Geopolitical Risks and Agricultural Trade Diversification in Southern Africa: Port-level Evidence from the Russia-Ukraine War

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Abstract

With the spread of global agricultural value chains, international geopolitical risks often unintentionally trigger food insecurity in bystander countries. This study explores the impact of Russia's invasion of Ukraine on wheat supplies in South Africa and their trade diversification. Using port-level trade data, we show that South Africa, the main distribution route for South African wheat supplies, rapidly diversified its imports to mitigate geopolitical risk in the aftermath of the war. This sudden import diversification prevented the war-induced decline in average wheat imports, yet it led to an increase in the volatility of annual imports. More importantly, the import diversification contributed to more secure wheat supplies for southern African landlocked countries that were heavily reliant on border imports from South Africa. Our study highlights that sourcing diversification in a country with well-developed port infrastructure could be instrumental in stave off food insecurity in neighboring countries in times of geopolitical crises.

Keywords: The Russia-Ukraine War, Wheat, South Africa, Port Import, Trade Diversification
JEL Codes: F14, F63, O13, Q17

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1 Introduction

Great powers often maliciously abuse their political and economic levers to advance their political interests (Mearsheimer, 2001). Despite international condemnation, history repeats itself. The development of democracy has made a significant contribution to mediating recurrent state-sponsored armed violence in the modern world. However, it is also a feature of the modern international community that some large autocracies and less democratic states have been bold in their use of force to achieve their political goals (Acemoglu and Robinson, 2013). In particular, as global markets become increasingly interconnected due to the rise of global value chains, the military actions of these states can intentionally disrupt the flow of international trade beyond their borders and around the world. As more interest groups are harmed by disruption, these states may use trade disruption as a lever of power in the international community (Gowa and Mansfield, 1993; Martin et al., 2008; Li et al., 2023).

Such disruptions in international trade tend to place an economic burden on less developed countries. Politically and economically weaker countries often lack the governmental means to respond to exogenous trade disruptions in the early stages. In particular, countries with weak port infrastructure, which is essential for trade, are often limited in their ability to promptly diversify their imports in response to such crises, making it difficult to stabilize imports and reduce trade risks (Bonfatti and Poelhekke, 2017; Munim and Schramm, 2018). This is especially true for underdeveloped countries that are highly dependent on imports for necessities such as food, which in turn accelerates political instability within their societies and can even lead to riots, social unrest, and civil war (Patel and McMichael, 2014; Bellemare, 2015; Leach et al., 2020).

The recent military war launched by Russia against Ukraine on February 24, 2022, and the subsequent disruption of the international wheat trade is a prime example of such an event. As the world's largest grain producers and exporters, Russia and Ukraine play a critical role in global agricultural production and therefore have a significant impact on global food security. Many countries rely on these two countries for a significant portion of their grain imports, and as the war disrupted export infrastructure, it affected global grain markets, particularly wheat, leading to potential supply shortages and price spikes (Glauber and Laborde Debucquet, 2023). The turmoil is destabilizing global food markets, leading to food shortages and price volatility, which in turn is affecting food security across Sub-Saharan Africa. However, despite the importance of food security through import stabilization, there is a lack of empirical evidence on how African countries are responding through import diversification. Motivated by the fact that Russia and Ukraine are the largest wheat exporters and most southern African countries are heavily dependent on South Africa for their wheat needs, this study explores the consequences of military conflict in other countries on the wheat supply of non-conflict bystander southern Africa.

We begin by using monthly trade data by port in South Africa to assess the impact of the war on South Africa's wheat imports by port from January 2015 to July 2023. The results show that the war had no statistically significant impact on South Africa's wheat imports, suggesting that while other African and Middle Eastern countries experienced severe disruptions to their wheat supply chains due to the war, South Africa appeared to have cope with the shock relatively well. Given that South Africa has a well-developed port infrastructure compared to other African nations and has trade connections with a large number of countries, we examine the impact of the war on port-level import diversification, measured by the Herfindahl-Hirschman Index (HHI). Our results reveal that after the war, South Africa's major ports diversified their wheat imports, which can be interpreted as a strategic move to reduce their reliance on a limited number of countries and expand their trade partnerships across multiple countries. The results suggest that South Africa was able to avoid the aftermath of the war-induced crisis by being agile enough to swiftly diversify its wheat imports across ports.

Next, we look at the risks of diversifying South Africa's wheat imports. This is because sudden switching of import paths can lead to higher import volatility due to short-term supply shortages, contract delays, port infrastructure capacity constraints, and other factors. To do so, we measure import volatility by calculating the standard deviation of the growth rate (change) of the outcome within an arbitrary time period, following Davis et al. (2006) and Kurz and Senses (2016), and then examine the import volatility that the Russia-Ukraine War induced along with wheat import diversification. Interestingly, we find that post-war import diversification increases import volatility. Our result indicates that a negative correlation between diversification and import volatility before the war. However, post-war, this correlation undergoes a reversal. This result implies that South Africa manages to stabilize its wheat imports through supply chain diversification, but is not necessarily free from the war-related risks to which new supply chains are exposed. In other words, South Africa's import diversification is not free from the new war risks that diversified import routes face, and the risk of increased import volatility is likely still passed on to South Africa.

Lastly, we investigate the impact of the Russia-Ukraine Warr on the wheat imports of southern African countries from South Africa. Following the notion that the stability of South Africa's wheat imports may indirectly affect South Africa's overall wheat supply, we examine how wheat imports from South Africa affected the southern African countries in the postwar period. Using import data from all inland ports bordering South Africa, we analyze wheat imports from South Africa to four neighboring landlocked countries (Botswana, Zimbabwe, Lesotho, and Eswatini). Our result reveals that wheat imports from South Africa increased statistically significantly after the war, suggesting that South Africa's proactive strategy of diversifying its wheat imports contributed to a more stable wheat supply not only for South Africa, but also for neighboring southern African countries that are heavily dependent on South Africa for food. Our research suggests that during such crises, the rapid sourcing diversification of a major neighboring port country might plays an important role in avoiding a food crisis for the entire surrounding region.

This study contributes to the literature on the linkages between trade relations and food security. Much of the existing research has focused on food security in sub-saharan African countries (Bjornlund et al., 2022; Barrett and Upton, 2013). In particular, many studies have shown that food security in sub-Saharan Africa depends not only on domestic production but also on foreign imports (Dithmer and Abdulai, 2017; del Ninno et al., 2007; Hall et al., 2017; Bren d'Amour and Anderson, 2020). This is due to the region's expanding population, the shift to cash crop production, and the decline of the agricultural population due to urbanization. As a result, crisis in global trade has often led to catastrophic deterioration of food security in the sub-Saharan region (Verpoorten et al., 2013; Smith and Glauber, 2020). While existing studies have focused on food crises in Eastern, Middle, and Western Africa (e.g., the Democratic

Republic of the Congo (DRC), Nigeria, Sudan, Ethiopia, and South Sudan, and Kenya studied by Larson et al. (2014); Rahimi et al. (2023); Le Mouël et al. (2023); Al-Saidi (2023)), relatively few studies have focused on food security in Southern Africa (Botswana, Eswatini, Lesotho, and Namibia) due to the limited data available.

While food security crises in other SSA regions are largely attributed to political instability and poor governance (Barrett and Upton, 2013; Candel, 2014; De Waal, 2017), food security in Southern Africa has unique characteristics that make it different from other SSA regions. This is because these countries rely heavily on imports from South Africa for food, making them highly vulnerable to trade-related crises and risks emanating from South Africa (Food and Agriculture Organization, 2020). This study contributes to the existing literature on trade and food crises in Africa by using the case of the Russia-Ukraine War to examine the impact of South Africa's trade crisis on food crises in neighboring Southern African countries that are dependent on South Africa's food imports.

This research also enhances the existing body of literature on geopolitical risk and its impact on global food trade. Geopolitical crises, which are political, social, economic, and military crises in various countries or regions, have a significant impact on business operations, investments, and international relations beyond the country in question (Gupta et al., 2019; Fund, 2017; Liu et al., 2021; Cheng and Chiu, 2018; Blomberg and Hess, 2006; Blomberg et al., 2004; Aisen and Veiga, 2013; Caldara and Iacoviello, 2022; Góes and Bekkers, 2023; Balma et al., 2022). In particular, intra- and inter-state political instability, such as political unrest, military tensions, regime changes, civil conflicts, and coups, have historically triggered unexpected trade crises for neighboring countries (Qureshi, 2013; Murdoch and Sandler, 2004; Fang et al., 2020). Under the influence of global value chains, which have accelerated since the mid-1990s, the impact of international trade is becoming wider and deeper (World Bank Group, 2019; World Trade Organization, 2023; Antràs and Chor, 2021). The adverse trade impacts of these geopolitical crises often lead to even greater economic crises for poorer countries that are vulnerable to their own trade policy measures.

Within this large body of literature, the recent Russia-Ukraine War has received the most attention. In particular, a burgeoning body of research is focusing on the severe crisis in food global value chains caused by shortages of wheat, a key export of Russia and Ukraine (Hellegers, 2022; Carriquiry et al., 2022; Bentley et al., 2022; Abay et al., 2022; Ahn et al., 2023; Rose et al., 2023; Bertassello et al., 2023; Novotná et al., 2023; Carter and Steinbach, 2023). However, these studies are mostly limited to descriptive forecasts or simulation-based forecasting. Our study goes further in that it empirically demonstrates the impact of the recent outbreak of the military conflict on international agricultural trade, utilizing the relatively untapped advantage of South Africa's port-level monthly imports and exports data.

Lastly, this study speaks to the current literature on managing risks associated with global sourcing. In the era of global value chains, research on stable and sustainable global sourcing has recently received significant attention (Ersahin et al., 2024; Handley et al., 2023; Baldwin and Freeman, 2022; Dhyne et al., 2021; Roscoe et al., 2020; Bernard and Moxnes, 2018; Barrot and Sauvagnat, 2016; Hellerstein and Villas-Boas, 2010) In particular, the U.S.-China trade war in 2018 and the resulting tensions between the two countries have raised concerns about global supply chain dependence, especially in the semiconductor industry–the so-called "Chip War" (Miller, 2022). This has highlighted the importance of recent research on reducing and managing the risks of global sourcing (Fan et al., 2022; Charpin et al., 2021).

