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The Effect of Ukraine-Russia War on the Economies of Ukraine's Top Trading Partners

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ABSTRACT

This research paper studies the impact of the Ukraine-Russia war on the economies of Ukraine's top trading partners. Several earlier studies have examined the implications of the war for global trade and development, and how countries highly dependent on exports from the conflict region have responded. In our paper, we focused only on Ukraine, analyzed both import and export partners of Ukraine, and developed a framework to assess the impact of the war on various macroeconomic indicators for these partner countries. In particular, we established Difference-in-Difference based statistical models for Gross Domestic Product (GDP), food inflation, manufacturing production, gasoline prices and changes in inventories the for partner and non-partner countries over the pre-war and post-war years from 2021 through 2023. Our findings contribute to a better understanding of the devastating and far-reaching economic effects of the Ukraine-Russia war that serve as a cautionary tale for world citizens and leaders alike.

Keywords: Difference-in-Differences, Ukraine, Russia, Imports, Exports, War, Economic Impact

I. Introduction

The Ukraine-Russia war started on February 24, 2022, when Russia invaded Ukraine resulting in the largest war since WWII. The Russian invasion resulted in hundreds of thousands of military casualties, and tens of thousands of civilian casualties. Over 16 million Ukranians (39% of the population) were either displaced or forced to flee the country. The war had a major economic impact on Ukraine as its GDP contracted by 30.4% in 2022([4]). Ukraine's agricultural production suffered significantly leading to a drop in exports of wheat, maize, barley, seed oils and other products to the rest of the world. This resulted in a major global food crisis in 2022 and 2023, and we are yet to recover fully from it ([5]). While Russia experienced only a 2.4% drop in

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

GDP in 2022, many countries including USA and Canada banned Russian imports of oil and gas resulting in gasoline price inflation. World gasoline prices dropped back from the peak of $4/gallon in May 2022 to $2.5/gallon in 2023 largely due to USA releasing oil reserves, and Russia continuing to supply crude oil to India, China and other partners despite the embargo. However, gas prices at $2.5/gallon today are still 2.5x what they used to be before the war ($1/gallon) underscoring its impact. Ukraine's export of iron ore and steel are also impacted by the war resulting in 40% increase in prices immediately following it. While the prices have stabilized since then, the increase in global energy prices and weak demand for steel in China which consumes over 50% of the world's steel, has resulted in lower steel prices. Manufacturing production in countries like USA and China have fallen from 20% or higher at the end of 2021, to close to 0% in recent years. It is clear that the Ukraine-Russia war [6] impacted the economics of the iron and steel industry ([14]), and as a result, manufacturing production across the world.

While the war impacted many of the export partners of Ukraine and Russia, Ukraine's import partners such as Poland, China and Turkey were affected as Ukraine's imports of commodities dropped by over 77% in the immediate months following the war. As countries across the world got impacted by the war, higher inflation led to lesser consumption, and countries such as China experienced significant growth in their inventory (36% YOY in 2022 for China over 2021).

While the war had a devastating economic impact across the world, we hypothesize that Ukraine's trade partners were more impacted than other countries. In this paper, our goal is to test the hypothesis by quantifying the economic effects of the Ukraine's major trade partners, namely Poland, Romania, Turkey, China, Germany and the USA. We examined both imports and exports, and developed a mathematical model to assess the impact of the war on five economic indicators for trading partners - GDP, food inflation, manufacturing production, gasoline price inflation and changes in inventories. In Section 2, we describe all the data sources we used for this analysis. This includes the data on exports and imports, and the economic indicators for each of the partner countries. In Section 3, we explain the different commodities that Ukraine exported and imported in the years 2021 through 2023, and focus on a few commodities that impacted the five economic indicators for trading partners. In Section 4, we outline our methodology for the mathematical models that show how the economic indicators we have chosen are impacted by factors including the time period (pre-war vs post-war), whether the country is a trading partner or not, and the proximity of the country to Ukraine. In Section 5, we provide the results of our mathematical models for the five economic indicators, and offer a commentary on the results. In Section 6, we conclude with a summary of our key results, and some learnings that we hope world leaders would consider before they embark on more wars.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

II. Data

For this study, we used two sources of data. First, we obtained details of the commodities traded by Ukraine with partner countries from the U.N. Comtrade database (4). According to U.N. (5), "Commodities are products stemming from agricultural production or mining production that have not yet been transformed: agricultural products, tropical beverages, energy, minerals, ores and metals." [12]. Each commodity in U.N. Comtrade uses the Harmonized System (HS) code to classify and identify commodities. For example, the HS code for wheat and meslin is 1001, while the HS code of 2601 is for "iron ore and concentrates; including roasted iron pyrites". We obtained data from this database for major Ukraine imports and exports to the rest of the world over the years 2021 through 2023 [11]. We chose 2021 for pre-war analysis, 2022 as it was the year of the war, and 2023 to analyze if the war effects continued from the previous year.

The second data source we used was Trading Economics. This website provides all the major macroeconomic indicators for all countries in the world. This includes main indicators like GDP growth rate, inflation rate and unemployment rate, business indicators like manufacturing production and changes in inventories, prices such as food inflation and core inflation, and many more. For this study, we chose five indicators – GDP growth rate, food inflation, manufacturing production, gasoline price inflation, and changes in inventories. We downloaded monthly values of these indica-tors from 2021 through 2023 for all indicators except for GDP growth rates for which only quarterly data was available. We used GDP growth rate, food inflation and manufacturing production data to compare the economies of Ukraine's major export partners versus those countries in a control group. For import partners, we compared GDP growth rate, gasoline price inflation, and changes in inventories versus those of a control group of countries.

III. Overview - Ukraine's Exports and Imports

A. Ukraine's Exports

Ukraine is largely known for its wheat farming ranking seventh in the world ("Ukraine Agricultural Production and Trade," 2022) for wheat production [2]. Ukraine's exports are mostly made up of industrial and agricultural commodities. Most of Ukraine's land is agriculture based (71.2%), and as such agricultural products such as wheat, maize and sunflower seed dominate Ukraine's exports. Ukraine also has large iron reserves, and exported a significant amount of it to the rest of the world. The table below provides the highest exports in 2023.

Table 1. Ukraine's Largest Exports in 2023.

Product	HS Code	Share of Country's Exports (2023)	USD Export Value (2023)
Cereals	10	22%	$8.3 billion

ISSN: 2455-8834

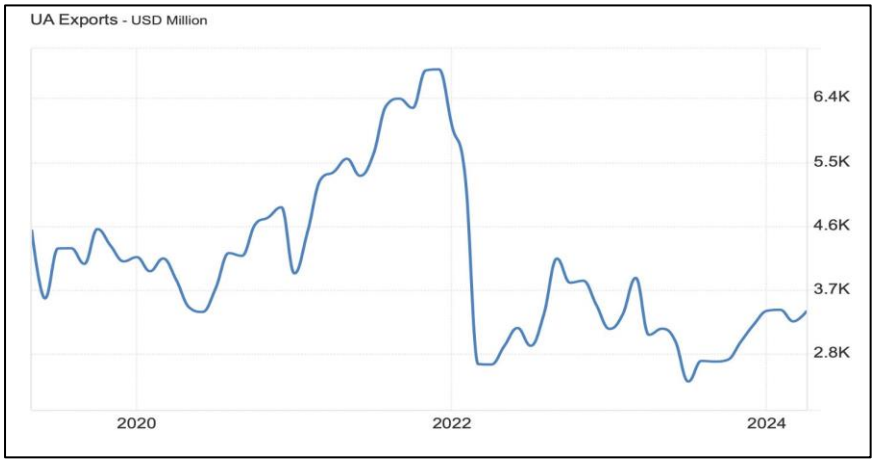
Volume:09, Issue:09 "September 2024"

Animal, Vegetable Oils	15	15.6%	$5.64 billion
Oil Seeds	12	7.79%	$2.81 billion
Iron & Steel	72	7.31%	$2.64 billion
Ores	26	5.16%	$1.87 billion

Ukraine's Exports Trend

Ukraine's exports were trending up in 2021, and in 2022 fell by 61% due to the war with Russia. A large part of this is due to disruption of agricultural activities as the war resulted in an estimated $40.2B in aggregate damages and losses for the agricultural sector (5). The war resulted in destruction of Ukraine's dams, supply chain infrastructure, and displacement of farmers resulting in significant impact to exports in the immediate months following the war. As we can see from the graph below, Ukraine's exports have not gone back to 2021/22 levels even in recent times.

