CIS 635 Final Project: How has the Russia-Ukraine Conflict Impacted Global Markets?

Garrit Reynolds, Joseph Vanliew, Katherine Parker, Sam Kiel

Grand Valley State University

Introduction

Russia and Ukraine were the world's first and fifth-largest wheat-exporting countries in 2021 (World Population Review, 2025). The conflict between these two nations has exacted a toll on global food security, particularly since the beginning of the full-scale invasion in February of 2022. Our group conducted a study in the economic domain to examine the effects of this conflict on the prices of agricultural products in the most affected nations. Our visualizations and data analysis show evidence suggesting a correlation between the full-scale invasion of Ukraine and the Black Sea Grain Initiative, on the exports of Ukrainian grain and the domestic prices of dependent nations. The invasion occurred on February 24, 2022; the Black Sea Grain Initiative was implemented on July 22, 2022, and it ended on July 17, 2023 (Glauber, McNamara, & Olivetti, 2023).

Our analysis covers trade and price changes across affected nations at the inception, conclusion (if applicable), and for the duration of relevant events. These price changes will be compared and aggregated to extract conclusions about the quantitative effect of these events on food security in the nations most affected.

The true effects the massive destruction of the war had on Ukraine and their ability to produce agricultural products will not be truly known for years to come, but, in studying how prices shifted in other countries, we can try to capture the initial magnitude. We took an exploratory, creative approach because many countries that heavily rely on Ukrainian agricultural products do not have transparent, clear data going back many years. Much of the data we found was incomplete, inconsistent, or simply nonexistent.

Related Work

Related works have discussed food security and the impact of the Russia-Ukraine conflict on global markets. For example, Elleby, Dominguez, Genovese, Thompson, Adenauer, and Gay (2023) used a simulation scenario to look at the effect of the Russia-Ukraine conflict on the price of various products for specific countries. Fan, Jia, and Lin (2023) estimated the effects of the Russia-Ukraine conflict on developing countries. They state, "specifically, increases in agriculture prices are estimated to reach 3%–18% in those countries that rely on grain imports from Ukraine" (Fan et al., 2023). Hensel (2024) discussed the change of UN FAO price indices for food from 2010 to 2023, noting a "substantial increase in prices following Russia's invasion of Ukraine, and the decline in food prices with the Black Sea Initiative and with additional global efforts to locate other food sources." From looking at works similar in concept to ours, we were inspired to look at a wider range of years to assess agricultural product prices for specific countries reliant on Ukrainian exports and compare our findings to the analyses and estimates of these studies. However, due to data limitations, we adjusted our focus to look at price volatility using export data, as well as looking at retail price data for countries dependent on Ukrainian wheat during the full-scale invasion and the Black Sea Grain Initiative.

Methods

Data Collection

The data we used for this project came from the Food and Agriculture Organization of the United Nations' Food Price Monitoring and Analysis Tool (FPMA), and we also used data from the BACI, which provides data on imports and exports for over 200 countries at the product level. From the BACI, we used the Harmonized System (HS) 92, version 202501 with data from 1992-2023. From the FPMA, we chose to export data from the following countries: Bangladesh, Egypt, Indonesia, Lebanon, Libya, Pakistan, and Ukraine. The countries (not including Ukraine) were chosen due to being a top importer of wheat from Ukraine, with a percentage from 23% to 62% of their wheat coming from Ukraine, according to Devadoss and Ridley (2024). We gathered data on the domestic prices of products within these countries and the international prices of wheat from Ukraine.

Data Pipeline

First, we performed the data acquisition. We exported a large zip file from the BACI website and then exported many CSV files from the FPMA website. Numerous filtered datasets were created to clean the data.

For the FPMA data, a pipeline was created to extract price data from the CSVs using attributes encoded in the column names themselves. Once the data was put into directories, we built a dictionary of unique attributes across all CSV files, with a count of occurrences as the value to the attribute key. Then, we created a function to group full column names by selected attributes, such as grouping the data by country or by the specific commodity.

Next, we created a function that randomly selects up to three columns and plots the self-min-max normalized price over time to expose any issues with the aggregation approach. Then, we created the main function, which serves as a filter. It takes a dictionary of filters, gets the relevant columns, collects the matching columns from all the CSV files, merges them into a single DataFrame, and then aggregates them by date, sorts, and then plots the data.