Whereas previous studies have centered on models and country-level flows of product imports and exports, we differentiate this research by studying how countries facing exogenous crises respond to global sourcing diversification at the port level, the frontline of cross-border trade. We also contribute to the literature by exploiting the agricultural global supply chain, which has received less attention in the literature, to provide evidence that diversification of imports stabilizes global sourcing in times of crisis beyond the country-wide level, even at the micro-level of the port level.

Our paper is organized as follows section 2 present our data and data description. section 3 examines the effect of the Russia-Ukraine War on South Africa's wheat imports and the consequences for import diversification strategies at the port level. In section 4, we study the impact of wheat import diversification policies in Africa on import volatility. section 5 explores South Africa's role in the supply of wheat to the rest of the continent. We conclude in section 6.

2 Data

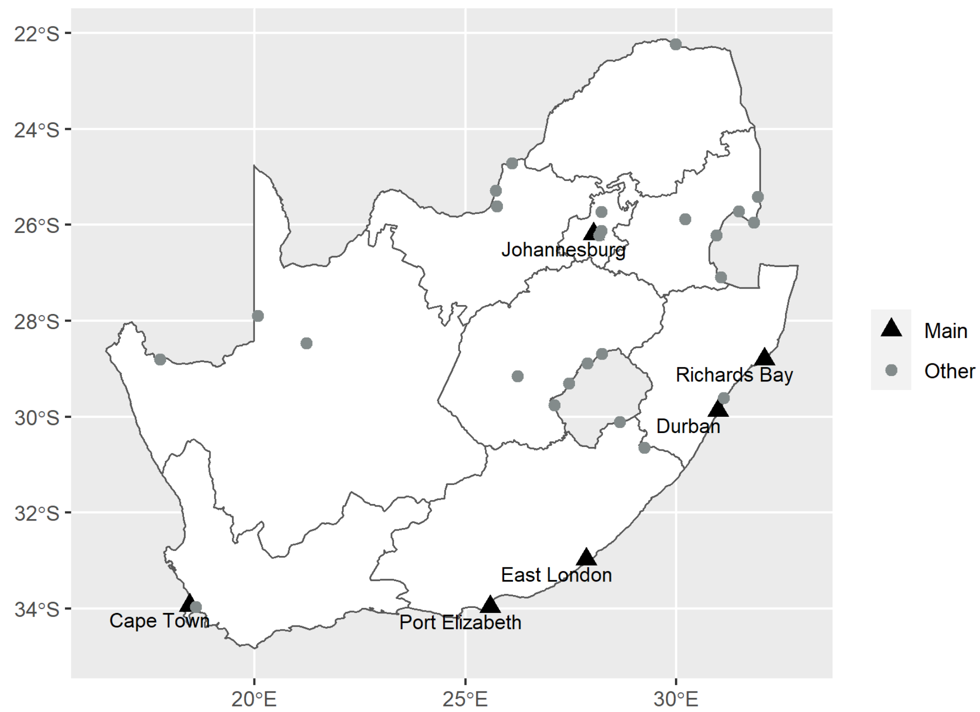
South Africa's strategic location at the southern tip of the African continent, coupled with its vast coastline along the Atlantic and Indian Oceans, places it as a key contributor to global trade flows (Chang et al., 2014; Havenga et al., 2017). The country's strategically important ports, situated on major maritime trade routes, play a pivotal role not only in facilitating trade for South Africa but also as vital conduits for landlocked nations in the Southern African region, such as Swaziland, Lesotho, Botswana, and parts of Zimbabwe (Ayesu et al., 2023). These countries heavily depend on South African ports for their imports and exports, utilizing them as unique gateways to international markets. Also, South African ports benefit from a well-developed transportation infrastructure, including efficient road and rail networks (Pieterse et al., 2016), enhancing the transportation of goods to and from the ports. In addition to serving as regional trade hubs, South Africa's ports, through their strategic location and international trade relations, create opportunities for Southern African countries to actively participate in and contribute to the broader dynamics of global commerce (Notteboom and Fraser, 2020).

To measure South Africa's port-level import and export flows, we leverage data from the Economic Complexity Observatory for South Africa's port-level trade data from January 2015 to July 2023. The data has monthly trade information for every port in South Africa with a 4-digit HS code. It provides trade flows between South Africa's ports and partner countries, whereas other publicly available data provide aggregated information at the country level, making it unique in capturing the port-level diversification strategies we want to show in this study.

We first define a "district office" as a geographically identifiable data unit located in South Africa, which we call a "port". Next, we categorized HS 1001 codes as "wheat" based on the Harmonized System (HS) classification. Finally, to sample the period from January 2015 to July 2023, if trade between district A and country B is only recorded in 2015 and no subsequent years, we combine the observations for that pair as having zero trade value in the other years. All pairs with zero imports or exports for the entire study period from 2015 to 2023 are then removed from the dataset.

For the export analysis, we included all ports for which trade records were observed in the data, as the majority of wheat exports do not rely on maritime transportation and involve land or air transport. For the import analysis, on the other hand, we limited the sample to six major ports (Cape Town, Durban, East London, Port Elizabeth, Richards Bay, and Johannesburg), given that wheat imports into South Africa from abroad are specific to certain ports. These are the ports of Cape Town, Durban, East London, Port Elizabeth, and Richards Bay, which are classified as major ports for seaborne wheat imports. We also included the dry port of Johannesburg, which is the fifth most important import port, accounting for approximately 2-5% of total imports from 2015 to 2022. Figure 1 displays geolocation information for ports in South Africa.

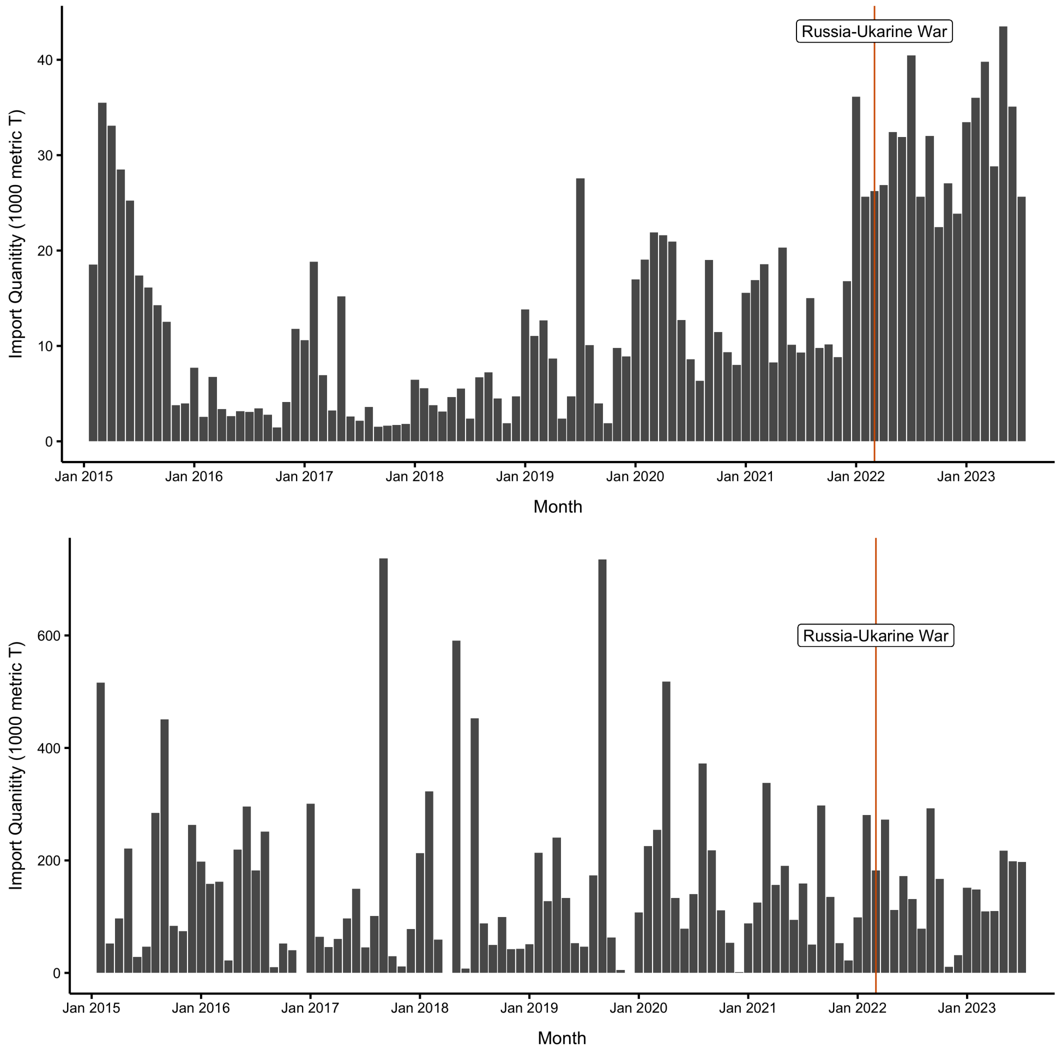
Figure 1: South African Ports: Geographical Distribution and Main Hubs



Notes: This figure illustrates the territory of South Africa and designated district office (port of entry) in The Observatory of Economic Complexity database. The main ports, namely Cape Town, Durban, East London, Port Elizabeth, Richards Bay, and Johannesburg, are indicated by black triangle point and labeled with their names. The remaining ports are indicated by gray circle point.

Figure 2 shows that, contrary to concerns raised in many of the existing literature, South Africa's wheat imports and exports to its neighbors were not substantially disrupted by the Russian-Ukrainian war. Adjusted for lower imports at the beginning of the year due to seasonality, South Africa's monthly wheat imports around February 2022 are not significantly different from the previous year. Interestingly, exports have actually been increasing since the conflict. This could suggest that neighboring trading partners may be sourcing wheat supplies from South Africa that have become scarce since the Russia-Ukraine War.

Figure 2: Wheat Export and Import Trends in South Africa



Notes: The top figure presents South Africa's monthly wheat import quantity from January 2015 to July 2023. The vertical line indicates the month of Russia's invasion (February 2022). The bottom figure presents South Africa's monthly wheat export quantity for the same period. The vertical line indicates the month of Russia's invasion (February 2022). Data is from The Observatory of Economic Complexity.

To ensure that the data from the Economic Complexity Observatory is sufficiently representative, we additionally compare it to UN Comtrade data. As shown in Figure A1, we find that the size of imports between the two data sources is similar in terms of annual volume. On the other hand, there is a slight difference in the size of exports. We note that the UNCTAD data lacks export volume information for 2017.

