-Ukraine war, other global shocks, and domestic financial and economic challenges. Specifically, the most notable perceived business risks among members of Cluster 4 were that the war exacerbates the challenges they already face due to the current economic slowdown in Egypt (r29) and environmentally induced challenges (e.g., adverse weather conditions) (r26), and the potential setback to their recovery from the consequences of the COVID-19 pandemic (r28). This cluster can be identified as "*Interlinked Multi-Crisis Risk Cluster*".

Cluster 5, consisting of 66 agrifood SMEs (15 % of the sample), can be labeled as the "Contractual Commitments and Trade Partner Risks Cluster". This label highlights the key risks perceived by its member agrifood SMEs, which are primarily related to their trade agreements and transactions with trading partners in the importing markets. The members of this cluster expressed concerns about the failure to fulfill contracted sales (r20), delays in port operations affecting export quality and causing rejections (r19), delays in purchasing and reduced collection of receivables (c12), and potential financial implications arising from importers' preference to pay in currencies other than USD, which may lead to financial consequences such as a shortage of USD needed for our input imports (r14).

Cluster 6, consisting of 99 agrifood SMEs (22 % of the sample) experienced fewer and lower level of perceived business risks compared to other clusters. However, one unique concern among members of this cluster, not prevalent in the other clusters, was the potential risk of cypher attacks or disruptions to communication channels, which could adversely affect shipments and deadlines with Russian and other foreign European importing partners. The cluster was thus denoted "Cybersecurity and Communication Risk Cluster".

5.2. The relationship between clusters of perceived business risks and agrifood SMEs' characteristics

Fig. 2 displays the results of the recursive partitioning model for the relationship between the identified 6 clusters of the surveyed agrifood SMEs based on their perceived business risks and the characteristics of enterprises. The results reveal that the main market for exported agrifood commodities was the most determining explanatory variable. Specifically, the main export market was split into agrifood SMEs that primarily export to the EU and other European countries (left part of Fig. 2), and those exporting to other destinations such as Arab, African, Asian, and North and South American countries (right part). For agrifood SMEs exporting to Europe, additional significant splits into subsamples are observed, with the geographic location of the enterprises serving as the next significant determinant that divides the sample into two categories. One category includes enterprises situated in newly reclaimed land in *Fayoum* and the desert area in *Nubaria* and *Behaira*, corresponding to "Node 3" and comprising a subsample of 96 agrifood SMEs. Risks perceived by members of this sub-category are primarily relevant to Cluster 3 of the surveyed agrifood SMEs. The other subcategory comprises enterprises primarily located in old lands in the Nile delta and the valley (*Sharkia*, *Dakahlia*, and *Beni Suief*). This latter sub-sample is further divided based on the enterprise's experience in the agrifood export business, measured by the number of years of operation. The first is associated with "Node 5" and encompasses 41 agrifood enterprises with either a short (5–10 years) or long (over 20 years) experience in the business. The perceived risks by members of this category are mostly relevant to Cluster 1 of the surveyed enterprises (*Cost-Driven Risks' Cluster*). The other category is related to "Node 6", comprises 60 agrifood SMEs, and includes agrifood enterprises with medium experience in the business ranging from 10 to 20 years. The perceived risks by members of this category are mostly relevant to Cluster 2 (*Market Dynamics-driven Risks Cluster*).

Moving to the second subset of the sample, resulting from the first split based on the main export market, the results reveal that it can be further divided into two subsamples based on whether Russia or Ukraine serves as the main destination for agrifood SMEs' exports. Having either of these two countries as the main export market divides the subsample into two additional categories based on their other main export markets. One category forms a unique subgroup with the EU, Arab countries, and other markets, while the second category includes Asian, African, American, and other European countries. Once again, the geographic location proves to be a significant variable that further splits the