Figure 1: Ukraine's Export Value Trends, 2020-2024



Above graph displays a drop of exports for Ukraine in the first quarter of 2022 when the war started.

B. Ukraine's Imports

Ukraine's imports are primarily vehicles, machinery, and the fuels necessary to power these goods. With the country's energy consumption outpacing domestic energy production, mineral fuels and oils are Ukraine's top import in 2023 at $10.3B. Its main import partners were Russia and Belarus earlier, but Ukraine has been trying to reduce their dependence on these countries,

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

instead relying on Germany, China, and Poland in recent years. Ukraine's top 5 imports for 2023 are listed below:

Table 2. Ukraine's Largest Imports in 2023.

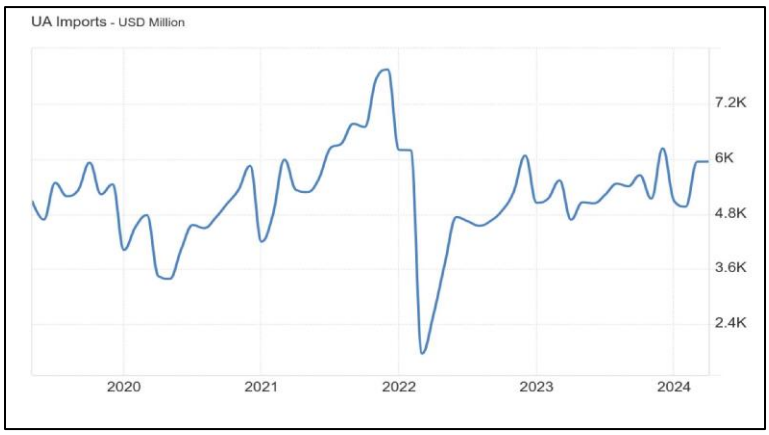
Commodity	HS Code	Share of Country's Imports (2023)	USD Import Value (2023)
Mineral Fuels and Oils	27	16.3%	$10.3 billion
Vehicles	87	10.9%	$6.96 billion
Electric Machinery	85	9.37%	$5.95 billion
Nuclear Reactors and Boil	84	8.33%	$5.3 billion
Other	99	7.73%	$4.91 billion

We will examine the impact of trends in imports of mineral fuels and oils, along with vehicles, in the sections below.

Ukraine's Imports Trend

Similar to the exports, imports of commodities into Ukraine suffered due to the war, and in the first two months of 2022, imports fell by 77%. However, over the next two years, imports started growing back to pre-2021 levels as Ukraine received more funding from countries like USA as humanitarian aid. The USA has passed 5 bills to date providing $175B in funding in the last two years, with $34B to aid Ukraine's budget. We will focus on 2022 when Ukraine's imports fell drastically due to the war.

Figure 2: Ukraine's Import Value Trends, 2020-2024



Like exports graph above, we see a drop in the first quarter of 2022.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

C. Ukraine's Import and Export Partners

Ukraine's top five import and export partners in 2023 are displayed below, along with the trade value and percentage of import/export for Ukraine:

Table 3: Ukraine's Import Partners in 2023

Import Partner	% of Ukraine's Imports	USD Value of Imports (2023)
China	16.4%	$10.4 billion
Poland	10.3%	$6.57 billion
Germany	7.96%	$6.06 billion
Turkey	7.43%	$4.72 billion
USA	4.51%	$2.86 billion

In our study below, we use these five countries as Ukraine's top import partners when studying the affected metrics.

Table 4: Ukraine's Export Partners in 2023

Export Partner	% of Ukraine's Exports	USD Value of Exports (2023)
Poland	13.1%	$4.75 billion
Romania	10.4%	$3.76 billion
China	6.65%	$2.4 billion
Turkey	6.54%	$2.36 billion
Germany	5.58%	$2.01 billion

We use these five countries as Ukraine's top export partners when studying their affected metrics below.

IV. Methodology

A. Macroeconomic Indicators

To assess the impact of the Ukraine-Russia war on import and export partners, we examined two approaches. In the first approach, we could examine the internal prices of various commodities (e.g. wheat and iron ore) within the export partner countries, say, Poland or Romania, and correlate these prices to the supply and price of exports from Ukraine. Similarly for import

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

partners, we could correlate the internal prices of commodities such as gas to the import demand and import prices in Ukraine. The second approach we considered was to understand how macroeconomic metrics such as food inflation and GDP in the partner countries were affected by trends for key commodities such as wheat and iron ore. This approach was taken by others such as [10] who assessed the combined impact of COVID and the Ukraine-Russia conflict on economies of countries around the world using a Two- State Least Squares (2SLS) method. We decided on the second approach for a few reasons including 1) the internal commodity prices were not available for various partner countries, 2) even if we had the internal commodity prices, the resulting correlations would not be very interesting since they would just be supply-demand curves for various commodities, 3) it was more interesting to study macroeconomic trends so that we could quantify the effect of the war in terms of how it affects the world at large.

For our study, we chose two major exports from Ukraine, wheat and iron ore, and studied the impact of the war on the supply of each of these exports. This part of our analysis was similar to what Bodek ([2]) did for their analysis of the impact of Ukraine war on commodities. For each of these two exports, we examined the impact on key macroeconomic indicators in the export partner countries. We theorized that the exports of wheat from Ukraine would impact the food inflation metric in Poland and other export partners, and that the exports of iron ore would affect the manufacturing production metric in the partner countries. Similarly, on the import side, we theorized that if Ukraine's mineral oil imports were affected due to the war, we could examine the correlated impact on the gas prices metric in import partner countries. In a similar vein, Ukraine's imports of vehicles could be correlated to the changes in inventory metric in the import partner countries. Finally, we also considered the effect of the war on the GDP growth of both import and export partners. We theorized that the Ukraine-Russia war would impact the GDP growth of Ukraine, but would also have an effect on all import and export partners. This is in line with the analysis done by researchers from Cato Institute in 2020 ([1]) who concluded that wars can impact GDP by as much as 24

We summarize the 5 metrics and Ukraine's import or export commodity we correlated these metrics with in the following table:

Table 5: Ukraine Trade Commodities and Affected Metrics

Macroeconomic Metric	% Type of	Correlated Ukraine Commodity
Food Inflation	Export	Wheat
Manufacturing	Export	Iron Ore
Gas Prices	Import	Mineral Oils
Changes in Inventory	Import	Vehicles
GDP Growth	Import & Export	GDP Growth

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

We will explore if there is an effect on each macroeconomic metric for specified type of partner depending on the export/import trends of Ukraine's commodities.

B. Comparing Averages Before and After the War

For each of the five metrics, we compared the average metric (e.g. Food inflation) for the one year (2021) before the war, and the year of the war (2022). This helped us broadly quantify the impact of the war before we dove deeper into the impact of the war.

C. Difference In-Differences (DID) Approach

Difference in Differences ("DID") is a statistical method described in the seminal paper by Card and Krueger in 1993 [7]. Our main contribution in this research is that of the use of DID for the quantitative analysis of the impact of the Ukraine war on macroeconomic indicators of partner countries. What we want to understand is whether or not partner countries were impacted more than other countries as a result of the war. One of the ways this can be done is to measure if an "outcome variable", for example, Food Inflation, is different for a "treatment group" – the partner countries, when compared to a "control group" – the non-partner countries due to a "treatment" – in this case the Ukraine war. DID is a regression technique that compares the average change over time of the out- come variable for the treatment group to the average change over time for the control group to calculate the effect of the treatment.