3 Russia-Ukraine War and Port-Level Import Diversification

3.1 The War's Influence on South Africa's Wheat Import

Baseline Prior to examining the impact of the Russia-Ukraine War on South Africa's port-level import diversification and subsequent import volatility, we first explore how the war has affected South Africa's wheat imports by estimating the following specification:

$$y_{ijt} = exp[\beta_0 + \beta_1 Post_t + D_{mo(t)} + \gamma_i + \delta_j]\varepsilon_{ijt} \tag{1}$$

The subscript t denotes time in month-year. i and j denote the major ports and exporting countries, respectively. y_{ijt} denotes the monthly wheat quantity, and $Post_t$ is a binary variable that equals to 1 after the Russia-Ukraine War in Feburary 2022 and 0 otherwise. $D_{mo(t)}$ denotes month dummies, $D_{yr(t)}$ denotes year dummies, γ_i denotes major port fixed effects, and δ_j represents exporter fixed effects. To account for the large number of zeros, we estimate the parameters using the pooled Poisson quasi-maximum likelihood estimation method (QMLE).

To take into account seasonal patterns or business cycles in wheat imports, we further analyze the impact on year-over-year change by estimating the following regression model:

$$\Delta y_{ijt} = \beta_1 Post_t + \gamma_i + \delta_j + u_{ijt} \tag{2}$$

where Δ operator denotes the difference between the time t and *t-12* values for a variable y and this specification is estimated by the pooled OLS regression.

Contrary to the concerns of many previous studies, as shown in Table 1, we find that the impact of the Russia-Ukraine War on South Africa's wheat imports is not statistically significant. In columns (1) and (3), we find that South Africa's on average wheat imports from all exporting countries tend to be negative after the war, but not statistically significant. This result might lead one to consider the restricted wheat imports from Russia and Ukraine as a result of increased imports from other countries. To check this, in columns (2) and (4), we exclude these two countries and look at imports, but even with these two countries excluded, the results are consistent.

Table 1: Russia-Ukraine War and Wheat Import in South Africa

	Monthly Quantity		YoY Change	
	All	Excl.UA-RU	All	Excl.UA-RU
	(1)	(2)	(3)	(4)
Post	-0.045	0.313	-0.057	-0.300
	(0.327)	(0.274)	(0.401)	(0.413)
Observation	9,579	8,549	8,554	7,644
Pseudo R^2	0.516	0.493		
R^2			0.001	0.001
Port FEs	✓	✓	✓	✓
Exporter FEs	✓	✓	✓	✓
Month FEs	✓	✓		

Notes: Columns (1) and (2) present results from Equation 1, and Columns (3) and (4) display results from Equation 2. *Excl.UA-RU* denotes the subgroup that excludes Ukraine and Russia. Standard errors are clustered at port-exporter pair and reported in parentheses. The p-values read as follows: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

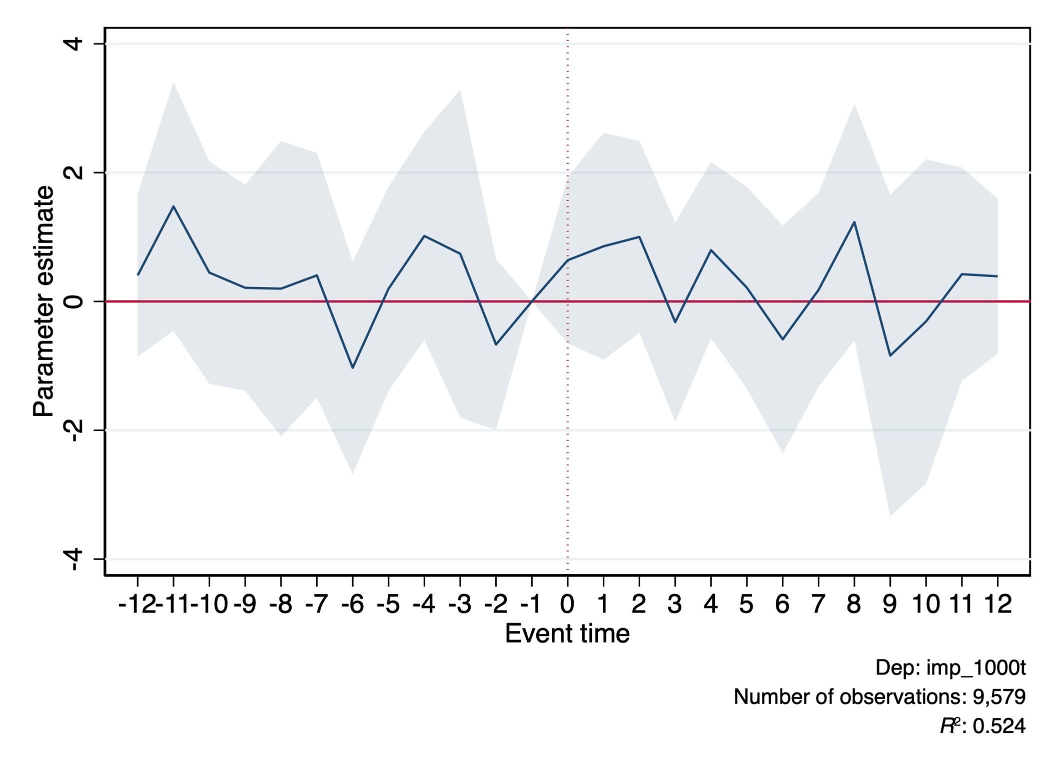
Dynamic Effects To examine how the effects of war change over time, we examine the dynamic effects of war using the following event study regression model:

$$y_{ijt} = exp[\beta_0 + \sum_{s=-12}^{s=12} \beta_s I_{t-s} + D_{mo(t)} + \gamma_i + \delta_j]\varepsilon_{ijt} \tag{3}$$

where $I_{ij,t-s}$ is the indicator of $t \pm G$ from the event indicating G month before and after the war. As shown in Figure 3, we find no statistically significant change in South African smuggling in each of the 12 months before and after February 2022. Taken together, these two results suggest that, contrary to many expectations, we do not find statistically significant evidence of a detrimental trade effect on South Africa's wheat imports following Russia's invasion.

This result suggests two key implications. First, given that many countries, especially those in Africa and the Middle East, have suffered severe distribution disruptions in the wheat supply chain as a result of the war, South Africa has weathered the shock relatively well. Second, given that South Africa has withstood the storm of the global wheat value chain crisis, there might be

Figure 3: Dynamic Effect of the Russia-Ukraine War on Wheat Import in South Africa



Note: This figure illustrates the dynamic impact of the war on South Africa's wheat import. The Y-axis represent the coefficients on event dummies and the solid line connects the each estimates on the event dummies. The X-axis indicates the event timeline and "Event time = 0" marks the month of the invasion. The month before the war is omitted as a reference category. The estimates are obtained by estimating Equation 3 and pooled Poisson estimator. The band is a 95% confidence interval.

relatively little food insecurity in the many Southern African regions that heavily rely on wheat imports from South Africa.

3.2 War Impact on South Africa's Wheat Import Diversification

As shown earlier, South Africa's wheat imports were not directly or indirectly affected by the war, which may suggest that the country may have been more strategic in its import diversification strategy than other countries. To delve deeper, we utilize South Africa's port-level import data to investigate whether the Russia-Ukraine War was linked to wheat import diversification at the port level in South Africa.

We begin by measuring import diversification at the port level, similar to Handley et al. (2023)'s measure of "foreign concentration" for U.S. import. This metric assesses the ease of finding alternative import sources in response to shocks. The measure employed is the

Hirschman-Herfindahl Index (HHI), defined for each port i as follows:

$$HHI_i = \sum_j \left[\frac{M_{ji}}{\sum_j M_{ji}} \right]^2 \tag{4}$$

M_{ji} represents the import value (quantity) of wheat from source country j at port i. The HHI (HHI_i) is calculated as the sum of squared import shares, where a lower value indicates a more even distribution of imports across sources at port i. This index can be computed for each time period.

Table 2 shows the HHI index for major ports. One thing to note from this table is that, compared to 2022, most ports diversified their wheat import in 2023. With the exception of Port Elizabeth and Richards Bay, which have a relatively small share of imports, all major ports have seen a decrease in the HHI index, especially Durban, which accounts for the largest share, from 0.53 to 0.43, and Cape Town from 0.70 to 0.39. This suggests a diversification of wheat imports at the port level in South Africa following the Russia-Ukraine War in 2022. This pattern generally holds when we compare only the HHI index averaged over January to July to ensure compatibility with the year 2023 (see Table A2).

Table 2: Average HHI Index for Each Main Port

Main Ports	Year									
	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Cape Town	0.64	0.42	0.61	0.41	0.29	0.58	0.59	0.70	0.39	0.52
Durban	0.61	0.45	0.54	0.62	0.46	0.53	0.62	0.53	0.43	0.54
East London	0.13	0.08	0.00	0.00	0.17	0.08	0.17	0.42	0.14	0.13
Johannesburg	0.38	0.61	0.70	0.59	0.63	0.81	0.71	0.42	0.14	0.58
Port Elizabeth	0.46	0.33	0.08	0.33	0.36	0.29	0.13	0.25	0.43	0.29
Richards Bay	0.21	0.00	0.17	0.17	0.00	0.22	0.50	0.17	0.29	0.19
Total	0.40	0.32	0.35	0.35	0.32	0.42	0.45	0.41	0.30	0.37

Note: HHI indexes are calculated for each main port in each month-year from Jan 2015 to Jul 2023 and averaged over month for each years.

Subsequently, our baseline specification is as follows:

$$HHI_{it} = \alpha_1 HHI_{i,t-1} + \beta_1 Post_t + D_{mo(t)} + D_{yr(t)} + \gamma_i + \varepsilon_{it} \tag{5}$$

where HHI_{it} represents the HHI index for each main port i at time t. We include the lag variable in the model to account for the potential persistence of diversification.

In addition to the baseline model, we further introduce variation in postwar shocks by incorporating the variable $importance_i$, a unique value assigned to each major port to account for the fact that the greater the linkage between a port and tradable goods, the more exposed the port is to shocks. Specifically, we interact this value with the postwar time indicator to construct an "exposure" variable. To measure this exposure variable, we employ port-specific coefficients from Verschuur et al. (2022). These coefficients quantify the domestic and global economy's dependence on trade flows through ports, using links between transportation models and multi-regional input-output tables (MRIOs) for 1,278 ports in 178 countries, capturing each port's layer of the global supply chain. The alternative specification is follows as:

$$HHI_{it} = \alpha_1 HHI_{i,t-1} + \beta_1 Importance_i \times Post_t + D_{mo(t)} + D_{yr(t)} + \gamma_i + \varepsilon_{it} \tag{6}$$

We employ the QMLE fractional probit regression for both specifications, and the Table 3 shows the regression results. Columns (1) and (2) show the results for Equation 5 and columns (3) and (4) show the results for Equation 6, respectively. The marginal effects row represents the average marginal effect of the war.