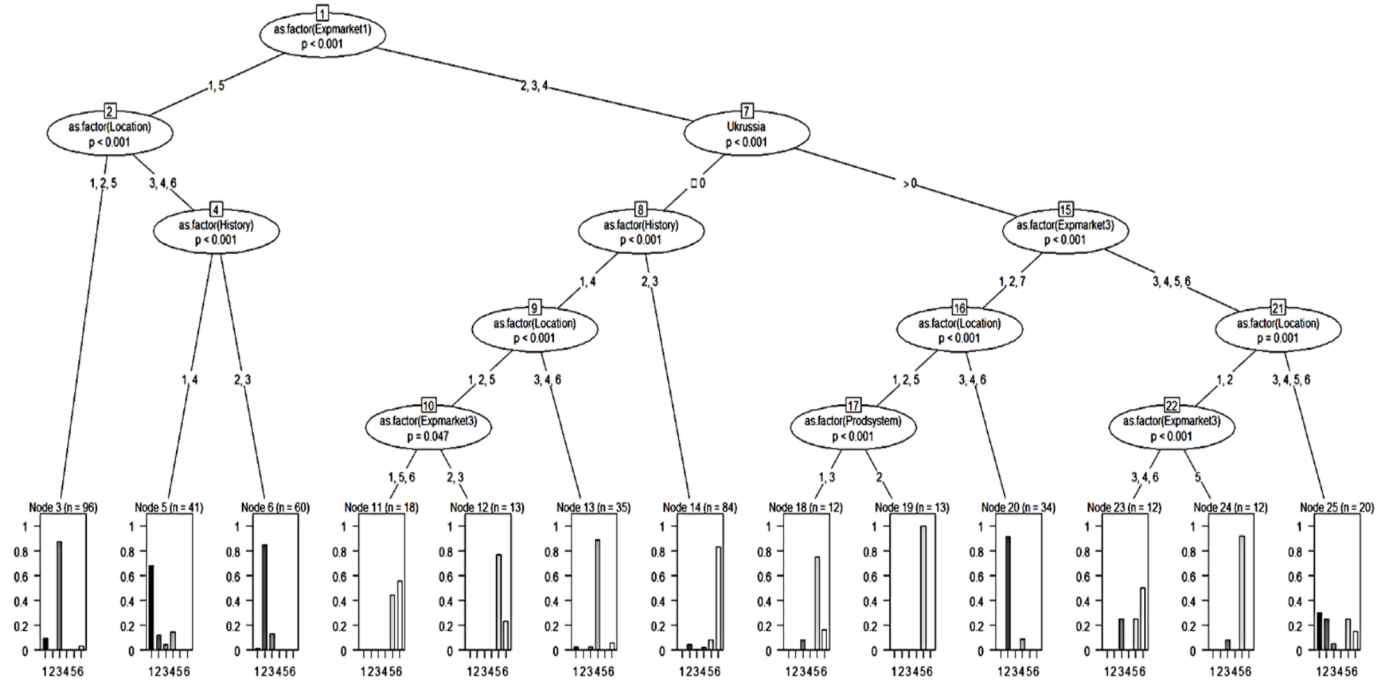

Fig. 2. Ordinal regression for the six clusters for perceived business risks with binary recursive partitioning using 24 company and market characteristics as explanatory variables. **Note**: End-nodes shows the probability of cluster membership for perceived business risks (Clusters 1 to 6) conditional on the distributional properties of the explanatory variables with the largest statistical association with the dependent variable based on Bonferroni-adjusted p-values. A set of 18 explanatory variables were used in the analysis (see Table A2, Appendix). Statistically significant covariates shown in Fig. 2 are: *Expmarket1* (the main export market for the SME's products), *Location* (the geographic location of the SME), *History* (years of experience in the agrifood export business), Ukrussia (whether the SME exports to Ukraine or Russia), *Expmarket3* (the third main export market for the SME's products), *Prodsystem* (whether the production system of the SME is organic, conventional or both).

agrifood enterprises into two spatially distinct subsets. The first subset consists of enterprises located in old lands in the Nile delta and the valley, associated with "Node 20" comprising 34 agrifood SMEs. The perceived risks by members of this category are mostly relevant to Cluster 2 of the perceived business risks. The second subset includes enterprises located in new lands and the desert. This subset is further divided based on their production system into two subgroups. The first comprises agrifood enterprises adopting organic farming systems, related to "Node 19" with 13 enterprises. The perceived risks by members of this subgroup are more relevant to Cluster 5 of the agrifood SMEs. The other subgroup includes 12 agrifood enterprises practicing conventional or mixed farming systems and is related to "Node 18". The perceived risks by members of this subgroup are mostly relevant to Cluster 5 of the perceived business risks.

Regarding agrifood enterprises that have their other main export markets in Asian, African, American, and other European countries, the geographic location once again proved to be the most significant determinant for splitting the subsample. It divided the enterprises into two distinct groups. The first group is related to "Node 25" and comprises 20 agrifood SMEs with mixed locations from both old and new lands. The perceived risks by members of this group are related to multiple clusters of the perceived business risks. The second group consisted of agrifood enterprises exclusively located in two newly reclaimed areas, *Nubaria* and *Behira*. This group was further divided based on their other main export markets into two subgroups. The first subgroup is related to "Node 24" and includes 12 enterprises that have other European countries as their main export destination. The perceived risks by members of this subgroup mainly pertained to Cluster 5 of the perceived business risks. The other subgroup is related to "Node 23" and consists of 12 agrifood SMEs with main export markets in Asia and America. The perceived risks by members of this subgroup were relevant to Cluster 6 of the surveyed agrifood SMEs.

5.3. Segmentation of the agrifood SMEs based on experienced business impacts

Table A5 in the Appendix A displays the results from the clustering of the surveyed agrifood SMEs based on their experienced (observed) business impacts. A three-cluster class solution provided the best fit and the cluster quality through the silhouette measure of cohesion and separation was acceptable (average silhouette 0.3).

Cluster I (n = 95, 21.1 % of the sample), referred to as "*Minimally Impacted*," consists of agrifood SMEs that did not experience any changes in their total revenue. In addition, members of this cluster reported either no change or a slight increase in their cost of raw materials, inputs, and total operating cost. These SMEs encountered infrequent delays or rejections of their consignments since February 2022. In terms of cash flow coverage, they had relatively longer periods for maintaining their operations, with a majority reporting cash flow coverage of 6 months or more. Layoffs were not a mitigation strategy pursued by members of this cluster, with most reporting no layoffs or only up to a 10 % reduction in their workforce.

Member enterprises in Cluster II (n = 236, 52.4 % of the sample), labeled as "Moderately Impacted," experienced slight decreases in revenue and no change or a slight increase of up to 10 % in their cost of raw materials, inputs, and total operating cost. In addition, members of Cluster II did not observe significant changes in the incidents of delays or rejections in their consignments since February 2022, with occurrences mostly categorized as "Neither frequently nor infrequently." Cash flow coverage for maintaining SME operations in this cluster ranged from 1 to 3 to 4–5 months, representing a medium period compared to other clusters. Members of the cluster have implemented or planned to implement layoffs of up to 20 % of their workforce.

Cluster III (n = 119, 26.4 % of the sample), referred to as "Substantially Impacted," consists of agrifood SMEs that experienced substantial decreases in their revenue exceeding 10 %, while their cost of

raw materials, inputs, and total operating cost increased by 10 % or more. Members of this cluster reported an increased frequency of delays in consignments or border rejections of their shipments since February 2022. These SMEs had shorter coverage periods ranging from less than a month to up to 3 months and have implemented or are planning to implement major layoffs, exceeding 20 % of their workforce.