Software and Packages Used

We used Python and relied heavily on packages used in class, such as Pandas, Numpy, MatPlotLib, and Seaborn. We also used JSON to store and transmit data.

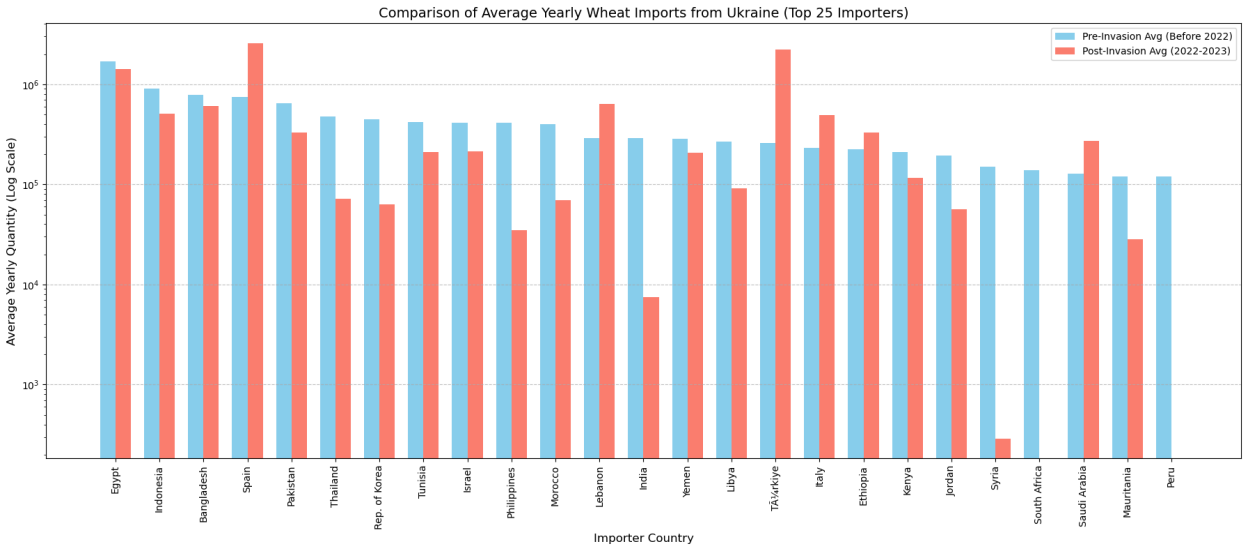
Experiments, Results, and Discussion

Volatility

We also have a dataset from the BACI that looks at Ukraine's wheat and maize exports from 1995 to 2023. To clean, we filtered the main dataset to only include wheat-related rows. Missing quantities are filled with 0s. Then, we summed total yearly wheat import quantities per country. Then, we split the dataset into pre-invasion (before February 1, 2022), and post-invasion, (equal to and greater than February 1, 2022), and then calculated the volatility of each group of data so we could compare. Volatility is measured as the standard deviation of the year-over-year percentage change of the average yearly quantities for each importer. Algeria and Angola showed very high pre-invasion volatility, meaning their wheat import quantities fluctuated significantly from year to year even before the invasion. For example, Angola's pre-invasion volatility of ~82% indicates volatile wheat import patterns. Because we only had data from 1995-2023, this doesn't give us enough data to compare the volatility rate post-invasion. In short, this dataset highlights the current data limitations for analyzing post-invasion wheat import patterns, while still offering insights into which countries historically had stable or volatile wheat import behavior. As more post-2022 data becomes available, this comparison will become more complete and meaningful.