For our analysis, the dependent variables are Food Inflation, Manufacturing Production, Gas Prices, Changes in Inventories and GDP growth. The independent variables are:

Is_Post_war: Whether the metric represents a time period after the war (i.e., 2022 vs 2021)

Is_Import_partner: Whether the metric is for an import partner

Is_Export_partner: Whether the metric is for an export partner

Proximity: Whether partner is within Europe (close to Ukraine) or remote

For our analysis, the treatment group consisted of two types: 1) Ukraine's top 5 export partners for 2023, namely, Poland, Romania, China, Turkey and Germany. 2) Ukraine's top 5 import partners for 2023, namely, Poland, China, Turkey, Germany and USA.

Our hypothesis was that the war affected Ukraine's trade partners more than non-trade partners. As such, we added a control group with 20 countries including Japan, India, UK, France, Brazil, Italy, Canada, Mexico, Australia, South Korea, Spain, Indonesia, Netherlands, Switzerland and Belgium. We compared the effect of the war on both the treatment and control groups.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

To summarize the way DID is implemented, it is necessary to understand the impact of post-war on the export partners of Ukraine for food inflation. Let us assign Food Inflation as the dependent variable "y". There are two independent variables 1) "T" which represents whether the Food Inflation is post war (i.e. belongs to the time period in 2022). 2) "S" which represents whether the Food inflation metric is for an export partner. The DID equation for this case is represented as

$$y = \beta 0 + \beta 1 * T + \beta 2 * S + \beta 3 * (T * S) + \epsilon$$

We perform a regression against both treatment and control groups and obtain the values of β1, β2, and β3. β1 indicates the dependency of Food Inflation on post-war. β2 indicates the dependency of Food Inflation on whether the partner is an export partner or not. And the important term β3 rep- resents the interaction term, which is the effect of post-war on an export partner. A high coefficient value accompanied by a low p-value (< 0.05) will tell us whether there is statistically significant impact for each of these β terms.

We performed 4 different studies in this paper to look at the following:

1. Is there an effect of war on the export partners: In this case, we regressed the dependent variables Food Inflation and Manufacturing Production on Is_post_war and Is_Export_Partner.

2. Is there an effect of war on import partners: In this case, we regressed the dependent variables Gas Prices and Changes in Inventories on Is_post_war and Is_Import_Partner.

3. Is there an effect of war on the GDP of partners: In this case, we regressed the dependent variable GDP growth on Is_post_war and (Is_Import_Partner or Is_Export_Partner).

4. Does the location of a country influence whether it was affected by the war: In this case, we regressed all five dependent variables on Is_post_war and Proximity.

In the next section, we provide the results of our analysis.

V. Results

A. Is there an effect of war on export partners?

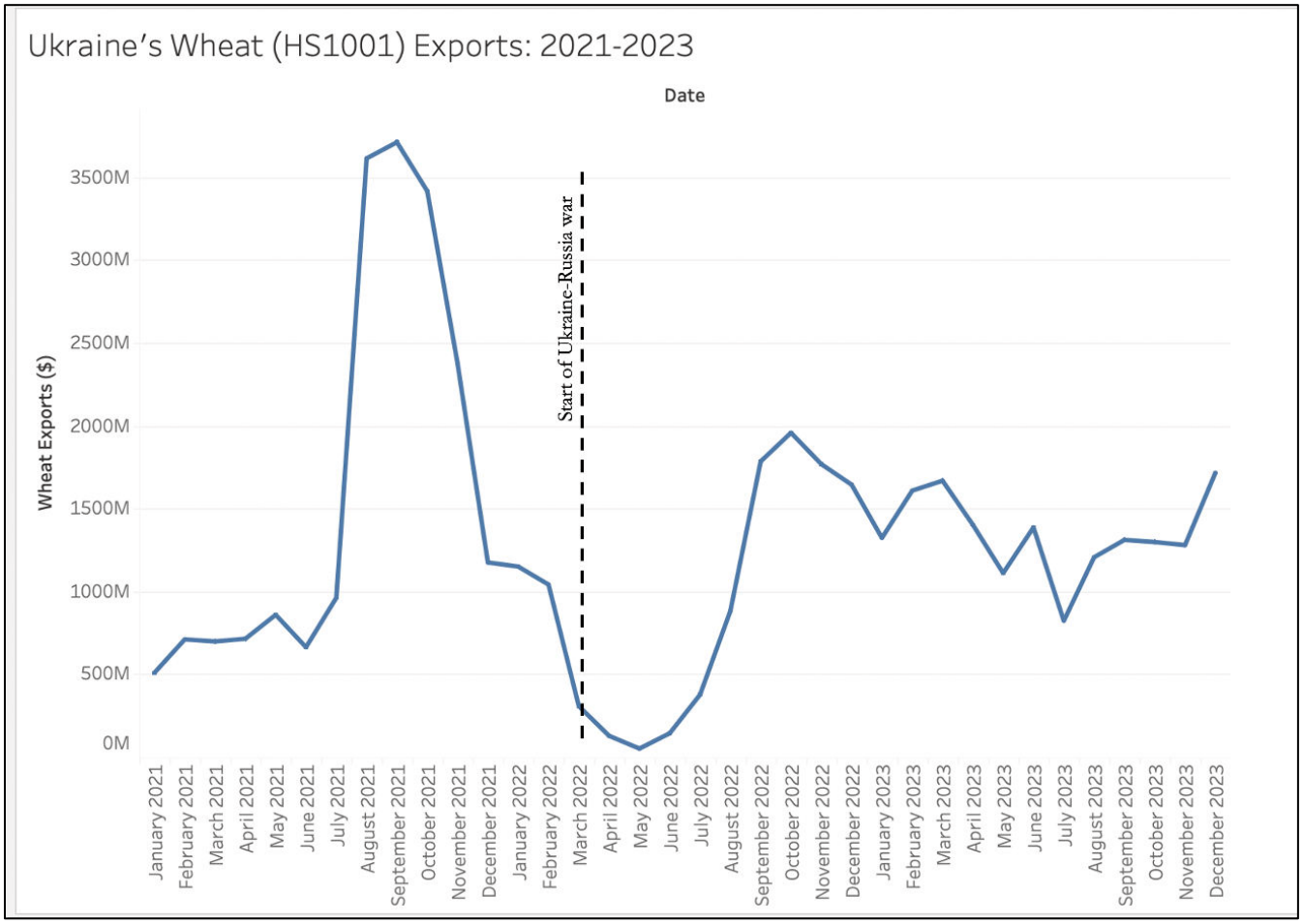
In the first DID study, we looked at two dependent variables – Food Inflation and Manufacturing Production.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Food Inflation: We first discuss Food Inflation and how it is influenced by wheat exports in Ukraine. The following figure shows the pre and post-war trends for wheat exports from Ukraine, and the global price of wheat.