5.4. *The relationship between the clusters of perceived business risks and clusters of experienced business impacts*

Fig. 3 shows how the assigned cluster membership for perceived business risks related to the Russia-Ukraine war predict the assigned cluster membership probability for the experienced business impacts. Notably, the results show an interesting distribution of the surveyed agrifood SMEs: on the right-most branch of the tree, 102 agrifood SMEs (Node 9), classified to belong to the *Cost- and Market Dynamics-driven Risk Cluster* (Cluster 3), were predicted to be either severely impacted (Cluster III, 62 %) or moderately impacted (Cluster II, 36 %) by the Russia-Ukraine war. A very small percentage (2 %) of this sub-sample experienced minimal impact from the war. On the left-most branch of the tree, we observe a sub-sample of agrifood SMEs categorized to belong to the risk groups labeled Cost-Driven Risk Cluster (Cluster 1) and Market Dynamics-driven Risk Cluster (Cluster 2). The experienced business impacts among members of this sub-sample (Node 5, n = 141) were scattered across the three clusters of observed impacts: minimal (Cluster I, 17 %), moderate (Cluster II, 50 %), and severe (Cluster III, 33 %). Between the right and left ends of the tree, we find agrifood SMEs classified to belong to the Cybersecurity and Communication Risk Cluster (Cluster 6, Node 8, n = 99), the Contractual Commitments and Trade Partner Risk Cluster (Cluster 5, Node 7, n = 66), and the Interlinked Multi-Crisis Risks Cluster (Cluster 4, Node 6, n = 42). On average, Agrifood SMEs belonging to these three clusters were predominantly predicted to be either moderately (62 %) or minimally (32 %) impacted by effects, with less than 1 % on average predicted to experience substantial impact. Overall, the strong association between perceived business risks and observed business impacts implies that the risks identified by agrifood SMEs significantly influence their actual business performance. This suggests that understanding and effectively managing perceived risks are crucial for agrifood SMEs to mitigate negative impacts of exogenous shocks on their operations and overall performance and ensure their resilience in the face of business disturbances.

6. Discussion and concluding remarks

The Russian aggression in Ukraine in February 2022 has posed an additional disruption to agrifood value chains in LMICs, occurring at a time when many of these chains were still contending with the consequences of the COVID-19 pandemic. Given that both Ukraine and Russia, in particular, are important trading partners for many LMICs, particularly in the Middle East region, serving as both import sources and export destinations for agrifood commodities, energy products and farm inputs, the war triggered ripple effects on various activities along agrifood SMEs' value chains. Nevertheless, to the best of the authors' knowledge, no study has yet been conducted in the context of LMICs to investigate the business risks arising from the war and the actual impacts experienced by agrifood SMEs, despite the crucial socioeconomic role of this segment of enterprises in fostering economic growth, facilitating agricultural trade, generating employment, and contributing to

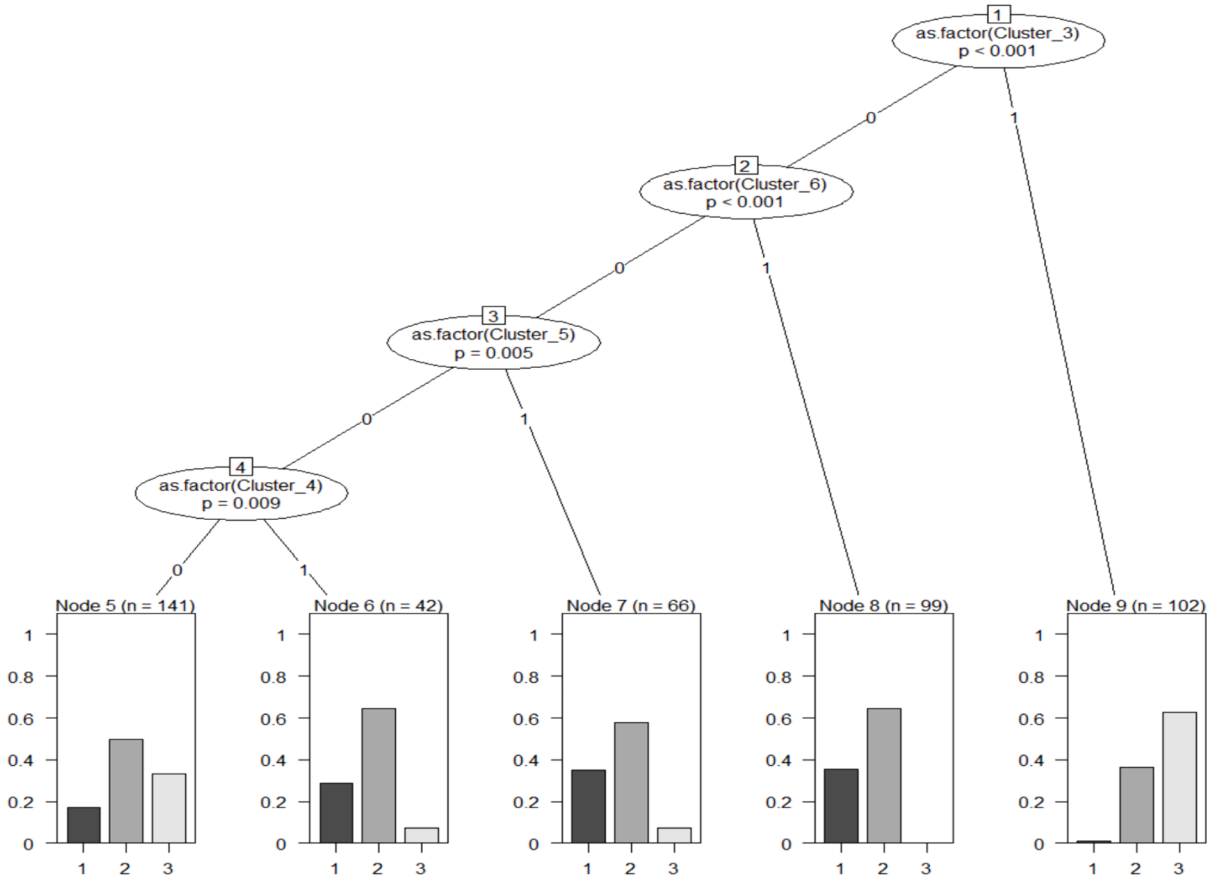

Fig. 3. Ordinal regression with experienced business impacts as response using the (indicator coded) clusters for perceived business risks as explanatory variables. **Note:** End-nodes shows the probability of cluster membership for experienced business impacts (Clusters 1 to 3) conditional on the cluster membership attribution for perceived business risks (Clusters 1–6). Partitioning of the explanatory variables is based on Bonferroni-adjusted p-values.

livelihoods and food security in these countries (World Bank, 2023).