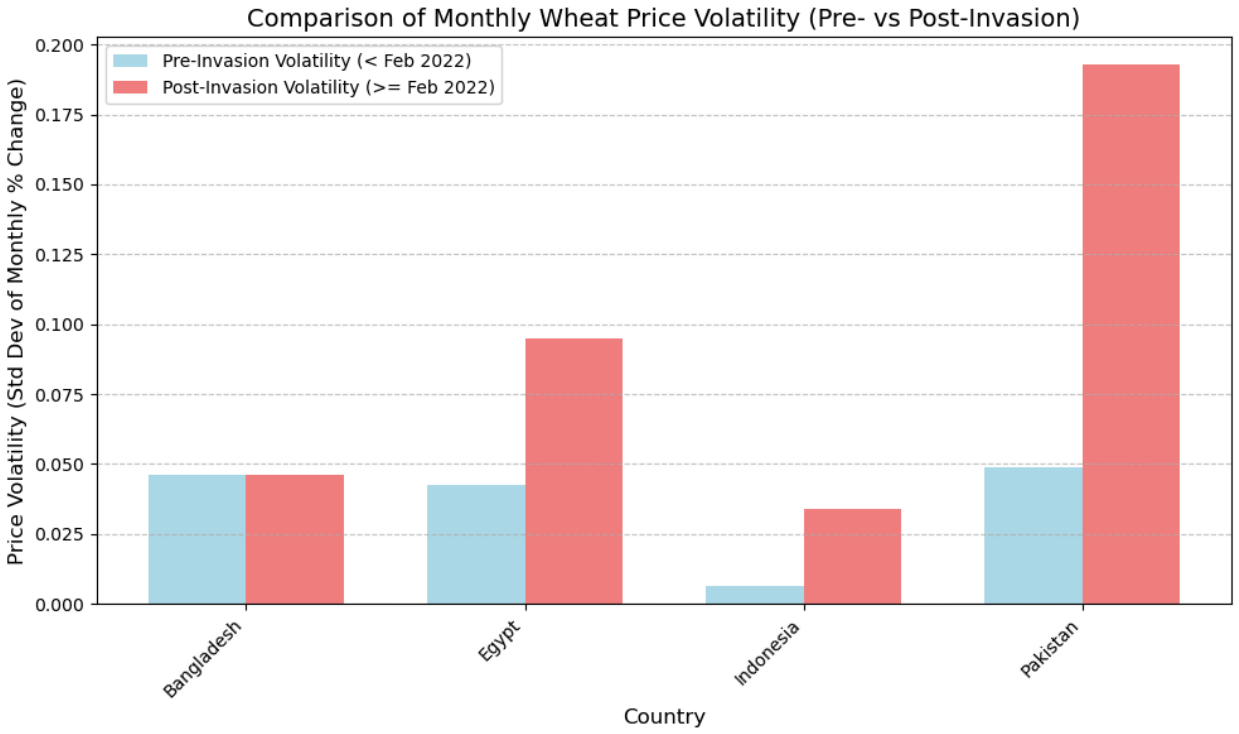
Change in Average Quantity Imported

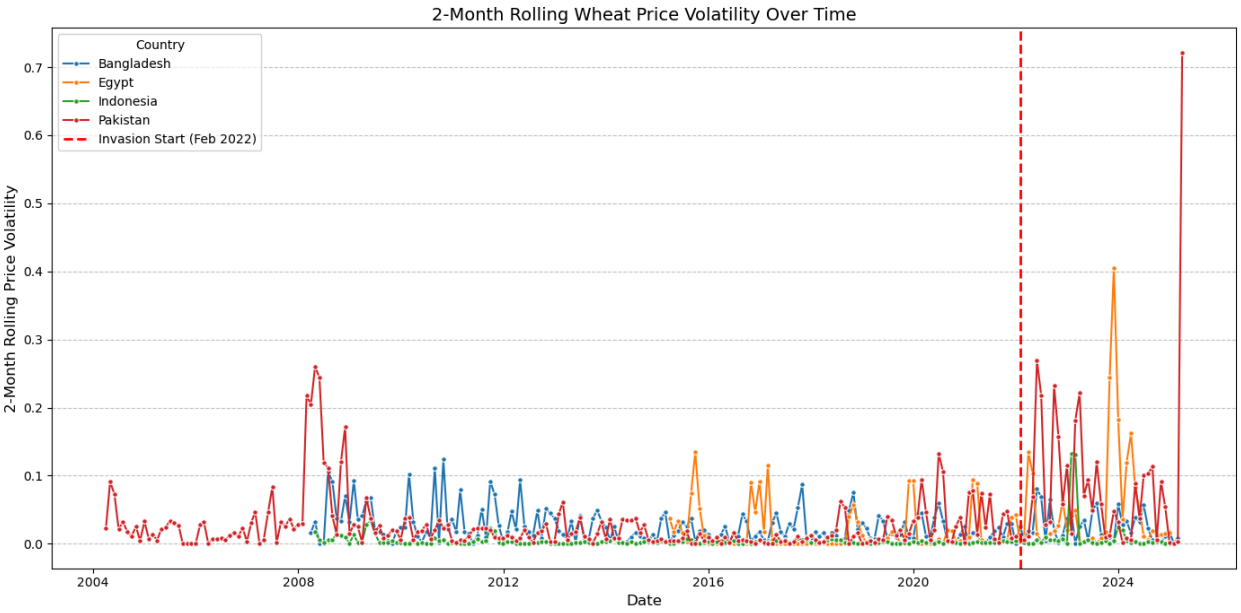
Next, we did a comparison of the average yearly quantity, pre and post-invasion, and calculated a percent change. Then, we sorted by pre-invasion average quantity to validate who the top importers of Ukrainian wheat were before the invasion. From this, we can see the top 25 importers.



