IMPACT OF THE GRAIN DEAL ON DOMESTIC GRAIN PRICES

by

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Abstract

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This thesis investigates the impact of the Russian full-scale invasion of Ukraine on global commodity markets, with a specific focus on the domestic wheat and corn prices following the introduction of the Grain Deal Initiative. As a significant player in global agricultural trade, the disruption caused by the invasion to Ukraine's key agricultural trade ports had immediate repercussions on the global commodity markets. The Grain Deal Initiative was introduced as a potential mitigating measure, and this thesis uses regression analysis to evaluate its effectiveness in offsetting the initial drop in wheat and corn Ukrainian prices due to the war. The findings suggest that while the initiative has partially offset the price drop for wheat, it has not had a significant impact on corn prices.

This thesis contributes to the ongoing discourse surrounding the Russian invasion's impact on agricultural markets and food security, providing insights for policymakers and stakeholders engaged in addressing this food supply disruption crisis.

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Chapter 1

INTRODUCTION

Ukraine plays an important role in global agricultural trade. With its abundant arable land covering over 70% of the country's territory and possessing a significant portion of the world's 'black soil,' Ukraine stands as a major player in agricultural production and known as Europe's "breadbasket" (Leshchenko 2021). The agricultural sector holds immense importance for Ukraine, providing jobs for approximately 14% of the population with agricultural exports reaching $27.8 billion in 2021, accounting for 41% of the nation's overall exports (USDA, 2022).

Grain production, in particular, is a significant contributor to Ukraine's agricultural sector. In the 2020/21 marketing year, Ukraine exported 102 million tons of grain, accounting for 24% of total global grain exports (Cramon-Taubadel 2022).

Same marketing year Ukraine emerged as the seventh-largest global producer of wheat. Ukraine's wheat exports in 2021 were worth an estimated $5.1 billion, finding their primary markets in Egypt, Indonesia, Turkey, Pakistan, and Bangladesh. (USDA 2022)

Ukraine also held the position of the world's sixth-largest producer of corn. The USDA (2022) reports that Ukraine's corn exports in 2021 were worth $5.9 billion, with China receiving 32% of the shipments, the European Union 30%. Other significant destinations for Ukrainian corn exports included Egypt, Iran, and Turkey.

Over 90% of Ukraine's agricultural exports were shipped through Black Sea ports, with Odesa and Mykolaiv being the key ports for international trade flows (Martyshev et al. 2023).

The Russian full-scale invasion of Ukraine has had a significant impact on global commodity markets, particularly in the export sectors of wheat, corn, sunflower seeds, oil, and fertilizers.

The consequences of the invasion were felt immediately, as key ports crucial for agricultural trade were either occupied or blocked, resulting in agricultural goods becoming trapped within Ukraine's borders, both at ports and inland elevators (Martyshev et al. 2023).

These disruptions have led to instability in global food trade, causing price surges and increased volatility (Glauber et al. 2022). According to the World Bank (2022), this event is categorized as the largest commodity shock since the commodities boom of the 1970s.

The uncertainty generated by the invasion has had a disproportionate impact on lower-income countries that heavily rely on Ukraine's grain exports. For these countries, where food expenditure constitutes a significant portion of household income, the disruptions in the global food trade and the resulting price volatility have exacerbated their vulnerability (V. Cramon-Taubadel 2022).

The impacts of the pandemic and the invasion of Ukraine have raised significant concerns regarding global food security and highlighted the issue of overreliance on a few countries, like Russia and China, for a considerable amount of essential commodity exports such as agricultural and energy products. These challenges are compounded by the urgent need to address climate change, as the effects of global warming are already being felt worldwide.

The pressure to simultaneously mitigate and adapt to these multifaceted challenges has resulted in increasing uncertainty within the global food system.

This uncertainty has further led to heightened volatility in food and fossil fuel prices in recent years. Fluctuating prices for essential commodities create additional challenges for both producers and consumers, affecting food affordability and accessibility.