Figure 3: Ukraine's Wheat Exports: 2021-2023



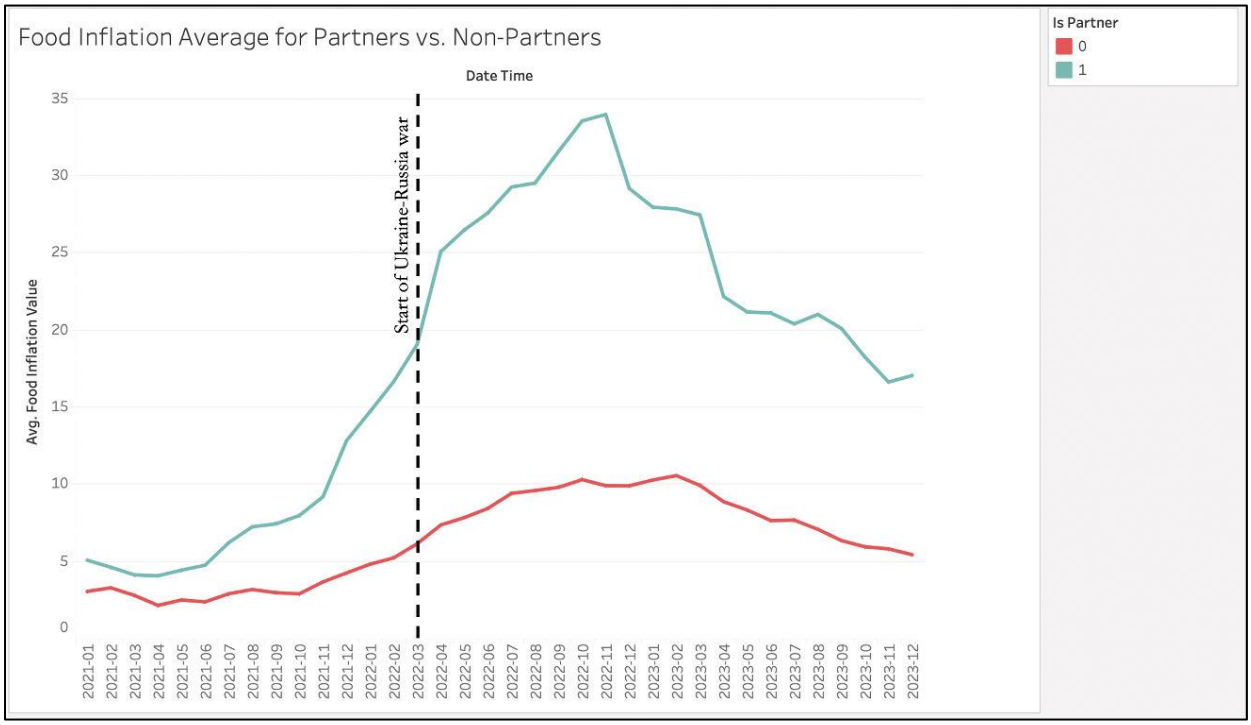
Source: U.N.Comtrade

This figure shows that the Ukraine's wheat exports were significantly impacted due to the war, and as a result, wheat prices shot up globally before they settled down in 2023. We hypothesized that Ukraine's wheat exports would affect Ukraine's partner countries negatively resulting in high food inflation. We tested this hypothesis by first looking at the average Food Inflation in partner countries before and after the war, and comparing these averages against those in the control group. The figure below shows a comparison of the average trend in Food Inflation for control and treatment group countries.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Figure 4: Food Inflation Averages: Partners vs. Non-Partners



Source: Trading Economics

The following table shows the averages before the war and after the start of the war:

Table 6: Average Food Inflation Growth for Partners vs. Non-Partners

Country Type	% Pre-War	Post-War	% Change
Export Partners (Treatment)	7.76%	24.79%	219.2%
Non-Partners (Control)	3.14%	8.17%	160%

We see a greater percentage change of food inflation after the war for partners than for non-partners.

This is supported by our DiD analysis below.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Next, we performed a DID analysis for which we regressed Food Inflation against Is_Export_partner and Is_Post_War for the treatment and control groups. We present the DID results below:

Table 7: DiD Analysis for Manufacturing Production

Coefficient	C0	C1(is_partner)	C2(post_war)	C3
Value	3.24	4.52	5.00	12.02
P > |t|	(0.000)	(0.010)	(0.000)***	(0.000)***

We see a statistically significant interaction term and post-war coefficient.

We make the following key observations from this DID analysis:

1. "Is_partner" has a coefficient of 4.52 with very low, statistically significant p-value of 0.10. This shows that the Food inflation of an export partner is affected more than that of a control group country.

2. "Post_war" has a coefficient 5.00 with a very low p-value, statistically significant p-value of 0.0. This shows that Post_War, Food Inflation is higher for all countries compared to before the war.

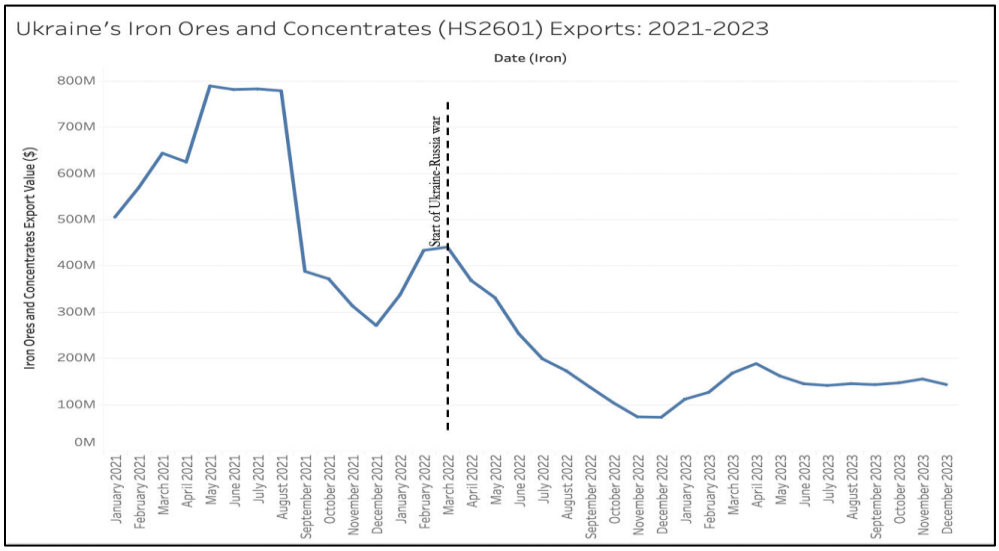
3. Finally, the most critical result is that the interaction term between Post_War and Is_Partner at 12.02 with a very low p-value, statistically significant p-value of 0.0 clearly shows that if you are a Ukraine export partner, the impact on Food Inflation post war is much higher than if you are not an export partner.

Manufacturing Production: Next, we analyzed how manufacturing production in Ukraine's export partners was affected as a result of the Ukraine war. We chose this metric as we saw the Ukraine's iron ore production dropped significantly after the war (see figure below) leading to an increase in prices. We hypothesized that this would have an impact on manufacturing production in the rest of the world.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Figure 5: Ukraine's Iron Ore Exports: 2021-2023

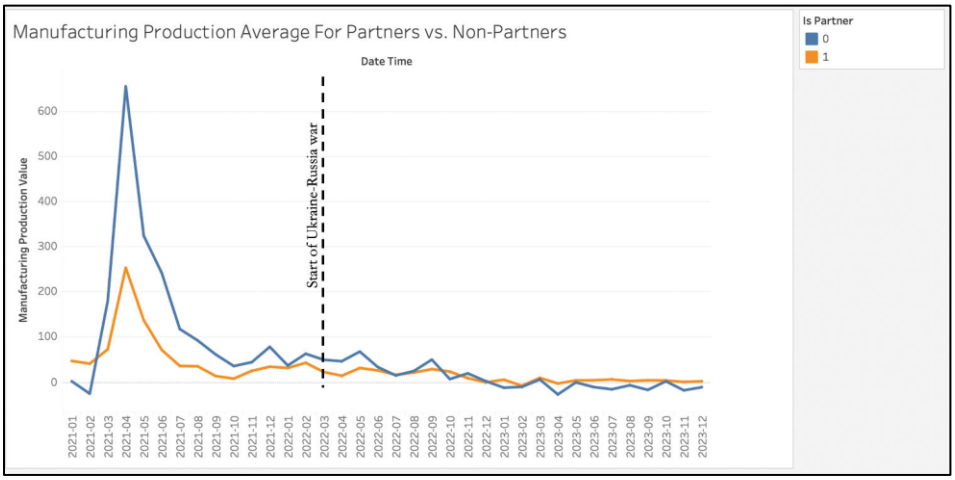


Source: U.N. Comtrade

We can again see a steep decrease in the first quarter of 2022 near March - like our food inflation data. We will explore the effects of this decrease in iron ore exports.