Wheat Price Data from FPMA

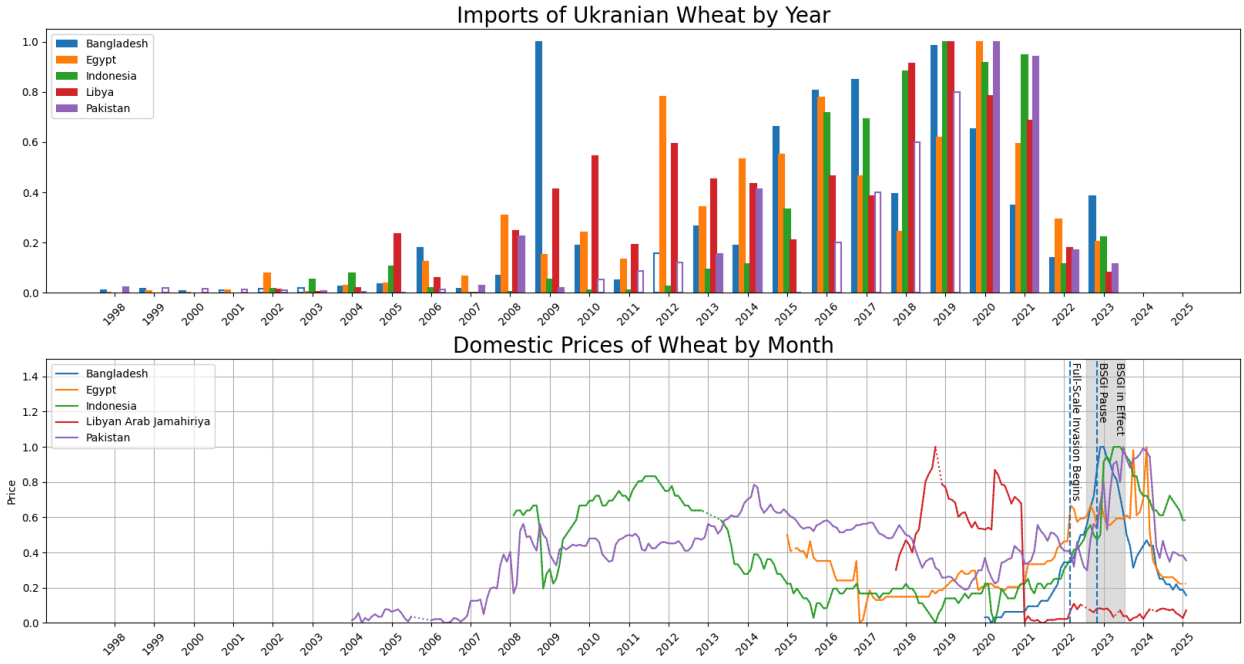
Then, we loaded the wheat price data CSVs from the FPMA for the selected countries: Indonesia, Bangladesh, Egypt, and Pakistan. Those countries were chosen due to having enough quality historical data on their Ukrainian agricultural imports. We reshaped the data for analysis and then filtered it by wheat products. Then, we did a price volatility analysis looking at monthly means by country and analyzed them by pre and post-invasion.