The war has its most severe impact on Ukraine. As of November 10, the indirect costs of the war on Ukraine's agriculture were estimated to be a staggering $34.25 billion, which accounted for 75% of the country's agricultural output in the previous year. Additionally, the physical damages incurred amounted to $6.6 billion, a figure that had risen to $8.7 billion by February 2023 (KSE 2022, 2023).

Moreover, the invasion led to increased export costs, resulting in a depreciation of Ukrainian commodity prices. The costs of exporting agricultural products, which were previously around $30-40 per ton, surged to over $200 per ton (Martyshev et al. 2023). This sharp escalation in export costs has contributed to a significant revenue shortfall for Ukrainian farmers, plunging many into financial distress and placing them at the brick of bankruptcy.

In the face of these challenges, Ukrainian agricultural producers explored alternative export routes, like trucks, rail and Danube River port. But high transportation costs pose significant obstacles. The additional capacity was limited to 1 million metric tons per month for rail and 600,000 tons for trucks (Martyshev et al. 2023). As a result, grain started accumulating rapidly within Ukraine, surpassing the available storage capacity (Kirby 2022).

In the final week of July 2022, the United Nations and Turkey facilitated the signing of a Grain Deal initiative between Ukraine and Russia. This agreement aimed to establish a 'grain corridor' involving three Ukrainian ports: Odessa, Chornomorsk, and Pivdennyi (UN 2022). The agreement was signed in Istanbul on 22 July 2022. Its objective was to establish procedures for the safe export of grain from these specified ports, with the aim of addressing the food crisis.

The effect of the grain corridor was almost immediate, resulting in a marked increase in the exportation of Ukraine's key agricultural commodities such as wheat, corn, barley, and oil products. The agricultural exports doubled roughly from three million metric tons in July to six million metric tons by September (Martyshev et al. 2023). As of November 2022, over 435 ships left the ports carrying over 10 million metric tons of food products. Around 13% of them were wheat that went to low-income countries (USAID 2022).

This upturn indicated that the corridor was partially successful in re-establishing Ukraine's role in international food markets and offsetting some of the disruption caused by the war. Transportation costs for wheat and corn, represented by the difference between Ukrainian and international prices dropped by approximately $30-70 per ton.

However, a substantial price gap persists between Ukrainian and international prices, showing significant logistical and economic barriers (Martyshev et al. 2023). The uncertainty surrounding the exact impact of the grain corridor agreement on domestic prices persists.

In the broader context, even before the grain corridor agreement came into force, global commodity prices had been exhibiting a downward trend, albeit from inflated levels due to the ongoing Covid-19 pandemic (Glauber et al. 2022). Multiple factors may account for this decline. Favorable harvest outcomes in Brazil, Western Europe, and North America could have eased market pressures, while other economic factors such as reduced demand and a strong US dollar may have also contributed to lower commodity prices (Laborde et al. 2022).

Research efforts have been made to assess the impact of the war and the Grain Deal agreement on global commodity prices. However, at this moment, there is yet to be a research done on assessment of the impact of the Grain Deal on Ukrainian domestic prices. This study aims to address this gap by conducting an

econometric analysis to measure the grain corridor's influence on the domestic prices of wheat and corn. By conducting a regression analysis, this study will seek to identify the presence and magnitude of any structural breaks in the pricing of these commodities. The insights drawn from this research could be valuable to both researchers and policymakers in the agricultural sector.

Chapter 2

LITERATURE REVIEW

The full-scale invasion of Ukraine by Russia has provoked considerable shifts in global food supply chains, leading to substantial disruptions worldwide. Given both Ukraine's and Russia's important role in the global agricultural market, these disruptions have initiated widespread discourse and pressing questions about the impacts of the war on agricultural trade and food security. This topic has gained significant attention within academic circles, inciting researchers to investigate the ramifications of war on the agricultural market, as well as influence of the Grain Deal.