Based on Equation 5, an estimation of the marginal effect reveals an average decrease of 0.205 in the size of the HHI index following the war. Additionally, when taking into account the relative exposure outlined in Equation 6, it is observed that a one-unit increase in the exposure measure correlates with a 0.05 decrease in the HHI index.

This finding indicate that following the war, South Africa's primary ports diversified their wheat imports. This can be construed as a strategic move to broaden trade alliances across various nations, mitigating the reliance on a limited number. Such diversification serves to diminish the susceptibility to external political volatility or regional conflicts. Furthermore, the

Table 3: War Impact on South Africa's Wheat Import Diversification

	Port-level Diversification (HHI Index)			
	(1)	(2)	(3)	(4)
Lag HHI	0.140	0.106	0.269	0.223
	(0.174)	(0.155)	(0.179)	(0.152)
Post	-0.057	-0.699**		
	(0.195)	(0.254)		
Exposure (Importance*Post)			0.025	-0.159+
			(0.026)	(0.084)
Marginal Effects	-0.019	-0.205***	0.008	-0.050*
	(0.066)	(0.071)	(0.007)	(0.026)
Port FE	✓	✓	✓	✓
Month FE	✓	✓	✓	✓
Year FE		✓		✓
Observation	612	612	510	510

Note: Columns (1) and (2) present results from Equation 5, and Columns (3) and (4) display results from Equation 6. The Marginal Effects row represents the average marginal (partial) effects of the variable *Post* and *Exposure*. Standard errors are clustered at port-level and reported in parentheses. The p-values read as follows: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

adjustment of trade volume or proportion with existing countries also contributes to achieving diversification. Building upon the insights from the preceding Table 1, during the wheat import crisis triggered by the Russia-Ukraine War affecting numerous countries, South Africa, positioned as a key hub in the South African trade network, demonstrated agility by promptly diversifying its wheat imports on a port-by-port basis. This strategic maneuver allowed South Africa to avert the repercussions of the war-induced crisis.

4 Port Diversification and Import Volatility

So far, we have seen that South Africa coped well with the international wheat supply chain disruption triggered by the Russia-Ukraine War by diversifying imports at the port level after the war. While diversification has performed well in maintaining South Africa's total wheat imports, on the other hand, the rapid diversification of wheat imports may increase risks to the stability of import flows on a port basis. Swiftly shifting from established import routes may heighten volatility in imports due to short-term shortages, contractual delays, limitations in port infrastructure capacity, and other factors. In this analysis, we examine how South Africa's import diversification has affected the annual volatility of imports.

We begin by measuring the import volatility by calculating a a standard deviation of the growth rates (change) of outcome within an arbitrary time window following (e.g., Davis et al., 2006; Kurz and Senses, 2016). Specifically, we use the residual monthly change (v) to calculate the wheat import volatility in South Africa as follows:

$$\Delta imp_{ij,y,m} = imp_{ij,y,m} - imp_{ij,y,m-1} = \overline{\Delta imp}_{ij,m} + v_{ij,y,m} \quad (7)$$

where $\Delta imp_{ij,y,m}$ monthly growth rate as a difference between two subsequent month. the residual change ($v_{ij,y,m}$) is defined as the change or growth that is not explained by the average monthly changes in port-exporter import during the sample period ($\overline{\Delta imp}_{ij,m}$).

In the initial phase, we compute the residual, denoted as $v_{ij,y,m}$, by conducting an OLS regression of monthly import changes on port-export-month dummies. As outlined in Equation 8, we define the volatility (σ) as the standard deviation of the residual (v) within a 12-month window. This process results in the annual volatility, considering the available data for each year (e.g., for the year 2023, where we have data for 7 months, the window spans 7 months).

$$\sigma_{ij,y} = \sqrt{\frac{1}{w}\sum_{m=2}^{w} v_{ij,y,m}^2} \qquad \text{for } y = 2015, ...2023 \quad (8)$$

We next analyze the relationship between port diversification and the import volatility by estimating the following model:

$$\sigma_{ijy} = \alpha_0 + \beta_0 Post_y + \beta_1 HHI_{iy} + \beta_2 Post_y \times HHI_{iy} + \gamma_i + \delta_j + \varepsilon_{ijy} \quad (9)$$

where y denotes the year, $Post_y$ represents a binary variable with a value of 1 post-event (years 2022 and 2023) and 0 otherwise. $HHIiy$ denotes the average monthly HHI for the primary port i in year y. The HHI index is time-demeaned in our analysis.

Table 4 reports the results of the regression analysis. Column (1) show the results using the current HHI variable, while Column (2) shows the results using the lagged HHI variable instead of the current period, respectively. Recall that HHI is used as an indicator of the concentration of wheat imports at each port. If this index increases and reaches 1, it means that the port is concentrated in a small number of importing countries. Conversely, a lower HHI index indicates less concentration, meaning that imports are more evenly distributed or diversified. We find that HHI and import diversification are positively correlated in all specifications before the war. This implies that the more diversified wheat imports are, the less volatile they are. This is consistent with the literature that more diversified sources reduce the volatility of wheat imports, while more concentrated imports from a few countries increase the volatility of imports.

Table 4: Port Diversification and Annual Import Volatility

	Import Volatility	
	(1)	(2)
Post	-0.066	-0.087
	(0.178)	(0.183)
HHI	1.911***	
	(0.380)	
HHI*Post	-5.559***	
	(1.104)	
Lag HHI		1.647**
		(0.606)
Lag HHI*Post		-2.222*
		(1.130)
Exporter FE	✓	✓
Observation	846	752
Pseudo R^2	0.430	0.411

Note: Standard errors are clustered at port-exporter pair and reported in parentheses. The p-values read as follows: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

However, we observe in both models that the slope coefficient of the HHI reverses to a negative relationship after the war. We find that the interaction terms are -5.559 in column (1) and -2.222 in column (2), respectively. This suggests, in other words, that after the war, diversification of imports no longer mitigates instability as effectively as before, but rather exposes ports to more risk. Taken together, our results provide a suggestive evidence that South Africa diversifies its imports to spread its supply chain, but the risk of volatility in South Africa's imports increases because the new and existing supply chain is also exposed to war-related crises. In other words, South Africa's import diversification is not free from the emerging risks associated with war that affect its import channels, and the risk may be transmitted to the country.

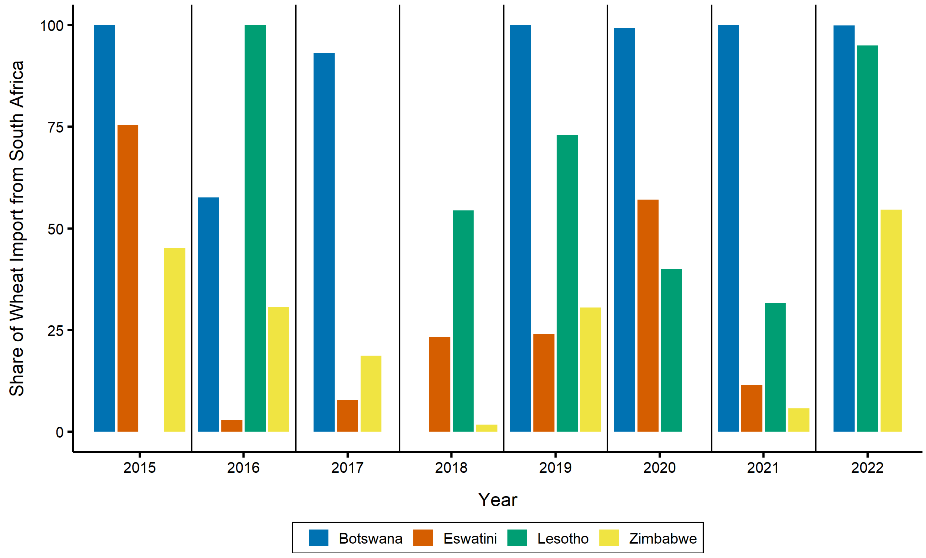
5 Russia-Ukraine War and Southern Africa's Wheat Sourcing

In this section, we turn our attention to the impact of the Russia-Ukraine War on wheat imports for countries across southern Africa. Considering that many developing countries, particularly African countries in the sub-Saharan region, have been severely hit in wheat imports due to the Russia-Ukraine War, one would think that the Southern African region would be no exception. However, we would focus on the fact that, unlike other African countries, Southern African countries, including Botswana, Eswatini, Lesotho, and Zimbabwe, have traditionally been highly reliant on wheat imports from South Africa (Jayne et al., 2006). Guided by the notion that the stability of South Africa's wheat imports might indirectly affect the overall wheat supply in southern Africa, we now explore how wheat imports from South Africa have been affected in the post-war period for the countries of southern Africa.

Prior to the parametric analysis, we examine the dependence of the Southern African region on South African wheat imports prior to the Russo-Ukrainian War. In particular, we focus on the overland import route for the Southern African region, which includes the four landlocked countries bordering South Africa: Botswana, Eswatini, Lsotho, and Zimbabwe. These countries are isolated from the rest of the world by waterways and rely on transportation through overland ports for wheat.

Using UN Comtrade import database, the trend of these four countries' annual wheat imports from South Africa from 2015 to 2022 is shown in Figure 4. These countries have in common that South Africa is a large part of their wheat imports. In the case of Bostswana, it relies on South Africa for almost all of its wheat imports. Lesotho, which is geographically surrounded by South Africa, also has a high share of wheat imports from South Africa. It is noteworthy that, compared to 2021, all countries (with the exception of Eswatini, for which data is not available) imported significantly more wheat from South Africa in 2022, the year the war broke out. Given that wheat production in these neighboring countries is small relative to consumption, this suggests that their dependence on South African wheat imports increased after the war.