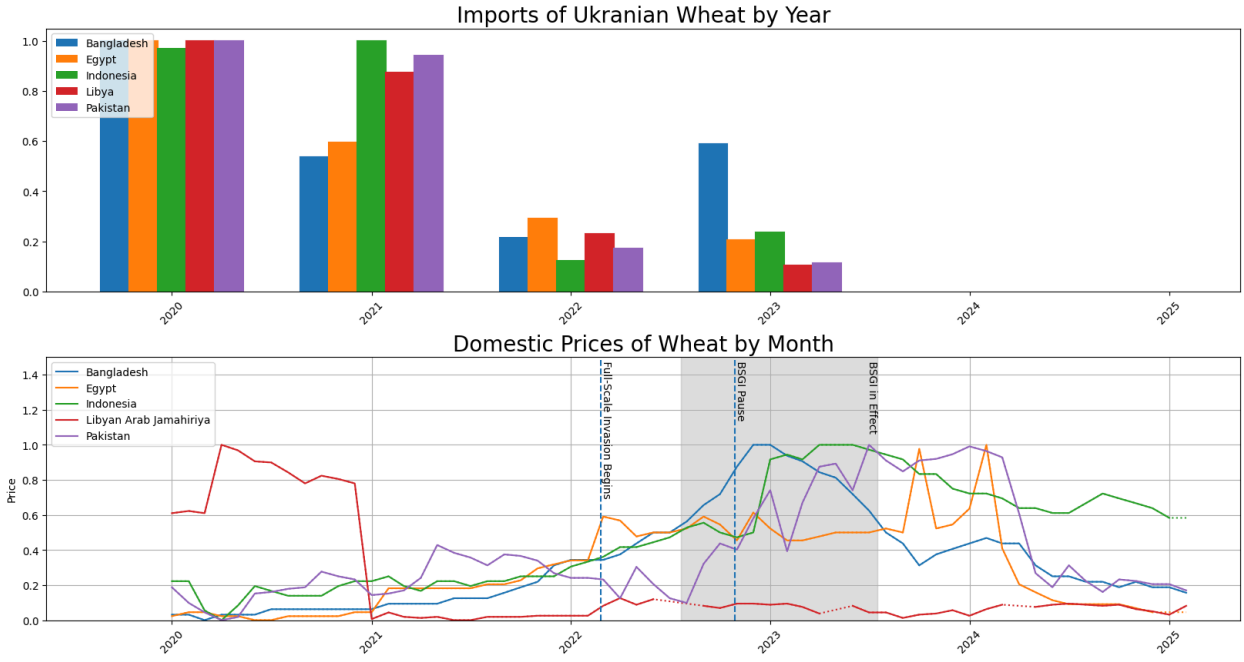




Analysis of Prices and Imports of Ukrainian Wheat

Then, we changed our focus and wanted to look more deeply at the effect of the war on imports of Ukrainian wheat in the countries most dependent, and how it changed year by year. To do this, we made a histogram of import quantity by relevant country normalized by their max, as well as a line plot of prices min-max normalized against themselves.





Percent Change in Ukrainian Import Quantity Pre War to During War

We also looked at the difference in how much rice and wheat from Ukraine was imported by those countries during the war as compared to prior. From this table, there was a major change between how much was imported from Ukraine pre war, to during the war, with as much as an 85% reduction in Pakistan.

	Bangladesh	Egypt	Indonesia	Libya	Pakistan	Average
Pre War Mean (Metric Tons)	1162932	4561787	2768804	512488	2252210	2251644
During War Mean (Metric Tons)	608071	1418027	504529	91269	331481	590675
Percent Change	-47.712%	-68.915%	-81.778%	-82.191%	-85.282%	-73.176%