In this section, we present a review of some of the relevant literature in this field, encompassing an array of studies that attempt to evaluate the effect economic shocks, supply chain disruptions and remedy policies have on commodity markets.

In their research, Ihle R et al. (2022) investigated the influence of the full-scale war between Russia and Ukraine on synchronization of global commodity prices. They applied the concordance index to gauge time-varying co-movements and analyzed the trajectory of 15 crucial global commodity price indices from 2010 to 2022. Their findings suggest that disruptions in supply chains due to the war heightened the synchronization of grain, energy, and fertilizer prices globally, resulting in a significant contagion across various food and non-food markets. They conclude by emphasizing the necessity for policy interventions to boost the resilience of global food supply chains, particularly in times of crisis.

The same study also emphasizes that literature investigating supply chain disruptions, as relative to our research, is categorized into internal and external relative to supply system. Internal include disruptions that originate within the

system itself related to supply and demand. External include natural disasters and man-made disruptions, like COVID-19 pandemic and Russia-Ukraine war.

One relevant study in the field of internal supply chain disruption is conducted by Götz et al. (2016), which focuses on measuring the effects of wheat export controls in Ukraine and Russia on wheat prices. The authors use a price transmission model framework to identify effects of export controls on the domestic prices, considering the impact of harvest failures as well. The analysis is conducted at the regional level, providing insights into the functioning of export controls in large countries. The results reveal significant regional heterogeneity in the strength of domestic price effects of the export ban imposed in Russia during the 2010/11 period. The study finds that the wheat price dampening effects can reach up to 67%, with the most pronounced impact observed in the major wheat exporting region that has direct access to the world market. This effect is then transmitted to other regions through increased and reversed interregional trade flows. In contrast, the regional variation of export controls' domestic price effects in Ukraine is relatively small.

Götz et al. (2013) conducted a study that aimed to investigate the correlation between export restrictions and the existence of multiple spatial price equilibria, specifically focusing on the impact of wheat export quotas in Ukraine. The analysis specifically examined temporary export restrictions during periods of international commodity price peaks. The researchers applied a smooth transition cointegration model to the wheat export quota in Ukraine and discovered that the domestic wheat price remained approximately 30% lower than the international wheat price during two recent price spikes. This indicated the presence of price insulating effects and the existence of multiple spatial equilibria between domestic and world market prices.

Studies on external supply chain disruptions were widely conducted to measure the effect of the pandemic in recent years.

For example, in a recent study by Bairagi et al. (2022) in India, the authors used a phone survey to measure the impact of the COVID-19 pandemic on the prices of some essential food items. Using regression analysis based on the reduced form of the inverse demand function, the study found that the prices of basic food items such as wheat flour and rice experienced significant increases during the pandemic compared to the pre-pandemic period. In contrast, the price of onions demonstrated a significant decline during the same period. These results emphasized the important effect of panic-buying, hoarding, and the storability of food items in context of external supply chain disruptions. Additionally, the study revealed that remittance income and cash transfers from the government had a negative impact on commodity prices. This finding implies that families may have shifted their demand away from essential foods during the pandemic due to the availability of alternative income sources.

Another notable study by Martin W et al. in 2023 reviews recent fluctuations in commodity prices, emphasizing the substantial rise in wheat prices. Their research centers on the extent to which domestic markets remain insulated from these shifts and their subsequent effects on global prices. To explore this, they utilized Error Correction Models in their econometric analysis, uncovering stable long-term relationships between global wheat prices and most domestic prices of wheat products, though the rate of price transmission varied significantly across countries. Furthermore, their examination of the price shocks during the Covid-19 pandemic and the Russian-Ukrainian war revealed that price insulation amplified the overall rise in global wheat prices twofold, simultaneously escalating their volatility during periods of both price increase and decline.