The present study contributes to filling this gap in the literature by *i*) investigating the factors that influenced the perceived business risks arising from the Russia-Ukraine among a sample of Egyptian agrifood SMEs, and *ii*) examining how such perceived business risks relate to the experienced impacts on their business performance. The primary contribution of this study lies in its unique approach to analyzing perceived business risks and connecting them with observed impacts. This sets it apart from existing studies on agrifood SMEs during exogenous shocks, which have typically concentrated solely on either: risk perception; business impacts and mitigation strategies; or have addressed both of them separately in independent analyses. By bridging the "risk-impact" gap, our study offers deeper insights into the experiences of agrifood SMEs during the early stages of this conflict, which can enable them to better prioritize risk management strategies and allocate resources effectively. In doing so, we initially clustered the surveyed agrifood SMEs based on their perceived business risks, then investigated the conditional relationship between the clusters of SMEs associated with these perceived risks and their firm and market characteristics. Subsequently, we segmented them based on the business impacts they experienced as a result of the war, and finally explored the relationship between the clustering of experienced business impacts and the clustering of perceived business risks. The findings of our analysis carry wider implications that can be applied to agrifood SMEs both in Egypt other LMICs to inform policies aimed at mitigating the consequences of geopolitical conflicts on agrifood SMEs, and their subsequent impacts on businesses, employment and livelihoods across the economy. The following subsections discuss the main findings of the study and their policy implications.

6.1. The Russia-Ukraine war has posed a diverse range of business risks to agrifood SMEs

The results of the risk-based clustering analysis reveal that the Russia-Ukraine has exposed the surveyed enterprises to a wide spectrum of risks with consequences affecting their business performance. A significant portion of the enterprises formed clusters that were characterized by perceived risks primarily associated with increased operating costs and challenges in relation to conducting business activities, as well as changes in demand and limited access to importing markets (Clusters 1to 3, 54 % of the sample). The majority of perceived business risks can be categorized as "direct" risks since they primarily affect the operations and functioning of the surveyed enterprises, thereby putting strain on their competitiveness, financial resources, and profitability. This finding aligns with the recent literature on risk perception among Egyptian SMEs amidst external shocks, particularly the COVID-19 pandemic (e.g. CHF McSe, CHF Management and Consulting Services Egypt, 2020; Abu Hatab et al., 2023). For instance, Ali et al. (2022) find that the COVID-19 pandemic had direct consequences for Egyptian SMEs, exemplified by operating cost increases of up to 50 %, revenue reductions of up to 40 %, and approximately half of these enterprises temporarily suspending operations (CHF McSe, CHF Management and Consulting Services Egypt, 2020).

In addition, the results show that the business risks posed by of the war have permeated various stages of agrifood SMEs' supply chains, which encompass activities from production, processing, distribution to exporting of agrifood commodities. According to the literature, this could threaten not only their business operations but also their organizational survival (Sullivan-Taylor & Branicki, 2011; Lu et al., 2020; Fei et al., 2020). Considering that agrifood SMEs represent a crucial "middle" stage in the agrifood chains of LMICs, facilitating postharvest activities that link producers to both domestic and foreign consumers, the risks posed by exogenous shocks on these enterprises present additional risks that threaten to endanger LMICs' fragile food systems and foreshadow worrying impacts on food security and nutrition (Barrett, 2020). In other words, while it is intuitively understood that the strength of the "middle" is crucial for the proper functioning of any "chain", the absence of a well-functioning agrifood SME sector jeopardizes the sustainability of the entire food supply chain during times of crisis. This calls for more efforts to address this "missing middle" in research endeavors and policy interventions to understand the precise effects of exogenous shocks on agrifood SMEs and their propagation across the food chain to support these enterprises in navigating risks posed by such shocks and mitigating their consequences, which is essential for building resilient food supply chains that withstand external shocks and crises.

Notably, the results indicate that part of the business risks perceived by agrifood SMEs primarily originate beyond the enterprises themselves and were channeled to them through other actors and stages of the agrifood value chain. An example of such risks indirectly transmitted risks is the shortage of fertilizers and the subsequent increase in their prices, along with the rise in prices of other agricultural inputs, which, in turn, elevated the cost of commodities sold or exported by the enterprises and diminished their competitiveness in international markets. Another example is the inability of contract farmers, who supply the enterprises with agrifood commodities, to fulfill their obligations due to circumstances caused by the war. In addition, another category of indirect risks is related to enterprises' perception of risks resulting from the effects of the war on "other" systems unrelated to the food system (e.g. energy system and trade system), or originating from the "interplay" between the risks posed by the war and risks arising from other shocks. For instance, the surveyed enterprises expressed concerns about potential disruptions in their agrifood export flow due to the implications of the war for the regional trading system, such as the financial measures and trade sanctions imposed on and by Russia. The enterprises noted also that the war could further impede their recovery from the consequences of the COVID-19 pandemic and exacerbate the challenges already faced due to the current economic slowdown in Egypt. These findings are consistent with those of Sindakis & Aggarwal (2022), which demonstrate that measures implemented in the healthcare system to contain the spread of the COVID-19 pandemic had indirect negative effects on the business performance of Egyptian SMEs. This impact was observed through disruptions in supply chains logistics due to lockdowns and travel restrictions, which affected the timely delivery of agricultural products to international markets (Zaazou and Salman Abdou, 2022). Additionally, these containment measures led to increased transportation costs and caused shifts in consumer demand and preferences, resulting in fluctuations in orders and sales volumes for agrifood SMEs' products (El-Haddad & Zaki, 2022; Abu Hatab et al., 2023).