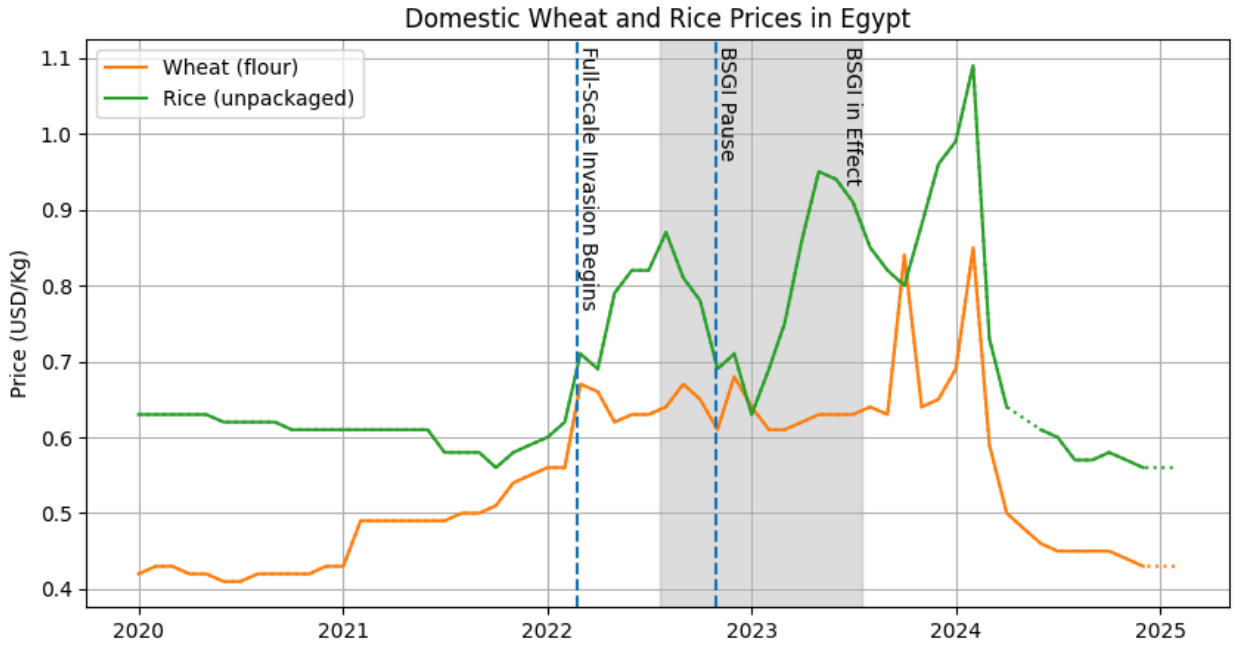
Statistical Analysis

We conducted a simple Pearson correlation test between wheat and rice prices within and outside the period of key events like the Ukraine war or the BSGI. We also looked at whether those changes were statistically significant. ‘r’ reflects the Pearson correlations, and ‘p’ indicates the statistical significance, or more explicitly, the likelihood of a random relationship. The first and most expected example is shown in Egypt, a country very dependent on Ukraine and relatively nearby in shipping terms. During the BSGI, Egypt’s wheat prices became insulated, shown by a large increase in p-value, indicating a broken relationship between rice and wheat prices, likely due to increased grain shipments. Another example of the effect of this war is

Libya. This nation reflects a strong effect of the Black Sea grain initiative, with a significant correlation between wheat and rice outside of the BSGI period and an insignificant relationship within it. Unsurprisingly, these two Mediterranean nations were greatly affected by the BSGI. The Pearson correlation between domestic Pakistani wheat and rice prices was altered dramatically by the war, and minimally by the BSGI, with significant relationships through all periods. Not all countries showed the same trends. Bangladesh and Indonesia had insignificant relationships in price between wheat and rice, preventing us from drawing any confident conclusions about the events in Ukraine on their economies.

	rIn	pIn	rOut	pOut
Bangladesh War Correlations	0.453396	5.484462e-03	0.353786	7.621358e-02
Bangladesh BSGI Correlations	0.064685	8.416997e-01	-0.038888	7.886029e-01
Egypt War Correlations	0.755346	3.761482e-07	0.404308	1.242674e-04
Egypt BSGI Correlations	-0.024169	9.405678e-01	0.703941	3.873361e-17
Indonesia War Correlations	-0.789889	1.685251e-08	-0.056551	4.719875e-01
Indonesia BSGI Correlations	-0.900203	6.579581e-05	-0.077320	2.928800e-01
Libyan Arab Jamahiriya War Correlations	0.394782	2.534660e-02	0.922645	2.474267e-22
Libyan Arab Jamahiriya BSGI Correlations	0.256360	4.746378e-01	0.948088	1.478038e-37
Pakistan War Correlations	0.454808	5.322445e-03	0.820713	1.473496e-48
Pakistan BSGI Correlations	0.871274	2.233901e-04	0.779756	8.195459e-46

To focus more closely on Egypt, you can see the trend of the price of wheat and flour from 2020 to 2025, and see the peaks and troughs that seem to correlate with the invasion, and the pause and effect of the BSGI.