In similar lines to the analysis for Food Inflation, we compared the average trend for Manufacturing Production in treatment and control group countries (see figure below), and the averages before and after the war (see table below).

Figure 6: Manufacturing Production Averages: Partners vs. Non-Partners



Source: Trading Economics

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Table 8: Average Manufacturing Production Growth for Partners vs. Non-Partners

Country Type	%Pre-	%Post-	% Change
Export Partners	12.28%	1.95%	-83.7%
Non-Partners (Control)	9.12%	0.68%	-92.5%

We see there is not much difference in the percent change of manufacturing production growth depending on partner - which is supported by our DiD analysis below.

We then performed a Difference In-Difference regression on our manufacturing production data, as above. Our regression equation is as such:

$$Manu.Prod. = C_0 + is\_partner * C_1 + post\_war * C_2 + (post\_war * is\_partner) * C_3$$

The learned coefficients with their p-values are listed below:

Table 9: DiD Analysis for Manufacturing Production

Coefficient	C0	C1(is_partner)	C2(post_war)	C3
Value	9.30	2.72	-8.73	-1.33
P > |t|	(0.000)	(0.0098)	(0.000)***	(0.525)

Our DID analysis for this case showed that:

1. Is_Partner is not statistically significant.
2. Is_Post_War is statistically significant.
3. The interaction term is not statistically significant.

This shows that the war impacted the Manufacturing Production for all countries similarly, unlike Food Inflation which impacted Ukraine's export partners to a higher degree. This is likely because the staple diet of number of countries in the control group (e.g. Japan, India, South Korea, Brazil) consists of other grains such as rice, where iron and steel are critical commodities that enable manufacturing production in all countries.

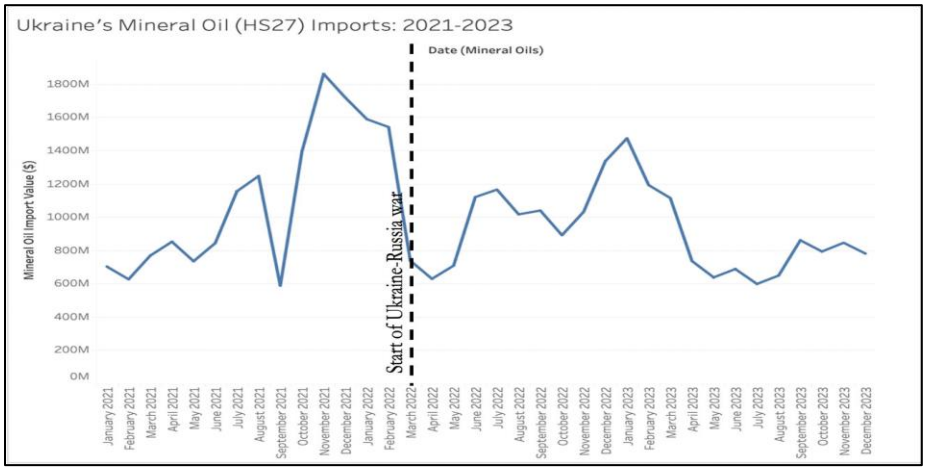
B. Is there an effect of war on the import partners?

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

As we saw in earlier sections, Ukraine's imports were affected significantly at the onset of war. In particular, Ukraine's imports of mineral oil and vehicles were severely impacted as can be seen in the figures below.

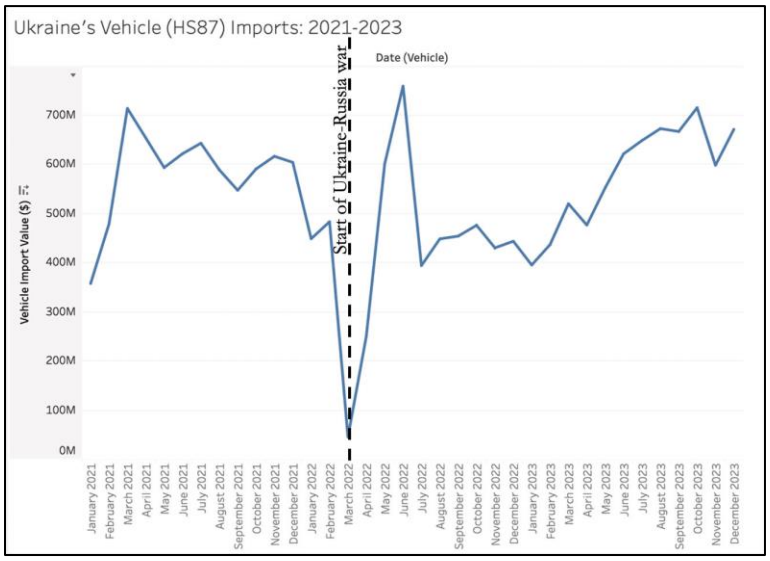
Figure 7: Ukraine's Mineral Oil Imports: 2021-2023



Source: U.N. Comtrade

We see a drop in mineral oil imports in Feb-March 2022, and a slight increase after. But, import levels never recovered to pre-war figures.

Figure 8: Ukraine's Vehicle Imports: 2021-2023



Source: U.N. Comtrade

ISSN: 2455-8834

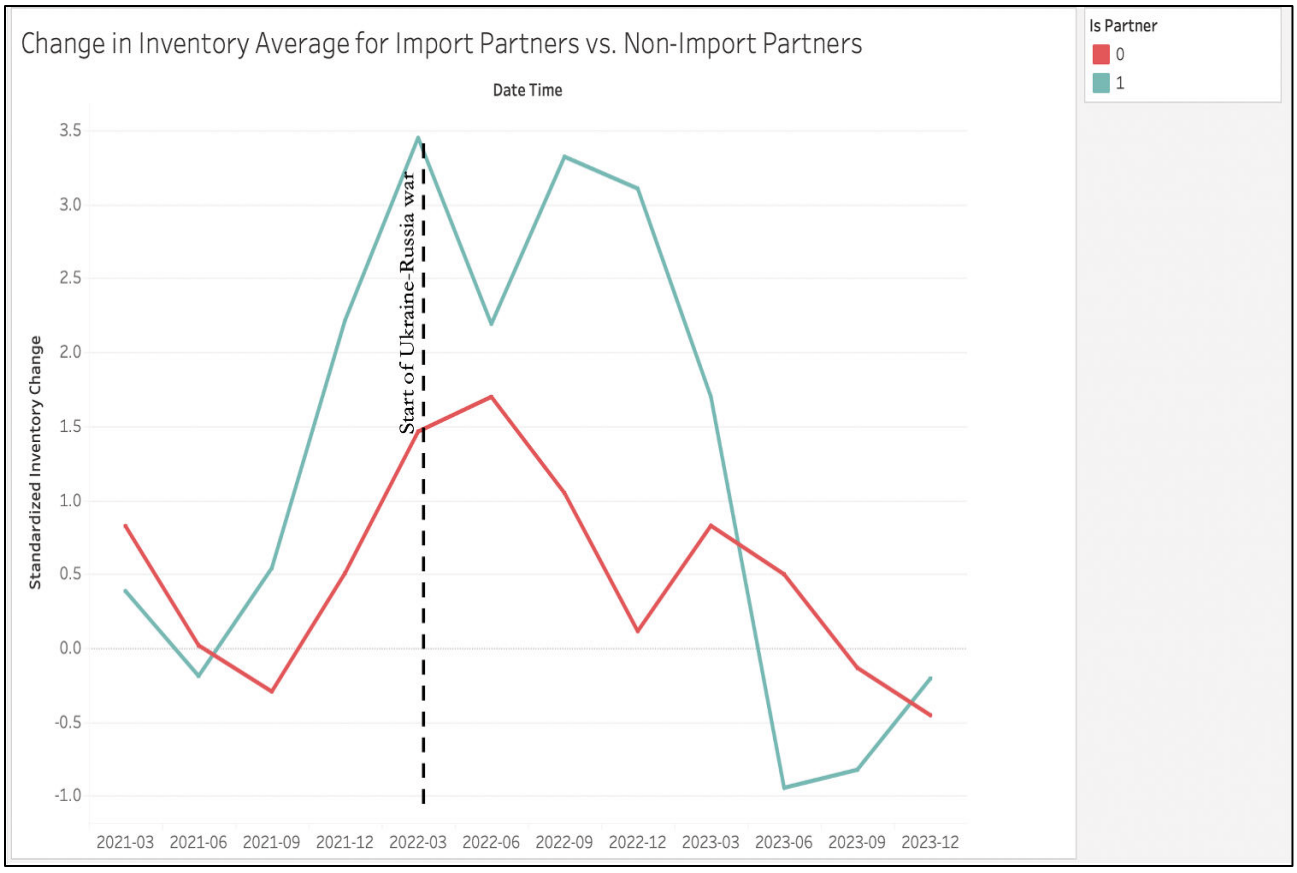
Volume:09, Issue:09 "September 2024"