Figure 4: Dependence of Neighboring Landlocked Countries on Wheat Imports from South Africa

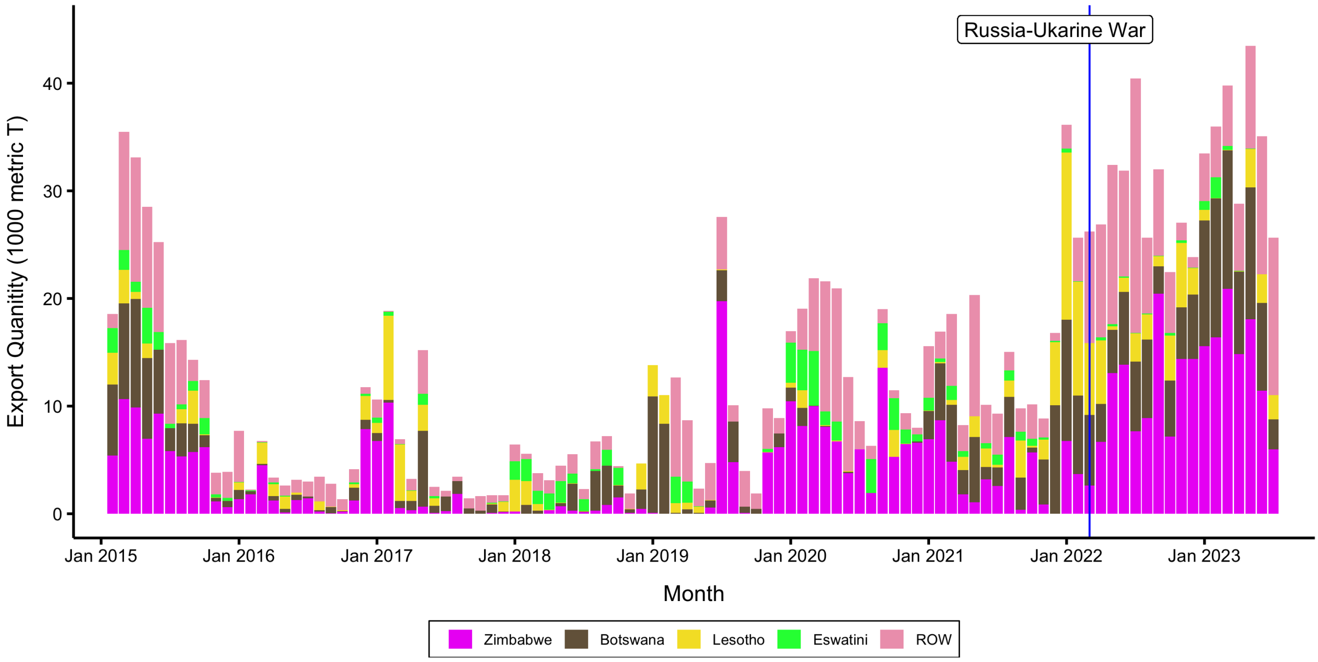


Note: This figure depicts the percentage share of wheat imports from South Africa across four neighboring landlocked countries. The Y-axis is measured in percentages (%), and each bar represents an individual country. Empty bars indicate missing data. The information is sourced from UN Comtrade.

For a more granular picture of wheat trade overland, we further show the trend of wheat exported using ground transportation, including road and rail, on a monthly basis from January 2015 to July 2023 using the port-level Economic Complexity Observatory data. These ports include all the ground ports in the border areas of South Africa shown in Figure 1 and the trend is shown in Figure 5.

As shown in the table above, the region's wheat imports from South Africa by overland sharply increased after February 2022, when the war erupted, compared to the trend in the years prior to that. Even excluding the short-term spike in wheat imports from South Africa in the first half of 2020 due to the outbreak of the pandemic, we can still see that South Africa's exports to neighboring landlocked countries increased by an average of more than three times in the second half of 2022. This suggests that since the war, South Africa, and in particular landlocked countries bordering South Africa, have dramatically increased their sourcing of wheat imports from South Africa as a way to address the crisis in the global wheat supply chain.

Figure 5: Trend in Wheat Exports to Neighboring Landlocked Countries via Ground Transportation (Road and Rail)



We next empirically investigate the consequences of the Russia-Ukraine War on the wheat exports of neighboring South African importers from South Africa by estimating the following specification:

$$y_{ikt} = exp[\beta_0 + \beta_1 Post_t + D_{mo(t)} + \gamma_i + \eta_k]\varepsilon_{ikt} \quad (10)$$

The subscript t represents time in the format month-year, with i and k denoting ports and importing countries, respectively. y_{ijt} is the monthly quantity of wheat exports, and $Postt$ is a binary variable, equal to 1 in any time after February 2022, otherwise 0. $Dmo(t)$ indicates month dummies, $D_{yr(t)}$ represents year dummies, γ_i denotes port fixed effects, and η_k represents importer fixed effects. The parameters are estimated by pooled Poisson QMLE. In addition to our baseline model, we examine the influence of the conflict on the year-on-year change. We also conduct a subgroup analysis by categorizing wheat importers into two groups: the four adjacent landlocked countries and other wheat trading partner countries, as specified in Table A1.

The Table 5 reports the results. We find that exports from South Africa increased by an average of 183% ($e^{1.042} - 1$) after the war, as shown in column (1), which is statistically significant. This result is also consistent when we look at the YoY change, with an increase of 10% ($e^{0.096} - 1$), taking into account that there might be seasonality in wheat trade. This effect, as shown in columns (2) and (3), is slightly more pronounced for the four landlocked countries that trade with their neighbors by ground than for the other countries.

Table 5: The Effects of Russia-Ukraine War on Southern Africa's Wheat Imports from South Africa

	Monthly Quantity			YoY Change		
	All	Landlocked	Others	All	Landlocked	Others
	(1)	(2)	(3)	(4)	(5)	(6)
Post	1.042***	1.084***	0.937***	0.096*	0.270	0.030^{+}
	(0.167)	(0.206)	(0.283)	(0.046)	(0.160)	(0.016)
Observation	11,845	2,678	8,755	10,829	3,003	7,826
Pseudo R^2	0.562	0.500	0.527			
R^2				0.007	0.019	0.004
Port FE	✓	✓	✓	✓	✓	✓
Exporter FE	✓	✓	✓	✓	✓	✓
Month FE	✓	✓	✓			

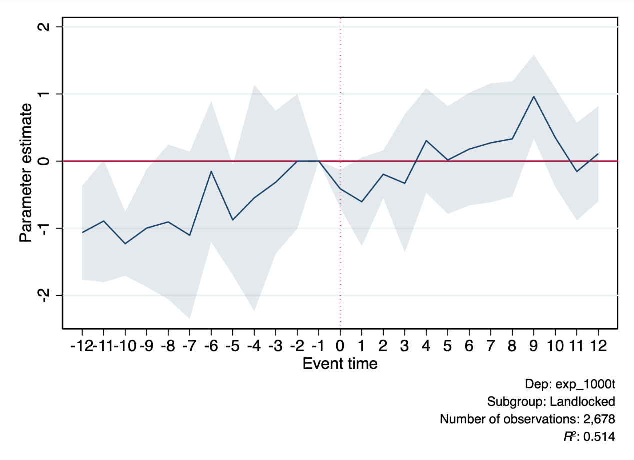
Note: Landlocked countries include four nations that are adjacent to South Africa: Botswana, Zimbabwe, Lesotho, and Eswatini. The other subgroup includes the remaining importing countries, excluding the four landlocked ones listed in the Table A1. Standard errors are clustered at port-importer pair and reported in parentheses. The p-values read as follows: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

We further used the model in Equation 3 to show the dynamic effect of the war on wheat imports from South Africa in Figure 6. We find that in the landblock countries and the other country group, which includes a number of African countries, imports from South Africa tend to increase for about nine months after the war. This increase then tends to decline in both groups beyond nine months.

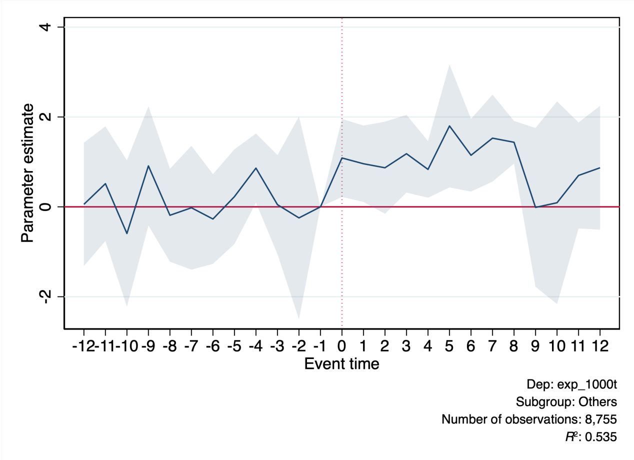
In the previous sections, we have examined South Africa's import diversification strategy after the Russia-Ukraine War South Africa stabilized its wheat supply by diversifying its imports at the risk of increased import volatility at ports of entry. Based on our findings in this section, South Africa's proactive diversification of its wheat sourcing has resulted in a more secure wheat supply, not only for South Africa, but also for neighboring Southern African countries that are heavily dependent on South Africa for food.

Taken together, our results suggest important implications from the angle of global food supply chains. In the face of a disruption in the global food supply chain, such as the Russia-Ukraine War, poorer countries with lower self-sufficient food productivity are more likely

Figure 6: Event Studies on the Impact of the Russian Invasion of Ukraine on South Africa's Wheat Exports



(a) Landlocked Countries



(b) Other Countries

Note: The figure visually illustrates the dynamic impact of the war on South Africa's wheat exports to four adjacent landlocked countries. Landlocked countries include four nations that are adjacent to South Africa: Botswana, Zimbabwe, Lesotho, and Eswatini. The Y-axis represent the coefficients on event dummies and the solid line connects the each estimates on the event dummies. The X-axis indicates the event timeline and "Event time = 0" marks the month of the Russian invasion. The month before the war is omitted as a reference category. The estimates are obtained from the regression of a modified version of Equation 3 for export analysis and pooled Poisson estimator. The band is a 95% confidence interval.

to experience a severe food insecurity. Our research suggests that during such crises, rapid sourcing diversification in a nearby major port country–in the context of our study, South Africa–plays an important role in averting a food crisis for the surrounding region as a whole. As such, policymakers may need to explore strategies beyond direct food aid, including measures such as supporting port infrastructure in intermediate supply countries or offering conditional tariff and non-tariff benefits to enhance the resilience of global supply chains.