Overall, these findings underscore a distinct characteristic of contemporary agrifood value chains in LMICs, which consist of complex networks and multidirectional interlinkages between multiple actors and organizations operating at national, regional, and global scales (Feyaerts et al., 2020). As a result, disruptions to activities of actors within agrifood value chains (e.g. agrifood SMEs) may originate from disturbances affecting other systems or value chains, and these disruptions are often dynamic due to the presence of feedback loops (Abu Hatab, 2022). Therefore, in order to enhance the resilience of agrifood value chains against unexpected events, it is essential to move away from the classical "linear" understanding of agrifood supply chains, which views one actor simply supplying materials or resources to another. Instead, systematic approaches should be adopted, ones that consider the interconnectedness among actors and organizations within agrifood value chains across different scales, treating them as holistic systems rather than isolated elements. In this respect, future research endeavors should aim to unravel the complex cause-and-effect dynamics within agrifood value chains amidst exogenous shocks by examining the interrelationships between drivers and consequences of these shocks, which can help identify transformative pathways towards building resilient agrifood value chains in LMICs that can withstand and recover from disruptions (Begimkulov & Darr, 2023).

6.2. The position of the enterprises in the agrifood value chain explains the perceived business risks of the war

The results of the recursive partitioning model for the determinants of cluster membership regarding perceived business risks indicate that the position of the surveyed enterprises in the agrifood value chain, *i.e.* what and how enterprises perform the export activities, largely predicts their perceived business risks from the war. Factors such as market specialization, geographic location, business experience, and the adopted production system were identified as the covariates with the greatest relevance and strongest explanatory power for cluster membership. Specifically, the primary market for exported commodities emerged as the most determining factor of the perceived business risks among the surveyed enterprises, with those exporting mainly to the EU and other European countries perceiving significantly higher business risks arising from the war. Another important determinant of cluster membership is related to Russia and Ukraine being the main export destination for the surveyed enterprises' agrifood exports. Agrifood SMEs with main export destinations in the EU and other European countries including Russia and Ukraine were more likely be belong to enterprise clusters perceiving risks related to contractual commitments and transactions with their trading partners including failure to fulfill contracted sales, reduced quality of their exported commodities due to delays in port operations, and decreased demand for their agrifood exports. In addition, exporters to these markets in our sample were also more likely to belong to Cluster 6 of the enterprises, which uniquely perceived a concern related to the potential risk of cypher attacks or disruptions to communication channels that may negatively affect their shipments to Russian and other European importing partners. These results are in concert with previous studies, which show that agrifood enterprises targeting specific markets and consumer segments experience different risks from external shocks compared to enterprises operating in other market segments (e.g. Chowdhury, 2011; Kubíčková & Toulová, 2013).

These findings tend to suggest that existing trade facilitation agreements between Egypt and the EU, such as the EU-Egypt Association Agreement, have failed to function as a buffer against unexpected shocks to Egyptian agrifood SMEs. In contrast, Abu Hatab et al. (2021) revealed that agrifood SMEs exporting to the EU significantly perceived less risks during the COVID-19 pandemic compared to enterprises with other main export destinations, which was partially attributed to the effect of trade facilitation arrangements between the two sides. A possible explanation can be that the European countries were heavily impacted by the Russian-Ukraine war, which aggravated the effects on the shipping charges to Europe as the war made traditional shipping routes more dangerous or unpassable, and increased the expenses associated with shifting exports to alternative or new markets. In this regard, Abdullah (2015) criticized the EU-Egypt Association Agreement for the absence of comprehensive crisis management mechanisms, which increases the vulnerability of agrifood businesses to unforeseen risks, and discourage them from engaging in cross-border trade and expanding their export activities. Therefore, our results highlight the need to incorporate robust risk management provisions into bilateral and regional agreements with LMICs to encourage risk assessment and management practices, enhance the sustainability of trade relations, and create a more favorable environment for agrifood SMEs' to engage in beneficial trade activities.

Two other significant determinants of cluster membership in relation to perceived risks are the geographic location and the production system adopted or sourced from by the surveyed enterprises. Generally, previous studies reveal that the physical location of an enterprise within the supply chain network can impact its vulnerability to various risks and disruptions (Bai & Harith, 2023; Zaazou and Salman Abdou, 2022). Specifically, Egyptian agrifood SMEs located in "old lands" in the Nile Delta are generally characterized by adoption of traditional farming practices and significantly lower export-to-total sales ratios, compared to agrifood enterprises situated in "new lands" reclaimed in the desert. This explains the substantial effect of the geographic location of an agrifood SME on its risk perception from a geopolitical conflict taking place in Europe being a main destination for the exports of a large share of the surveyed enterprises, especially those perceived risks related to Cluster 3 (Cost- and Market Dynamics-driven Risks Cluster). Likewise, the production system adopted or sourced from by the surveyed enterprises was found to be a significant determinant of membership in risks' clusters, due to its strong association in the context of Egypt with the geographic location and the main export market for agrifood SMEs. That is, agrifood enterprises located in the desert lands are more likely to target mainly the EU markets, and thus they are more likely to adopt organic farming systems or source their agrifood commodities from farms certified for organic farming to be able to access and compete on the European market. Therefore, adoption of organic farming was found to be associated to risks perceived by members of Cluster 5, including those related to contractual commitments and transactions with their trading partners, failure to fulfill contracted sales, and decreased quality of exported commodities that may cause rejections due to delays in port operations.