As above, we see a drop in vehicle imports from Feb to March 2022 - we will explore the effects of these trends below.

We hypothesized that Ukraine's import reduction would impact inventories and in particular, gas prices in import partner countries. We analyzed Changes in Inventories, and Gas prices using our DID method below.

Changes in Inventories: We assessed the Changes in Inventories across both import partners of Ukraine, and control group countries. First, we present the changes in averages in the figure below and the table. Note that as for the import partners, values for inventory change are much higher than that of non-import partners. Therefore, we standardize each list of inventory changes in terms of standard deviations using the zscaler library in Python. Thus, the coefficients and graph axes are in terms of standard deviations for inventory change (units).

Figure 9: Inventory Change Averages: Import Partners vs. Non-Partners



Source: Trading Economics

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Table 10: Average Inventory Change (Units) for Partners vs. Non-Partners

Country Type	% Pre-War	Post-War	% Change
Import Partners (Treatment)	-12.1m	41.0m	440.0%
Non-Partners (Control)	8357.3	10329.5%	23.6%

We can see a drastic difference in the percent change of inventory change for import partners as compared to non-import partners after the war.

DiD Analysis:

Table 11: DiD Analysis for Change in Inventory

Coefficient	C_0	C_1(*is_partner*)	C_2(*post_war*)	C_3
Value	0.30	0.28	**0.62**	**-1.41**
$P > \|t\|$	(0.000)	(0.425)	**(0.029)****	**(0.0019)****

Observations:

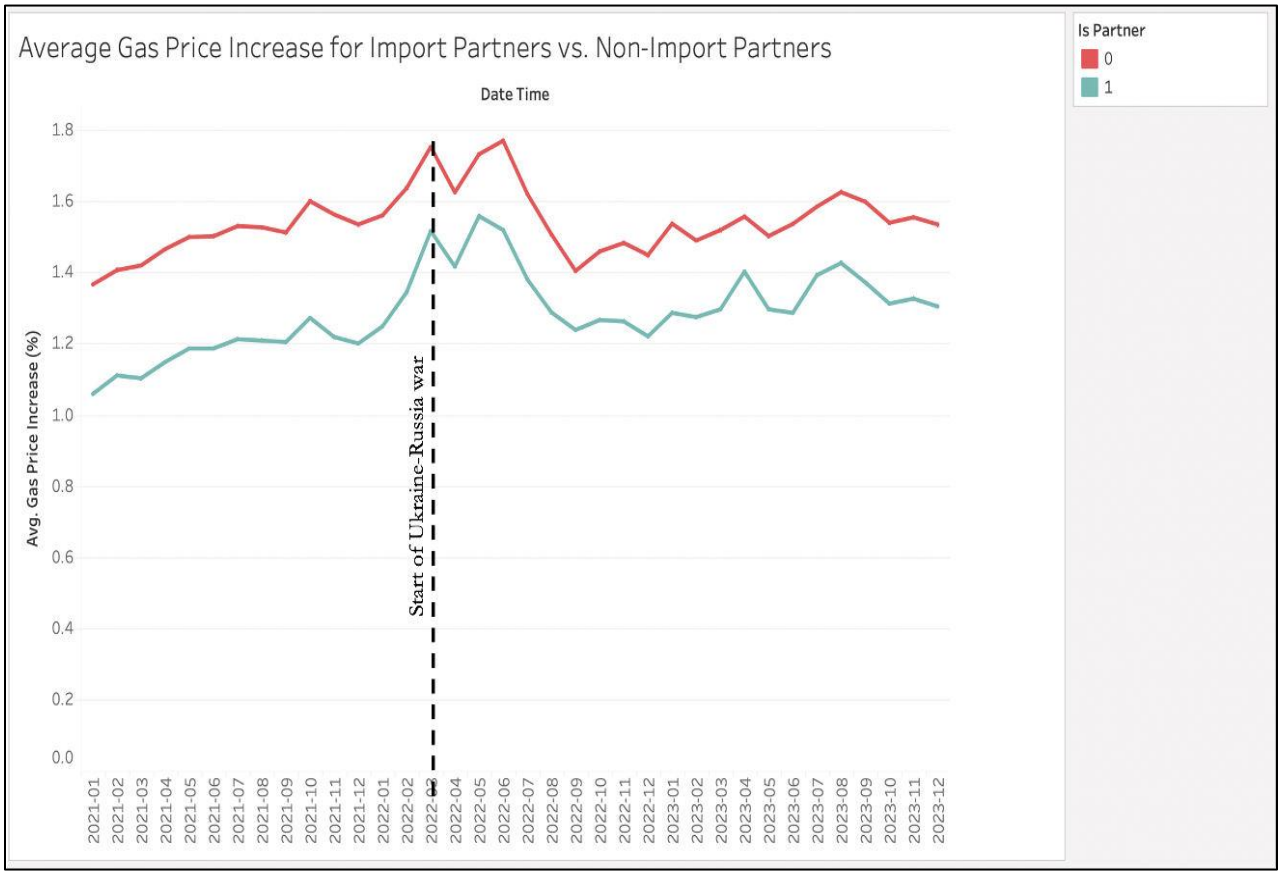
1. Changes in Inventories did not depend on whether the country was an import partner or not alone.
2. Inventory rose after the war started for all countries.
3. Importantly, inventories rose higher for import partners of Ukraine compared to non-partners.

Gas Prices: We assessed the gas prices across both import partners of Ukraine and control group countries. The details are below.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Figure 10: Gas Price Change Averages: Import Partners vs. Non-Partners



Source: Trading Economics

Table 12: Average Gas Price Change (%) for Partners vs. Non-Partners

Country Type	% Pre-War	Post-War	% Change
Import Partners (Treatment)	1.26%	1.50%	19.2%
Non-Partners (Control)	1.52%	1.72%	13.2%

Gas prices increased for both import partners and non-partners, which is supported by Ukraine's mineral oil imports decreasing during the war but slightly increasing after the war.

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

DiD Analysis:

Table 13: DiD Analysis for Gas Price Change

Coefficient	C_0	C_1(*is_partner*)	C_2(*post_war*)	C_3
Value	1.52	**-0.26**	**0.20**	0.04
$P > \|t\|$	(0.000)	**(0.000)*** **	**(0.002)** **	(0.744)

What we observe is that:

1. Gas price increases are always higher for non-partners compared to partners, and this shows up in the p-values as well.
2. Post-war both partners and non-partners suffered an increase in gas prices. However, there is no significance for the interaction term, which says that important partners did not get impacted any more by the war than non-partners.