Conclusions

Our analysis demonstrates that the Ukraine war and the subsequent Black Sea Grain Initiative (BSGI) significantly impacted wheat, rice, and markets in some dependent countries. This is manifested in measurable effects on wheat import quantities and domestic food prices in countries heavily reliant on Ukrainian exports. By combining import data from the FPMA and the BACI, with normalized price trends and statistical correlation analysis, we were able to identify patterns of disruption and stabilization across periods and regions.

We observed that for many countries, especially Egypt and Bangladesh, the correlation between local wheat prices and global prices became significantly stronger during the war period, suggesting increased sensitivity to global supply shocks. In Egypt, for instance, a strong positive correlation ($r \approx 0.76$, $p < 0.001$) emerged during the war, indicating a direct transmission of global price volatility into domestic markets. Interestingly, this correlation diminished or even reversed during the BSGI, suggesting that grain exports facilitated under the initiative may have helped stabilize domestic prices, buffering countries from the full impact of the conflict.

Not all countries followed this pattern. Indonesia, for example, displayed a strong negative correlation during the war, which may reflect domestic price controls, alternative sourcing strategies, or other factors that warrant further investigation. Similarly, Pakistan and Libya showed reductions in wheat import volumes of up to 85% during the war, underscoring the scale of the trade disruption.

Due to challenges in data availability and quality, that include gaps, inconsistencies, and limited post-invasion data, some analyses remain exploratory. However, the trends observed highlight the immediate economic consequences of the war and suggest that coordinated international responses, like the BSGI, may have had a stabilizing effect on food security for some countries.

Moving forward, as more post-2022 data becomes available, it will be critical to revisit these trends and refine our understanding of the conflict's lasting effects on global food systems.

Data and Software Availability

The github repository can be found at the following link:
https://github.com/GVSU-CIS635/term-project-gjk/
The BACI data can be downloaded at the following link:
https://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37
The FPMA data can be downloaded at the following link:
https://fpma.fao.org/giews/fpmat4/#/dashboard/tool/international

In addition, there is a Requirements file in the github that includes the name of all software used.

References

Devadoss, S., & Ridley, W. (2024). Impacts of the Russian invasion of Ukraine on the global wheat market. *World Development*, *173*. https://doi.org/10.1016/j.worlddev.2023.106396

Elleby, C., Dominguez, I. P., Genovese, G., Thompson, W., Adenauer, M., & Gay, H. (2023). A perfect or persistent storm for global agricultural markets: High energy prices and the Russia-Ukraine war. *Choices Magazine: A publication of the Agricultural & Applied Economics Association*, *38*(2), 4–9. Retrieved February 28, 2025, from https://research.ebsco.com/c/6l5vh5/viewer/pdf/rk3yvi5yuj

Fan, F., Jia, N., & Lin, F. (2023). Quantifying the impact of Russia–Ukraine crisis on food security and trade pattern: evidence from a structural general equilibrium trade model. *China Agricultural Economic Review, 15*(2), 241-258. https://doi.org/10.1108/CAER-07-2022-0156

Food and Agriculture Organization of the United Nations. (n.d.). Food Price Monitoring and Analysis Tool: International Prices Dataset [CSV]. https://fpma.fao.org/giews/fpmat4/#/dashboard/tool/international

Gaulier, G., & Zignago, S. (2025). BACI: International Trade Database at the Product-Level: 1995-2023 (Version 202501) [CSV]. CEPII. https://www.cepii.fr/DATA_DOWNLOAD/baci/data/BACI_HS92_V202501.zip

Glauber, J., McNamara, B., & Olivette, E. (2023, July 20). *Russia terminates the Black Sea Grain Initiative: What's next for Ukraine and the world?.* IFPRI. Retrieved April 18, 2025, from https://www.ifpri.org/blog/russia-terminates-black-sea-grain-initiative-whats-next-ukraine-and-world/

Hensel, N. (2024). The Russia-Ukraine crisis: How regional conflicts impact the global economy. *PRISM Security Studies Journal*, *10*(4), 102–122. Retrieved February 28, 2025, from https://research.ebsco.com/c/6l5vh5/viewer/pdf/jcz5rabj7b

World Population Review. (2025). *Wheat exports by country 2025.* Retrieved April 18, 2025, from https://worldpopulationreview.com/country-rankings/wheat-exports-by-country