Overall, these findings have an important implication for policies conductive to the transformation of agrifood value chains in LMICs, while they emphasize the importance of managing trade-offs between the opportunities and benefits that exporting to specific markets (e.g. the EU) offer to agrifood enterprises and the risk of the market concentration and heavy reliance on these destination markets. For instance, the concentration of the import markets of the Egyptian agrifood SMEs in the EU countries can pose several risks to their operations and overall business sustainability by exposing them to vulnerability to market shocks, fluctuations in demand, changes in consumer preferences, or shifts in trade policies, which can have a significant impact on their export performance and profitability (Apostolopoulos et al., 2021). Therefore, agrifood SMEs should utilize government's trade promotion programs, and invest in market intelligence to identify and assess new market opportunities and adapt their exports to meet the demands of different markets.

Finally, the results revealed that business experience plays a role in shaping an enterprise's perception of the risks posed by the Russia-Ukraine war. This finding is consistent with previous studies on the export performance of Egyptian agrifood exporting SMEs, which consistency show that firms' experience in the agrifood export business significantly improves their performance, especially with respect to decreasing the probabilities of border rejections and exiting export markets on the EU (El-Haddad & Zaki, 2022). With regard to the Russia-Ukraine war, established enterprises with a longer history of operations may have built resilience and developed contingency plans to navigate the challenges posed by the war. They may have established relationships with alternative suppliers or have diversified their markets, allowing them to adapt more effectively to the disruptions caused by the war.

6.3. The observed business impacts of the Russia-Ukraine vary across the agrifood SMEs

The results show that the Russia-Ukraine war had widely varied impacts on the business performance of the sampled agrifood enterprises. Around half of the sample was moderately impacted (Cluster II), with slight changes in their revenue and total operating cost, minor changes in the incidents of delays or border rejections of their consignments since February 2022, medium durations of cash flow coverage for maintaining SME operations, and small-scale workforce optimization actions or plans. The other half of the sample formed two distinct clusters each representing around a quarter of the enterprises that were either substantially or minimally impacted by the war. Previous research on SMEs' supply chain resilience shows that exogenous shocks have uneven impacts on agrifood SMEs due to several factors relating to enterprises' characteristics, including their size, geographic location, market exposure, and level of integration into global value chains (e.g.

Mohammed et al., 2023). The adaptive capacity of individual SMEs also varies and plays crucial role in determining the extent of the observed impacts (Brucal & Grover, 2023). Moreover, the regulatory environment and government policies for different segments of the enterprises may influence agrifood SMEs' resilience to exogenous shocks. Such high heterogeneity among the surveyed enterprises both in terms of their position in the value chain, as discussed in the previous section, and the significant variations regarding their observed impacts of the war call for more targeted measures that address and respond to the specific needs and circumstances of each subgroup of enterprises during times of crises. Adequate institutional support, such as effective risk management frameworks and disaster preparedness programs, along with access finance, including credit facilities and insurance mechanisms, can enhance SMEs' ability to anticipate and mitigate the impacts of external disruptions (Gródek-Szostak et al., 2022). In addition, the remarkable variations among the surveyed enterprises in terms of the observed outcomes should encourage policymakers to facilitate multi-stakeholder collaboration and information sharing among agrifood enterprises, export associations, and relevant stakeholder to enable knowledge and best practices sharing that can help them learn from each other's experiences to improve their capabilities regarding management of business risks.

6.4. The perceived business risks are significant determinants for membership in the clusters of observed impacts

Lastly, the results reveal that four out of the six clusters of perceived business risks are significant predictors of cluster membership for the observed outcomes of the war by the surveyed enterprises. This finding substantiates the findings of previous research, which reveal association between anticipation of risk and observation of the outcomes of extreme events among on small and medium businesses (e.g. Koh et al., 2006; Sopha et al., 2020). While Table 1 in the Appendix A shows that around three-quarters of the surveyed enterprises neither have specialized units nor internal strategies for risk management, our findings imply that policymakers should prioritize initiatives aimed at promoting risk awareness and providing support to agrifood SMEs in developing and implementing risk management practices. Achieving this aim requires introducing capacity-building programs, creating knowledge-sharing platforms, and providing financial incentives (e.g. financial support, or tax incentives) to equip them with the necessary knowledge, resources, and tools to identify and mitigate risks, thereby minimizing the risks and consequences of exogenous shocks on their business performance.

CRediT authorship contribution statement

Assem Abu Hatab: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Carl-Johan Lagerkvist:** Writing – review & editing, Validation, Software, Resources, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A1
Sample characteristics ($n = 450$).

Characteristics	Categories	Percent
Years in business (experience)	5 to 10	39.78
	10 to 15	36.44
	15 to 20	18.00
	More than 20	5.78
Total annual assets in million EGP	Less than 3	27
	3 to 5	20
	5 to 10	15
	10 to 20	9
	More than 20	3
Total annual sales in million EGP	Less than 1	6
	1 to 3	25
	3 to 5	38
	5 to 10	19
	Over 10	12
Number of employees	Less than 10	14.00
	10 to 20	41.33
	20 to 50	34.89
	Over 50	9.78
Sales in domestic market	No	69.33

(*continued on next page*)

Table A1 (*continued*)

Characteristics	Categories	Percent
	Yes	30.67
Company has branches	No	76.89
	Yes	23.11
Number of branches	1	44.23
	2	41.35
	3	14.42
Company has downstream activities	No	82.22
	Yes	17.78
Type of business	Exporting commodities produced by own farm	37.33
	Export commodities produced by the farm and collected others	30.67
	Exporting commodities produced by other farms	32.00
Company export to Russia	No	40.44
	Yes	59.56
Company's main market: Russia or Ukraine	No	69.56
	Yes	30.44
Certification status	No	10.67
	Yes	89.33
Specialist risk management unit	No	71.56
	Yes	28.44
Internal strategy for risk management	No	76.89
	Yes	23.11
Cooperative membership	No	36.00
	Yes	64.00

Source: survey results. I USD=18.9 EGP (July 2022).

Table A2
Summary statistics of the variables utilized in analyzing the relationship between agrifood SMEs' firm and market characteristics and the cluster membership associated with perceived business risks.