C. Is there an effect of war on the GDP of partners?

Figure 11: GDP Change Averages: All Partners vs. Non-Partners

Source: Trading Economics

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Table 14: Average GDP Price Change (units) for All Partners vs. Non-Partners

Country Type	% Pre-War	% Post-War	% Change
All Partners (Treatment)	2.0	0.85	-57.7%
Non-Partners (Control)	1.27	0.49	-61.3%

GDP seemed to decrease for both partners and non-partners after the war, as can be seen by the percent changes above and our DiD analysis below.

DiD Analysis:

Table 15: DiD Analysis for GDP Change

Coefficient	C_0	$C_1(is\_partner)$	$C_2(post\_war)$	C_3
Value	1.27	**0.72**	**-0.78**	-0.37
$P > \|t\|$	(0.000)	**(0.037)****	**(0.001)*****	(0.379)

Observations for GDP Change:

1. The GDP of all countries reduced after the war. This is a pretty significant observation that says that effects of a war are far reaching.
2. The interaction term is not statistically significant. This means that there was not much of a distinction post-war between partners of Ukraine and the control group countries, as far as GDP is concerned.

We summarize all the DID results so far into this table in which we focus on the Post_war and the interaction_terms across import and export partners.

Recall, our DiD Regression equation is:

$$Y = C0 + is\_partner * C1 + post\_war * C2 + (post\_war * is\_partner) * C3$$

Table 16: DiD Analyses for All Affected Metrics

Dependent Variable	Const	Is_Partner Coefficient (P-Value)	Post_War Coefficient (P-Value)	Interaction Term Coefficient (P-Value)

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Food Inflation	3.24	4.51 (0.010)**	5.00 (0.000)***	12.02 (0.000)***
Manufacturing Production	9.30	2.72 (0.098)	-8.73 (0.000)***	-1.33 (0.525)
GDP	1.27	0.72 (0.037)**	-0.78 (0.001)***	-0.37 (0.379)
Change in Inventory	0.30	0.28 (0.425)	0.62 (0.029)**	1.41 (0.019)**
Gas Price	1.53	0.64 (0.000)***	0.20 (0.002)***	0.04 (0.744)

D. Does the location of a country influence whether it was affected by the war?

We wanted to understand whether the Ukraine war effects were really only due to physical proximity of the trade partners such as Poland, Romania being located in Europe, and whether countries far away from Ukraine wouldn't be affected as much by the war. So, we replaced "Is_Partner" with a term "Proximity" which took a value of 1 for 6 "Treatment" countries namely Poland, Romania, Turkey, France, Germany and Italy. The "Control" countries consisted of 5 countries China, India, Brazil, Canada and USA, which were far away from Ukraine. We present the summary of our DID analysis below. Here our DiD regression equation is as such:

$$Y = C_0 + proximity * C_1 + post\_war * C_2 + (post\_war * proximity) * C_3$$

Table 17: DiD Analyses for Location Regression

Dependent Variable	Const Coefficient	Proximity Coefficient (P-Value)	Post_War Coefficient (P-Value)	Interaction Term Coefficient (P-Value)
Food Inflation	4.22	2.891 (0.265)	2.364 (0.328)	14.293 (0.000)***
Manufacturing Production	9.68	1.89 (0.399)	-7.53 (0.000)***	-2.89 (0.314)
GDP	1.85	-0.41 (0.424)	-0.73 (0.118)	-0.26 (0.679)
Change in Inventory	0.38	0.26 (0.569)	0.89 (0.125)	1.13 (0.155)
Gas Price	1.05	0.64 (0.000)***	0.24 (0.001)***	-0.02 (0.803)

Observations:

1.We observe that if a country is close to Ukraine physically, then it suffered a higher food inflation compared to remote countries. This is to be expected since countries like China, India and

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Brazil consume other grains such as rice which they produce themselves. Additionally, USA and Canada produce their own wheat. As a result, they are likely to be less impacted by food inflation caused due to lower wheat exports from Ukraine.

2.Gas prices and manufacturing production are both impacted by the war, irrespective of the proximity of the country to Ukraine.

3.We didn't see any interaction terms being significant for proximity alone other than for food inflation.

VI. Conclusions

In this paper, we used Difference-in-Difference techniques to analyze the impact of the Russia-Ukraine conflict on Ukraine's trading partners. We started with an overview of Ukraine's main im- port and export commodities, and Ukraine's partners including Poland, Romania, Turkey, Germany, China and USA. To assess the impact on trading partners, we analyzed how macroeconomic indica- tors such as food inflation, manufacturing production, GDP, gas prices and changes in inventories for partner countries, were impacted by the war. Our work showed that the Ukraine war had a significant impact not only on the partners, but also other non-partner countries around the world. Food inflation rose significantly after the war started, but the effects were most telling on Ukraine's export partners that depended on Ukraine for wheat supplies. Manufacturing production dropped across both partner and non-partner countries due to drop in exports of important commodities like iron and steel. The impact of this drop continues to be felt to this date (in 2024). One of the devastating impacts of any war is a hit to the GDP of both warring factions, and other countries in the world not involved in the war. We saw that post-war, GDP of all countries dropped. We saw that Ukraine's im- port partners saw a build-up in inventory to a greater degree than non-partners after the war started. Additionally, gas prices across the world rose as a result of the war, adding to the inflation woes of many countries.

The mathematical analysis of the macroeconomic indicators in partner countries clearly showed the devastating effects on the economies of trading partners, and other countries of the world. While we chose a few indicators only, we believe that the war would have impacted other metrics as well. Given these far-reaching temporal and spatial effects, we hope that leaders across the world will pay attention to their foreign policies, and try to avoid war as much as possible.

VII. Acknowledgements

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ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

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ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

IX: Appendix A: DiD Results

A. Export Partner DiD Analysis

Figure 12: Difference In-Difference Regression for Food Inflation

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.246
Model:	OLS	Adj. R-squared:	0.242
Method:	Least Squares	F-statistic:	71.31
Date:	Thu, 27 Jun 2024	Prob (F-statistic):	6.33e-40
Time:	05:33:59	Log-Likelihood:	-2603.8
No. Observations:	660	AIC:	5216.
Df Residuals:	656	BIC:	5234.
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	3.2475	0.920	3.531	0.000	1.442	5.054
is_partner	4.5182	1.759	2.569	0.010	1.064	7.972
post_war	5.0026	1.175	4.257	0.000	2.695	7.310
interaction term	12.0229	2.249	5.345	0.000	7.606	16.440

Omnibus:	457.298	Durbin-Watson:	0.087
Prob(Omnibus):	0.000	Jarque-Bera (JB):	6213.008
Skew:	2.974	Prob(JB):	0.00
Kurtosis:	16.804	Cond. No.	7.28

Figure 13: Difference In-Difference Regression for Manufacturing Production

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.127
Model:	OLS	Adj. R-squared:	0.123
Method:	Least Squares	F-statistic:	34.07
Date:	Fri, 05 Jul 2024	Prob (F-statistic):	1.43e-20
Time:	22:13:17	Log-Likelihood:	-2754.0
No. Observations:	708	AIC:	5516.
Df Residuals:	704	BIC:	5534.
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	9.3054	0.831	11.201	0.000	7.674	10.936
is_partner	2.7232	1.644	1.657	0.098	-0.504	5.950
post_war	-8.7362	1.061	-8.237	0.000	-10.818	-6.654
interaction term	-1.3351	2.101	-0.635	0.525	-5.461	2.791

Omnibus:	964.275	Durbin-Watson:	1.099
Prob(Omnibus):	0.000	Jarque-Bera (JB):	258560.005
Skew:	7.000	Prob(JB):	0.00
Kurtosis:	95.567	Cond. No.	7.36