6 Conclusion

In this study, we explore the impact of military conflicts in other countries on the wheat supply of non-conflict bystander southern Africa. We utilize monthly port-level wheat trade data from January 2015 to July 2023 in South Africa for this study. We begin by analyzing the impact of Russia's Ukraine invasion on wheat imports. The findings indicate that the war did not have a statistically significant impact on South Africa's wheat imports. This suggests that, unlike other African and Middle Eastern nations that faced more direct disruptions in their wheat supply chains due to the war, South Africa adeptly managed the shock. Following that, we investigate the impact of the war on the import diversification of ports to understand the trade adjustment mechanism. Port-level import diversification is measured using the Herfindahl-Hirschman Index method. Our findings suggest that South Africa manages imports by diversifying import sources in response to the war.

Moving forward, we explore the risks in terms of import volatility associated with diversifying South Africa's wheat imports. We find that import volatility and import diversification are positively correlated before the war, implying that the more diversified wheat imports are, the less volatile they are. However, we find this relationship is reversed in the post-war period, indicating that the more diversified wheat imports are, the more volatile they become. This suggests, in other words, that after the war, diversification of imports may no longer mitigate instability as effectively as before but rather expose ports to more risk.

Finally, our empirical analysis reveals a statistically significant increase in wheat exports from South Africa to neighboring landlocked countries following the war. Considering these countries' dependence on South Africa for wheat imports, our research sheds light on the crucial role of trade resilience in South Africa in preventing potential food crises in neighboring countries.

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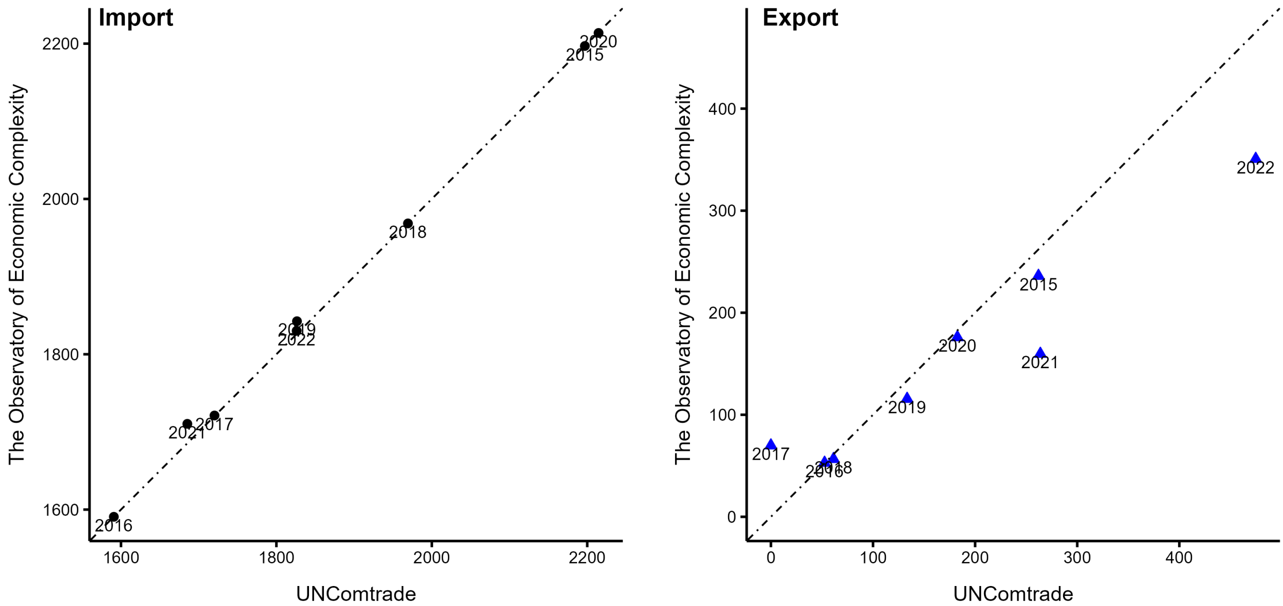
Appendix

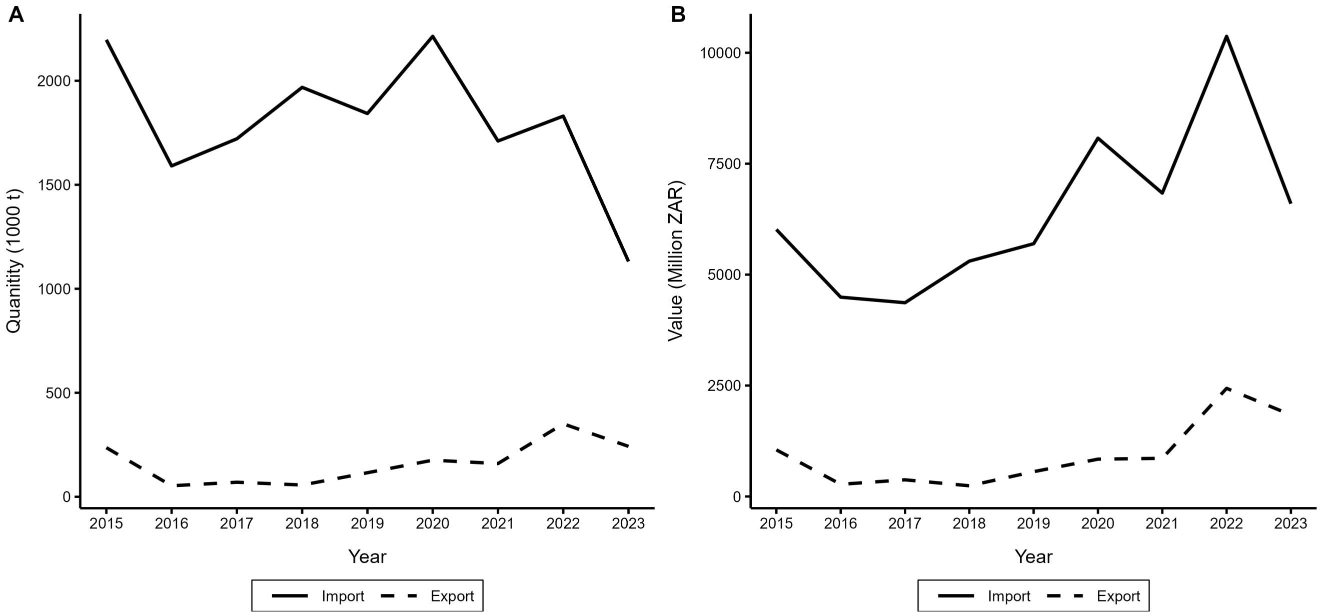
A Appendix Figures

Figure A1: The Representativeness of Trade Flow Data from The Observatory of Economic Complexity



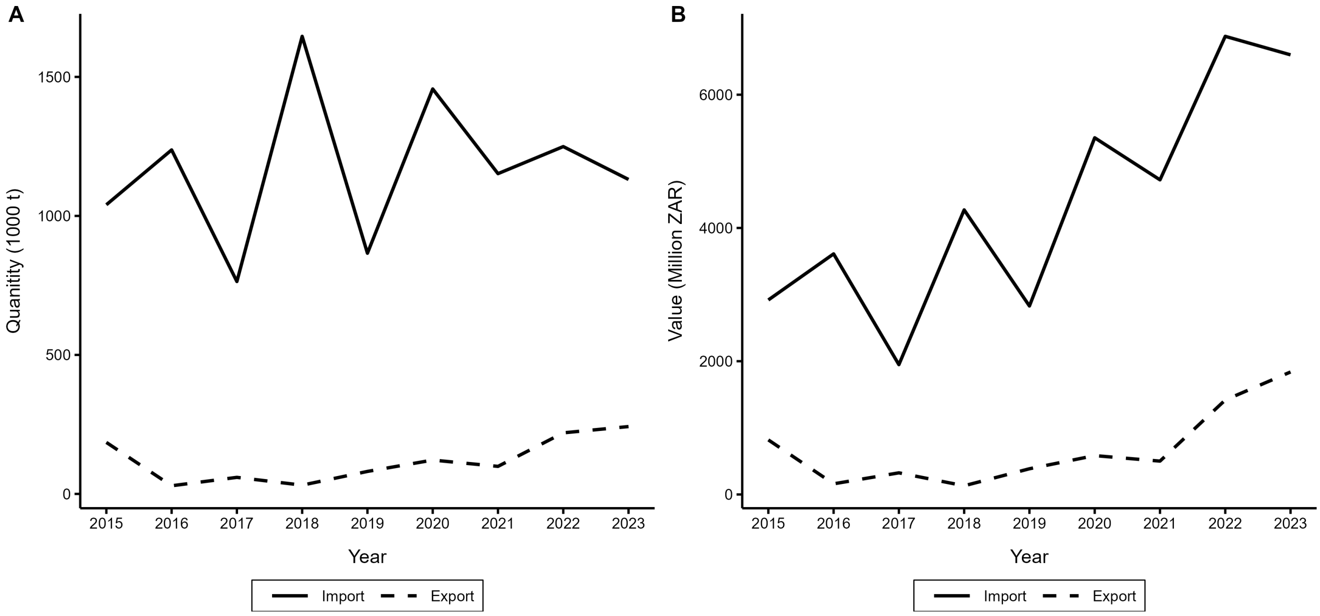
Note: This figure juxtaposes the annual quantities of wheat imports and exports from The Observatory of Economic Complexity and UN Comtrade. The Y-axis corresponds to The Observatory of Economic Complexity, and the X-axis corresponds to UN Comtrade. Unit of quantity is 1,000 Ton. A dot-dash line at a 45-degree angle serves as a reference, and data points aligning more closely with this diagonal line indicate greater similarity. We see a resemblance in import quantities between the two data sources across years. In contrast, we find some diaparity in the export quantity: UN Comtrade data lack export quantity information in 2017 and The Observatory of Economic Complexity seems underrepresented compared to UN Comtrade in 2021 and 2022.