Variable	Variable definition	Categories	(%) of sample
Location	The geographic location of the agrifood enterprise	Nubaria	16.67
		Behaira	16.67
		Sharkia	16.67
		Dakahlia	16.67
		Fayoum	16.67
		Beni Suief	16.67
Type of business	Source of the exported agrifood commodities	Own farm	37.33
		Own farm and collected from other farms	30.67
		Other farms	32.00
Experience	Number of years in the agrifood business	1 if 5 to 10 years	39.78
		10 to 15 years	36.44
		15 to 20 years	18.00
		Above 20 years	5.78
Sales	Total annual sales in EGP millions	Less than 3	30.89
		3 to 5	37.78
		5 to 10	18.89
		10 to 20	12.22
		More than 20	0.22
Production system	Agrifood production/export system of the agrifood SME	Conventional	29.56
		Organic	33.11
		Mixed	37.33

(*continued on next page*)

Table A2 (*continued*)

Variable	Variable definition	Categories	(%) of sample
Activities	Type of activities in which the business is engaged	Downstream	82.22
		Upstream	17.78
UKRussia	If the SME exports agrifood commodities to Russia or Ukraine	Yes	59.56
		No	40.44
UkRussiamain	If Russia/Ukraine is the "main" export market of the agrifood SME	Yes	69.56
		No	30.44
Export_market 1	The first main market of specialization	EU	40.44
		Arab market	8.89
		Asia	33.78
		North America	13.46
		Africa	3.33
		South America	0.00
		Other	0.00
Export_market 2	The second main market of specialization	EU	12.89
		Arab market	15.33
		Asia	36.67
		North America	21.33
		Africa	12.00
		South America	1.78
		Other	0.00
Export market 3	The third main market of specialization	EU	19.56
		Arab market	19.33
		Asia	14.89
		North America	21.56
		Africa	16.00
		South America	6.67
		Other	2.00
Export_products	Product of specialization	Fresh fruit and vegetables	62.89
		Processed fruit and vegetables	16.22
		Grains	7.11
		Medicinal, Aromatic and Spices	9.11
		Dried Vegetables	4.67
Certification	The certification status of the business	Certified	89.33
		Not certified	10.67
Coop	Whether the business is a member of any agrifood export association	Membership	64.00
		N membership	36.00
Employees	The number of employees at the agrifood SME	Less than 10 employees	14.00
		10 to 20 employees	41.33
		20 to 50 employees	34.89
		More than 50	9.78
Assets	Total asset of the agrifood SME in EGP millions	Less than 3 million	27.33
		3 to 5 million	20.00
		5 to 10 million	25.56
		10 to 15 million	15.33
		15 to 20 million	8.67
		Over 20 million	3.11
Department	If the agrifood SME has a specialized department/unit to deal with risk management	Yes	28.44
		No	71.56
Strategy	If the agrifood SME has an internal strategy for risk management	Yes	23.11
		No	76.89

Table A3
Mean score by clusters for perceived business risk.

Business risk items	Agrifood SMEs' clusters					
	C1	C2	C3	C4	C5	C6
r1. Our current products will face less demand in our export markets	64.4	80.5	52.9	19.6	16.7	15.5
r2. Logistics firms may suspend services for companies like mine because the war make shipping routes dangerous/unpassable	62	73.4	54.7	19.3	16.8	25.5
r3. Ocean shipping charges to be paid for my company exports will increase because the war make shipping routes dangerous/unpassable	72	51.3	60.7	64.6	12.7	9.7
r4. Alternative shipping routes will be longer, which may increase shipping cost and cause rejections due to decreased quality or loss in the exported products by our company	53.5	61.1	58.2	69.1	18.5	25
r5. Charges of alternative modes of transportation (e.g. air instead of by boat) for my company products will increase.	72.7	52.8	51	68.6	24.2	23.7
r6. Prices of inputs including fertilizers to my farm production will increase	47.6	67	19.2	26	29.9	19.8
r7. Our company will face problems of buying fertilizer and other farm inputs due to supply disruptions	57.2	70.5	36	18.9	19.1	23.5
r8. Shortages in fertilizers and other inputs can reduce agricultural production and yields of my company.	67.5	58	44.2	57.1	18.5	16.8
r9. Financial measures and trade sanctions imposed on and by Russia threaten to disrupt export flow my company exports	65.3	71.2	65.3	20	10.5	14.1
r10. Our ability to deliver existing orders will be inhibited because the shipping routes (e.g. Black sea) of our exports is blocked.	69.8	76.1	51.3	22	9.4	11.4
r11. There will be purchasing delays and reduced collection of receivables for my company products	68.9	40.2	29.8	72	42.5	25
r12. Shifting our exports to alternative/new markets will be costly for our company (e.g. new contracts, marketing campaigns, etc.) & will take time	72.5	50.9	42.5	75.4	43.6	9.3
r13. Our company will face higher competition in alternative markets to which we may shift our exports	68	50.8	48.9	77.1	49.7	9.1
r14. Importers may want to pay in currencies other than USD for our company exports which may have financial consequences for our company (e.g. shortage in USD needed for our input imports)	37.9	38.4	44.9	7.7	45.1	9.2
r15. Higher global prices of products with complementary relationships with products exported by our company may decrease foreign demand for our exports (e.g. cocking oil and potato)	59.4	74.4	48.1	19.3	18.9	17.2
r16. Potential cypher attacks or blocking of Gmail, Outlook or Google, etc., will interrupt our communication and company operations with Russian importers (or other foreign partners)	17.8	41.2	42.2	7.1	33.8	48.6
r17. There will be losses of my company products because of the port delays and lack of cooling and storage facilities	65.3	73.9	68.5	19.3	14.4	14.3
r18. Port operations will be delayed which will reduce the quality of my exports and cause rejections by the importer/retailer	57.9	51.9	57.1	22.6	57.8	31.9
r19. Our company will face failure to deliver contracted sales to our customers/retailers	58.9	50	60.4	12	51.2	31.3
r20. The revenue of our company will be affected by instability in foreign exchange rates	67.2	51.8	39.6	75.4	46.2	11.8
r21. The competitiveness of the company products from our Business for exports will be affected by instability in foreign exchange rates.	70.1	51.2	42.1	74	41	10.9
r22. Our company will have to layoff skilled labor and experienced employees with valuable information and knowledge	24.4	15.7	33.3	51.9	37.5	19.2
r23. Failure of regional or global governance of agrifood trade will affect our company (e.g. export or import-restricting policies, and other non-tariff barriers, e.g. import quotas).	60.2	69.5	53.7	22.4	48.9	19.8
r24. The war threatens to trigger regional conflict that can adversely impact our company activities	60.2	70	56.7	22.4	45.3	17.4
r25. The war threatens to compound the impact of other challenges that our company is facing (e.g. water scarcity and weather conditions)	62.5	57.7	24	74.3	28.3	15.9
r26. Suppliers under contract will not deliver to our farm due circumstances beyond their control	34.3	35.3	31.8	27.2	29.4	33.7
r27. The war threatens to adversely affect the recovery of my company businesses from the consequences of the COVID-19 pandemic	54.3	14.4	34.6	60.3	44.3	19.5
r28. The war threatens to compound the challenges that our company is facing due to the current economic situation in Egypt	65.4	19.1	32.1	62.6	48.2	20.7