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

B. Import Partner DiD Analysis

Figure 14: Difference In-Difference Regression for Change in Inventory

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.105
Model:	OLS	Adj. R-squared:	0.093
Method:	Least Squares	F-statistic:	8.861
Date:	Thu, 27 Jun 2024	Prob (F-statistic):	1.41e-05
Time:	06:03:04	Log-Likelihood:	-458.92
No. Observations:	231	AIC:	925.8
Df Residuals:	227	BIC:	939.6
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.3028	0.162	1.864	0.064	-0.017	0.623
is_partner	0.2765	0.346	0.800	0.425	-0.405	0.958
post_war	0.6182	0.281	2.197	0.029	0.064	1.173
interaction term	1.4124	0.599	2.358	0.019	0.232	2.592

Omnibus:	5.924	Durbin-Watson:	1.157
Prob(Omnibus):	0.052	Jarque-Bera (JB):	8.703
Skew:	-0.079	Prob(JB):	0.0129
Kurtosis:	3.938	Cond. No.	6.16

Figure 15: Difference In-Difference Regression for Gas Prices

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.071
Model:	OLS	Adj. R-squared:	0.067
Method:	Least Squares	F-statistic:	18.33
Date:	Sat, 06 Jul 2024	Prob (F-statistic):	1.82e-11
Time:	01:21:15	Log-Likelihood:	-469.85
No. Observations:	720	AIC:	947.7
Df Residuals:	716	BIC:	966.0
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.5193	0.021	71.431	0.000	1.478	1.561
is_partner	-0.2593	0.043	-6.094	0.000	-0.343	-0.176
post_war	0.2005	0.064	3.143	0.002	0.075	0.326
interaction term	0.0417	0.128	0.327	0.744	-0.209	0.292

Omnibus:	88.603	Durbin-Watson:	0.083
Prob(Omnibus):	0.000	Jarque-Bera (JB):	24.087
Skew:	-0.042	Prob(JB):	5.88e-06
Kurtosis:	2.108	Cond. No.	8.01

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

C. GDP DiD Analysis

Figure 16: Difference In-Difference Regression for GDP Change

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.104
Model:	OLS	Adj. R-squared:	0.093
Method:	Least Squares	F-statistic:	9.131
Date:	Sat, 06 Jul 2024	Prob (F-statistic):	9.68e-06
Time:	22:24:40	Log-Likelihood:	-423.37
No. Observations:	240	AIC:	854.7
Df Residuals:	236	BIC:	868.7
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.2714	0.190	6.681	0.000	0.897	1.646
is_partner	0.7286	0.347	2.097	0.037	0.044	1.413
post_war	-0.7795	0.233	-3.344	0.001	-1.239	-0.320
interaction term	-0.3747	0.426	-0.881	0.379	-1.213	0.464

Omnibus:	66.359	Durbin-Watson:	2.129
Prob(Omnibus):	0.000	Jarque-Bera (JB):	1295.152
Skew:	0.455	Prob(JB):	5.77e-282
Kurtosis:	14.344	Cond. No.	7.82

D. Proximity DiD Analyses

Figure 17: Difference In-Difference Regression for Food Inflation: Proximity

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.221
Model:	OLS	Adj. R-squared:	0.215
Method:	Least Squares	F-statistic:	36.98
Date:	Thu, 27 Jun 2024	Prob (F-statistic):	4.59e-21
Time:	06:16:19	Log-Likelihood:	-1652.4
No. Observations:	396	AIC:	3313.
Df Residuals:	392	BIC:	3329.
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	4.2247	1.886	2.240	0.026	0.517	7.933
proximity	2.8491	2.554	1.116	0.265	-2.172	7.870
post_war	2.3647	2.413	0.980	0.328	-2.379	7.108
interaction term	14.2829	3.267	4.372	0.000	7.860	20.706

Omnibus:	251.206	Durbin-Watson:	0.082
Prob(Omnibus):	0.000	Jarque-Bera (JB):	1779.348
Skew:	2.769	Prob(JB):	0.00
Kurtosis:	11.785	Cond. No.	8.13

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Figure 18: Difference In-Difference Regression for Manufacturing Production: Proximity

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.096
Model:	OLS	Adj. R-squared:	0.089
Method:	Least Squares	F-statistic:	13.90
Date:	Sat, 06 Jul 2024	Prob (F-statistic):	1.25e-08
Time:	23:05:11	Log-Likelihood:	-1601.2
No. Observations:	396	AIC:	3210.
Df Residuals:	392	BIC:	3226.
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	9.6822	1.657	5.842	0.000	6.424	12.941
proximity	1.8944	2.244	0.844	0.399	-2.518	6.306
post_war	-7.5343	2.120	-3.554	0.000	-11.703	-3.366
interaction term	-2.8970	2.871	-1.009	0.314	-8.541	2.747

Omnibus:	578.869	Durbin-Watson:	1.246
Prob(Omnibus):	0.000	Jarque-Bera (JB):	129088.852
Skew:	7.451	Prob(JB):	0.00
Kurtosis:	90.187	Cond. No.	8.13

Figure 19: Difference In-Difference Regression for GDP Change: Proximity

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.085
Model:	OLS	Adj. R-squared:	0.063
Method:	Least Squares	F-statistic:	3.951
Date:	Sat, 06 Jul 2024	Prob (F-statistic):	0.00985
Time:	23:06:21	Log-Likelihood:	-255.25
No. Observations:	132	AIC:	518.5
Df Residuals:	128	BIC:	530.0
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.8500	0.380	4.869	0.000	1.098	2.602
proximity	-0.4125	0.514	-0.802	0.424	-1.430	0.605
post_war	-0.7325	0.465	-1.574	0.118	-1.653	0.188
interaction term	-0.2612	0.630	-0.415	0.679	-1.508	0.985

Omnibus:	35.252	Durbin-Watson:	2.155
Prob(Omnibus):	0.000	Jarque-Bera (JB):	492.873
Skew:	-0.184	Prob(JB):	9.42e-108
Kurtosis:	12.459	Cond. No.	8.83

ISSN: 2455-8834

Volume:09, Issue:09 "September 2024"

Figure 20: Difference In-Difference Regression for Change in Inventory: Proximity

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.156
Model:	OLS	Adj. R-squared:	0.132
Method:	Least Squares	F-statistic:	6.569
Date:	Sat, 06 Jul 2024	Prob (F-statistic):	0.000406
Time:	23:07:31	Log-Likelihood:	-229.73
No. Observations:	111	AIC:	467.5
Df Residuals:	107	BIC:	478.3
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.3864	0.335	1.154	0.251	-0.277	1.050
proximity	0.2608	0.455	0.573	0.568	-0.642	1.164
post_war	0.8976	0.580	1.548	0.125	-0.252	2.047
interaction term	1.1295	0.789	1.432	0.155	-0.434	2.693

Omnibus:	6.988	Durbin-Watson:	1.224
Prob(Omnibus):	0.030	Jarque-Bera (JB):	8.162
Skew:	-0.364	Prob(JB):	0.0169
Kurtosis:	4.112	Cond. No.	6.58

Figure 21: Difference In-Difference Regression for Gas Price Change: Proximi

OLS Regression Results

Dep. Variable:	Value	R-squared:	0.553
Model:	OLS	Adj. R-squared:	0.549
Method:	Least Squares	F-statistic:	146.7
Date:	Sat, 06 Jul 2024	Prob (F-statistic):	6.85e-62
Time:	23:07:59	Log-Likelihood:	-74.065
No. Observations:	360	AIC:	156.1
Df Residuals:	356	BIC:	171.7
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.0548	0.024	44.637	0.000	1.008	1.101
proximity	0.6473	0.033	19.370	0.000	0.582	0.713
post_war	0.2454	0.071	3.462	0.001	0.106	0.385
interaction term	-0.0251	0.100	-0.250	0.803	-0.222	0.172

Omnibus:	30.480	Durbin-Watson:	0.127
Prob(Omnibus):	0.000	Jarque-Bera (JB):	35.795
Skew:	-0.756	Prob(JB):	1.69e-08
Kurtosis:	3.317	Cond. No.	8.44