Figure A2: The Annual Trend of Wheat Trade in Quantity and Value



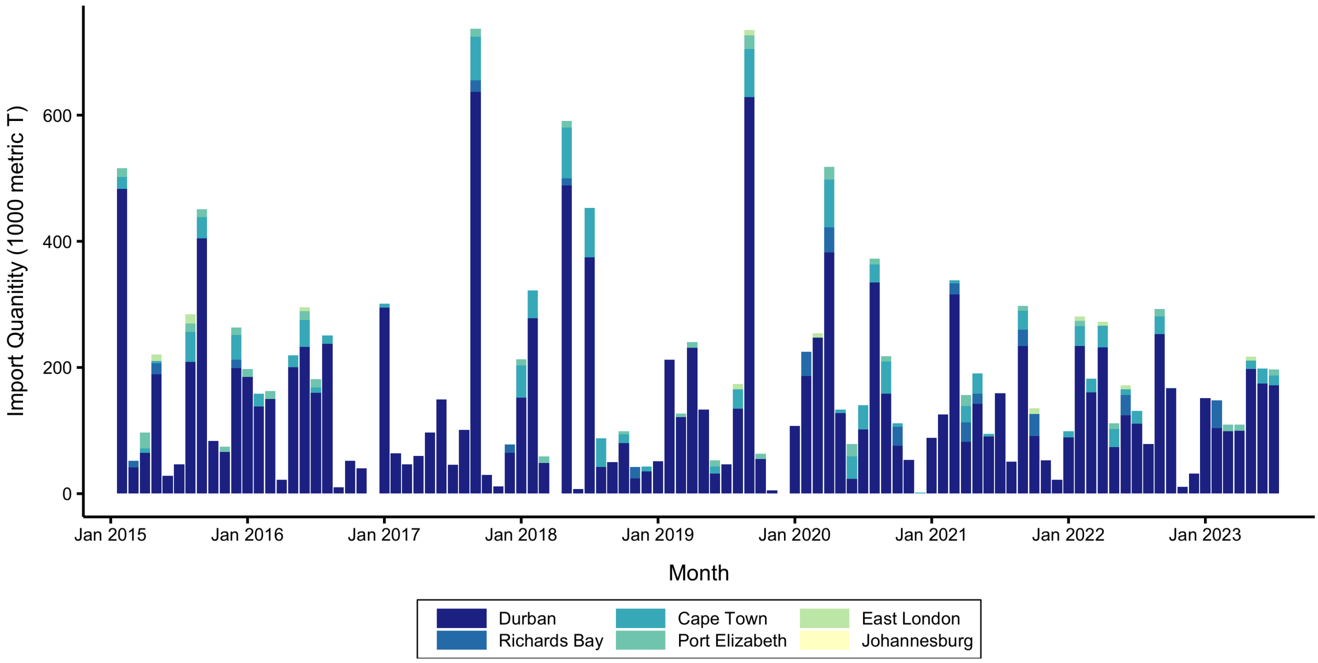
Note: Between 2021 and 2022, the import quantity increased by 7% and the export quantity increased by 120%. The import value rose by 51.7%, and the export value increased by 183%. Trade value is a nominal term. Table corresponding to this figure is Table A3

Figure A3: The Annual Trend of Wheat Trade in Quantity and Value - January to July



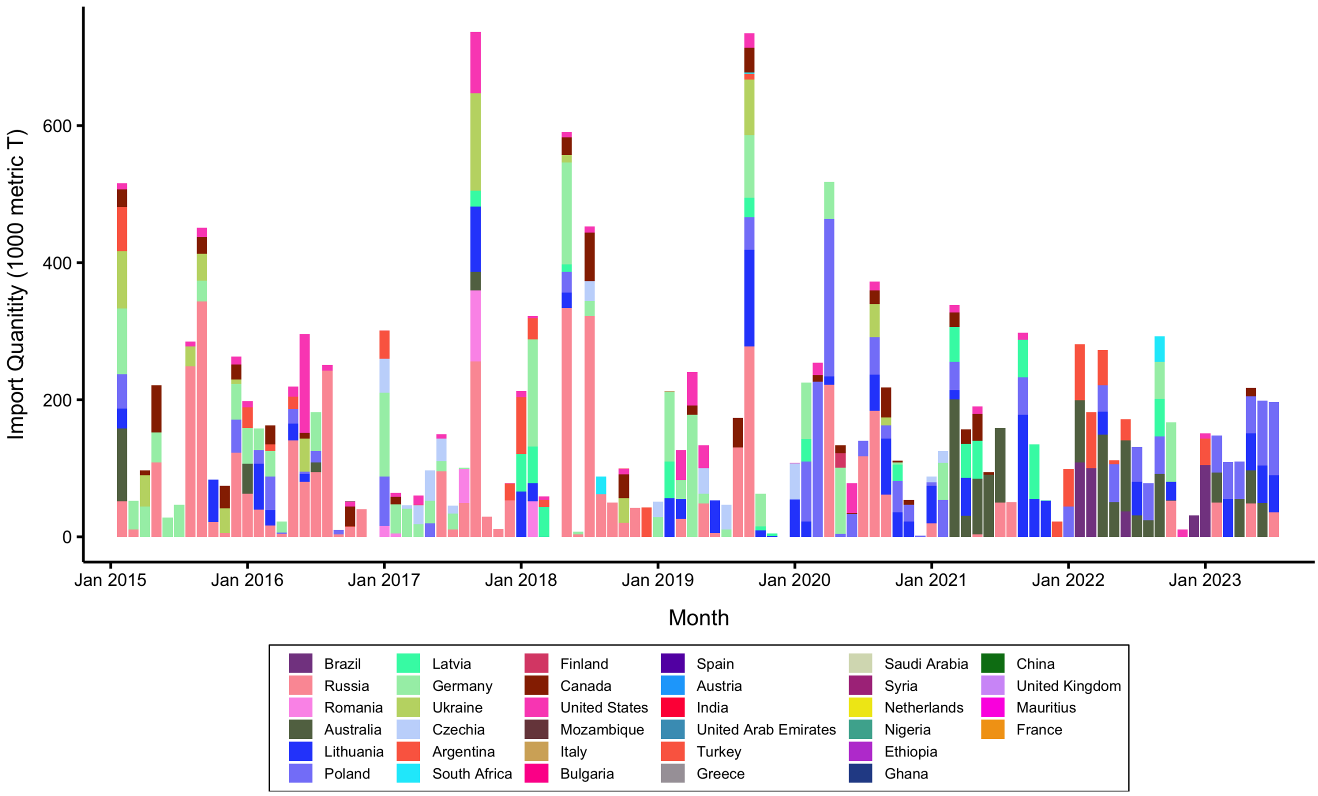
Note: As the data for 2023 is accessible solely for the period from January to July, we present the values summed from January to July on an annual basis to ensure compatibility with the year 2023. Between 2021 and 2022, the import quantity increased by 8.5% and the export quantity increased by 122%. The import value rose by 45.6%, and the export value increased by 183% Between 2022 and 2023, the import quantity decreased by 9.5% and the export quantity increased by 10.3%. The import value decreased by 4%, and the export value increased by 29.7%. Trade value is a nominal term. Table corresponding to this figure is Table A4

Figure A4: Wheat Import Through Main Ports



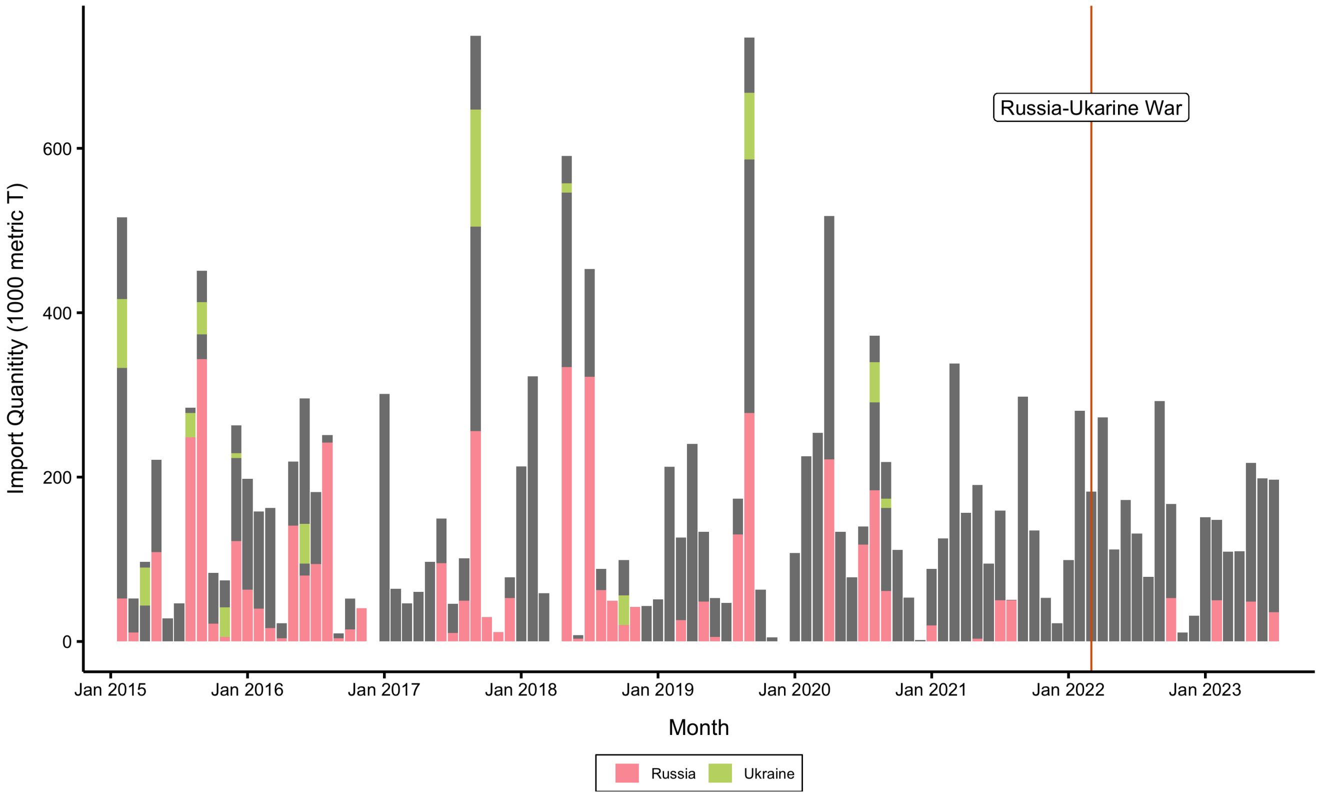
Note: The figure presents the South Africa's monthly wheat import quantity from January 2015 to July 2023 at each main ports. Data is from The Observatory of Economic Complexity