Note: Perceived business risk is on the range 0 to 100 per item. Cluster sizes are 45 (C1), 96 (C2), 102 (C3), 42 (C4), 66 (C5), and 99 (C6).

Table A4
Observed business impacts of the Russia-Ukraine war on the surveyed agrifood SMEs ($n = 450$).

Dimension of impact	Response	%
Total revenue in July 2022 compared with July 2021	Increased, but by less than or equal to 10 %	4.2
	Same as last year	18
	Decreased by less than or equal to 10 %	52.9
	Decreased by more than 10 %	24.8
Raw materials and inputs in July 2022 compared with July 2021	Increased by more than 10 %	7.1
	Increased, but by less than 10 %	57.6
	Same as last year	35.3
Total operating costs in July 2022 compared with July 2021	Increased by more than 10 %	5.1
	Increased, but by less than or equal to 10 %	55.3
	Same as last year	36.7
	Decreased by less than or equal to 10 %	2.9
Delayed consignments since February 2022	Infrequently	2.9
	Neither frequently nor infrequently	13.6
	Frequently	55.8
	Very frequently	27.8
Rejected consignments since February 2022	Never	1.8
	Infrequently	2
	Neither frequently nor infrequently	13.6
	Frequently	58
	Very frequently	24.7

(*continued on next page*)

Table A4 (*continued*)

Dimension of impact	Response	%
Cashflow for maintenance of the company's operation	Less than 1 month	4.4
	1–3 months	50.4
	4–5 months	32.4
	6 months or more	12.7
Percentage of staff layoffs under consideration/done	1–10 %	24.4
	11–20 %	60
	21–30 %	14.2
	More than 30 %	1.3

Table A5
Cluster profiles and frequencies for each of the seven observed impacts of the Russia-Ukraine war by the identified clusters of the companies surveyed.

Cluster	Size	Increased				Unchanged		Decreased			
		> 10 %		≤ 10 %				≤ 10 %		> 10 %	
		No.	%	No.	%	No.	%	No.	%	No.	%
a) **Total revenues**											
1	95	0	0	18	95	77	95	0	0	0	0
2	236	0	0	0	0	0	0	236	99	0	0
3	119	0	0	1	5	4	5	2	1	112	100

b) **Cost of raw materials and inputs**

Cluster	Size	Increased	Unchanged	Decreased							
		> 10 %	≤ 10 %		≤ 10 %	> 10 %					
		No.	%	No.	%	No.	%	No.	%	No.	%
1	95	1	2	35	14	59	42	0	0	0	0
2	236	15	24	154	62	67	48	0	0	0	0
3	119	46	74	60	24	13	9	0	0	0	0

c) **Operating costs (July 2022 versus July 2021)**

Cluster	Size	Increased	Unchanged	Decreased							
		> 10 %	≤ 10 %		≤ 10 %	> 10 %					
		No.	%	No.	%	No.	%	No.	%	No.	%
1	95	6	11	37	16	48	33	4	31	0	0
2	236	12	21	147	62	70	48	6	46	0	0
3	119	38	68	52	22	27	19	3	23	0	0

d) **Delayed consignments since February 2022**

Cluster	Size	Never	Very infrequently	Infrequently	Neither frequently nor infrequently	Frequently					
		No.	%	No.	%	No.	%	No.	%	No.	%
1	95	0	0	13	100	61	100	15	6	6	5
2	236	0	0	0	0	0	0	236	94	0	0
3	119	0	0	0	0	0	0	0	0	119	95

e) **Rejected consignments since February 2022**

Cluster	Size	Never	Very infrequently	Infrequently	Neither frequently nor infrequently	Frequently					
		No.	%	No.	%	No.	%	No.	%	No.	%
1	95	0	0	3	33	51	55	19	10	22	14
2	236	4	50	5	56	28	30	137	75	62	39
3	119	4	50	1	11	14	15	27	15	73	46

f) **Cashflow for maintenance of company's operations**

Cluster	Size	Less than 1 month	1 to 3 months	4 to 5 months	6 months or more				
		No.	%	No.	%	No.	%	No.	%
1	95	2	2	17	10	22	20	54	65
2	236	11	13	135	78	68	62	22	27
3	119	72	85	21	12	19	17	7	8

g) **Percentage of staff-layoffs under consideration/done**

Cluster	Size	No layoffs	1–10 %	11–20 %	21–30 %	> 30 %					
		No.	%	No.	%	No.	%	No.	%	No.	%
1	95	32	45	53	22	8	14	2	4	0	0
2	236	36	51	159	65	39	68	1	2	0	0
3	119	3	4	33	13	10	18	48	94	26	100

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodpol.2024.102712.

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