Figure A5: Wheat Maritime Import Through Main Ports By Source Country



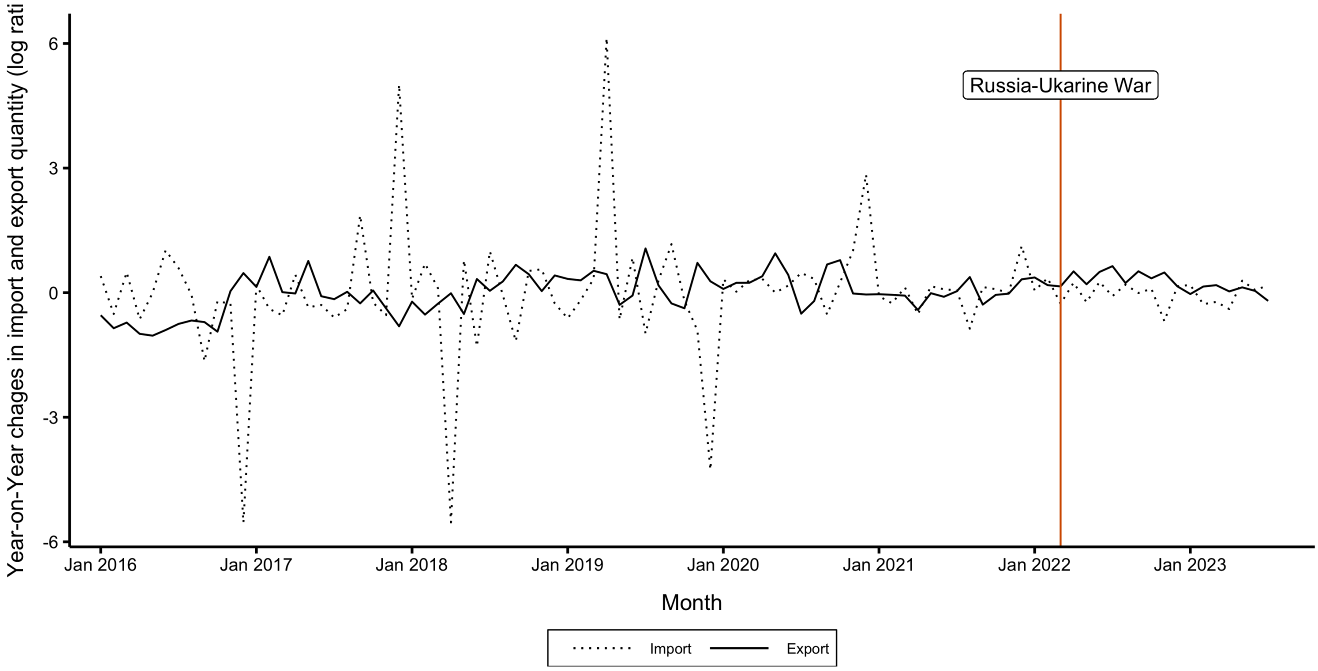
Note: The figure presents the South Africa's wheat import by source country. Data is from The Observatory of Economic Complexity.

Figure A6: Wheat Maritime Import Through Main Ports From War Countries



Note: The figure highlightes the share of wheat import from the Ukraine and Russia to South Africa. Data is from The Observatory of Economic Complexity.

Figure A7: Year-On-Year Changes In Wheat Trade



Note: he figure illustrates the year-on-year changes in the quantity of wheat imports and exports for South Africa. The Y-axis represents the logarithmic ratio of these changes. Data is from The Observatory of Economic Complexity.

B Appendix Tables

Table A1: List of Countries Trading Wheat with South Africa

Exporter	Importer
Argentina	Angola
Australia	Australia
Austria	Botswana
Brazil	Canada
Bulgaria	Democratic Republic of the Congo
Canada	Eswatini
China	Germany
Czechia	Greece
Ethiopia	Hong Kong
Finland	Indonesia
France	Kenya
Germany	Lesotho
Ghana	Madagascar
Greece	Malawi
India	Malaysia
Italy	Maldives
Latvia	Mauritius
Lebanon	Mozambique
Lithuania	Namibia
Mauritius	Netherlands
Mozambique	New Zealand
Netherlands	Nigeria
Nigeria	Reunion
Poland	Saint Helena
Romania	Seychelles
Russia	Sudan
Saudi Arabia	Sweden
Spain	Taiwan
Syria	Tanzania
Turkey	United Arab Emirates
Ukraine	United Kingdom
United Arab Emirates	United States
United Kingdom	Zambia
United States	Zimbabwe

Note: An exporter is a country that exports wheat to South Africa, while an importer is a country that imports wheat from South Africa. These countries are included in the dataset, covering the period from 2015 to 2023.

Table A2: Average HHI Index for Each Main Port - January to July

Name of Main Ports	Year									
	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Cape Town	0.71	0.57	0.57	0.35	0.22	0.37	0.79	0.86	0.39	0.54
Durban	0.67	0.37	0.45	0.44	0.48	0.57	0.50	0.44	0.43	0.48
East London	0.08	0.14	0.00	0.00	0.00	0.14	0.00	0.71	0.14	0.14
Johannesburg	0.43	0.64	0.66	0.63	0.53	0.83	0.51	0.43	0.14	0.53
Port Elizabeth	0.21	0.57	0.00	0.43	0.43	0.21	0.07	0.29	0.43	0.29
Richards Bay	0.22	0.00	0.00	0.14	0.00	0.29	0.43	0.29	0.29	0.18
Total	0.39	0.38	0.28	0.33	0.28	0.40	0.38	0.50	0.30	0.36

Note: The HHI indexes are calculated for each main port in each month-year from January 2015 to July 2023 and averaged over each month for each year. Since data for 2023 is available only for the period from January to July, we present the values averaged over January to July to ensure compatibility with the year 2023.

Table A3: Total Annual Wheat Import and Export of South Africa

	Quantity (1000 Ton)		Value (Million ZAR)	
Year	Import	Export	Import	Export
2015	2,196.96	236.04	6,016.75	1,051.00
2016	1,590.71	52.88	4,491.91	274.59
2017	1,721.15	69.87	4,366.69	375.49
2018	1,968.48	56.56	5,303.68	241.22
2019	1,842.55	115.51	5,696.53	559.16
2020	2,213.73	175.91	8,075.48	841.19
2021	1,710.42	159.64	6,837.52	859.64
2022	1,830.19	350.67	10,370.65	2,437.04
2023	1,131.14	242.29	6,598.33	1,838.56

Note: The data for 2023 is available only for the period from January to July so the trade value for the year 2023 is calculated as the sum from January to July. Trade value is nominal term. Data is from The Observatory of Economic Complexity.

Table A4: Total Annual Wheat Import and Export of South Africa - January to July

	Quantity (1000 Ton)		Value (Million ZAR)	
Year	Import	Export	Import	Export
2015	1040.09	185.31	2919.34	819.09
2016	1237.41	29.30	3611.06	159.90
2017	763.99	59.55	1948.55	324.68
2018	1646.00	31.48	4271.18	130.53
2019	865.79	80.87	2828.79	385.69
2020	1456.70	121.73	5353.57	583.23
2021	1152.02	99.03	4722.15	500.61
2022	1249.41	219.65	6876.22	1417.77
2023	1131.14	242.29	6598.33	1838.56

Note: As the data for 2023 is accessible only for the period from January to July, we present the values summed from January to July on an annual basis to ensure compatibility with the year 2023. Trade value is nominal term. Data is from The Observatory of Economic Complexity.

Table A5: Annual Wheat Import and Export Quantity by Main Ports

	Year								
Name of Main Ports	2015	2016	2017	2018	2019	2020	2021	2022	2023
Panel A: Import									
Cape Town	148.78	102.83	75.28	322.01	118.46	241.82	96.49	184.75	52.23
Durban	1894.68	1428.58	1602.11	1581.06	1651.94	1799.78	1453.63	1564.38	998.17
East London	26.00	6.60	0.00	0.00	16.50	6.60	9.03	19.48	6.69
Johannesburg	0.01	0.01	0.01	0.03	0.01	0.03	0.02	0.01	0.00
Port Elizabeth	85.27	52.50	12.50	35.34	54.00	56.70	26.00	28.71	29.90
Richards Bay	42.10	0.00	31.15	29.87	0.00	108.80	125.12	32.83	44.01
Panel B: Export									
Cape Town	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Durban	2.52	0.01	0.00	4.09	5.13	0.00	8.67	16.05	3.19
East London	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Johannesburg	0.17	0.50	0.44	0.38	0.04	0.00	0.00	0.00	0.00
Port Elizabeth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Richards Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Unit is 1000 t.

Table A6: Annual Wheat Import and Export Value by Main Ports

	Year								
Name of Main Ports	2015	2016	2017	2018	2019	2020	2021	2022	2023
Panel A: Import									
Cape Town	402.33	276.36	190.43	858.77	352.29	924.20	397.02	1046.58	277.33
Durban	5197.68	4043.73	4062.31	4268.52	5117.46	6541.19	5815.67	8857.67	5813.72
East London	71.38	19.20	0.00	0.00	50.92	21.51	31.79	101.56	43.02
Johannesburg	0.06	0.08	0.08	0.12	0.05	0.36	0.22	0.08	0.05
Port Elizabeth	229.89	152.43	31.99	86.76	170.58	221.80	105.40	178.05	165.67
Richards Bay	115.20	0.00	81.79	89.12	0.00	366.24	485.86	186.62	298.08
Panel B: Export									
Cape Town	0.26	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Durban	10.13	0.02	0.00	17.11	22.53	0.00	50.62	103.75	23.57
East London	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Johannesburg	3.87	10.27	4.19	3.97	0.26	0.00	0.00	0.00	0.00
Port Elizabeth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Richards Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Value is nominal term and the unit is Million ZAR.

Table A7: Summary Statistics for Variables in the Regressions

	Obs.	Mean	Standard deviation	Min	Max	Unit
Import	9,682	1.673	11.848	0	307.601	1000t
YoY Change of Import	8,554	-0.057	14.536	-293.189	307.601	1000t
Export	12,257	0.119	0.736	0	14.308	1000t
YoY Change of Export	10,829	0.013	0.741	-10.736	14.308	1000t
HHI_t	618	0.373	0.436	0	1	
Importance	515	0.725	1.634	0.000	4.875	
Import Volatility	846	4.62×10^6	1.26×10^7	0	1.65×10^8	Annual
Log Import Volatility	846	7.112	11.700	-22.383	18.921	Annual
HHI_y	846	0.425	0.198	0	0.812	

Note: YoY denotes Year-on-Year. The HHI_t is calculated for each main port in each month-year from January 2015 to July 2023, and the HHI_y is the average HHI index (month) within each year.