A study published in Journal of Agricultural Economics (Economic Impacts of the Black Sea Grain Initiative 2023), most relevant to our research, uses econometric analysis to measure the effect of Grain Deal having on international grain prices. They first use Bai and Perron test to find 4 breakpoints in the data. They find that two of the breakpoints indicate the beginning of Russian full-scale invasion and another, at the end of June, which they relate to Grain deal, signifying the significant of both points pointing at significant structure breaks at both points. They find that Wheat prices increased by 329% with beginning of invasion, while corn increased by 121%. Then they conclude based on the results that the Grain Deal did have a significant effect on world wheat prices, which brought them down by 8% but showed no significant effect on corn. The paper attributes this to the fact that corn production, due to war destruction, went down by 50% comparing to the previous crop year.

Overall, the literature highlights the complex dynamics of supply chain disruptions and their impacts on commodity markets. Understanding these effects is crucial for policymakers and stakeholders in managing and mitigating the consequences of disruptions on domestic and international food prices. Further research in this area, specifically examining the impact of the Grain Deal on domestic Ukrainian prices, will contribute to a comprehensive understanding of the effects of trade agreements and supply chain disruptions on agricultural markets.

Chapter 3

METHODOLOGY

This section describes the methodology we have adopted to evaluate the influence of the Grain Deal on domestic wheat and corn prices in Ukraine.

The models we have selected for this study are similar to those published in the Journal of Economic Analysis (Economic Impacts of the Black Sea Grain Initiative 2023). However, considering the specifics that determine domestic commodity prices in Ukraine, we have made adjustments. In particular, we recognize that the prices received by producers in Ukraine are determined by deducting transfer costs from international prices. (UCAB 2018) Consequently, we have decided to exclude the use of prices of other products for market control, as we assume that these factors are already encompassed within international prices.

Taking into account the specifics of pricing, our dependent variable will be the difference between international prices and Ukrainian prices. This choice allows us to measure the impact of the Grain Deal on logistics costs, which include transportation, storage, port terminal services, elevator services, documentation and other costs.

To ensure the robustness of our results regarding the effect of the Grain Deal on domestic wheat and corn prices, we will employ two different methods to determine the appropriate models. Although the resulting models will have nearly identical structures, using both approaches should add credibility to our findings.

3.1 Model with predetermined structural breaks

Let's now outline the structure of the first model we will create.

$$\ln(P_t^w - P_t^D) = \alpha + \beta_1 Invasion_t +$$
$$\beta_2 Grain\ Deal_t + \beta_3 suspension_t + \sum_{m=1}^{11} \gamma^m \iota_t^m + \epsilon_t \qquad (1)$$

where:

P_t^w – international (Euronext) wheat and corn prices observed at day t.

P_t^D – Ukrainian (EXW) wheat and corn prices at day t.

$Invasion_t$ – dummy variable that takes value of 1 starting from 24th of February 2022.

$Grain\ Deal_t$ – dummy variable that takes value of 1 starting from 1st of August, 2022.

$suspension_t$ – dummy variable that takes value of 1 starting between 29th of October and 1st of November, the time during which Russia suspended its participation in the initiative.

$\sum_{m=1}^{11} \gamma^m \iota_t^m$ – a series of 11 dummy variables introduced to account for seasonality trend.

In this model, we make the assumption that the structural breaks occurred on two specific dates: the 24th of February 2022, which marked the start of the full-scale invasion, and August 1st, the day the first ship left port within the Grain Deal Initiative. To incorporate these structural breaks into our model, we introduced independent variables in the form of dummy variables. These dummy variables take the value of 1 after the occurrence of the event and 0 before. To control for possible market panic caused by Russia suspending its participation in Grain Deal, we include another dummy variable to control for this time.

By analyzing the results, we should be able to determine whether these structural

breaks had a significant impact on the price gap. This will be done by assessing the p-value, which is an indicator of the statistical significance, and examining the coefficients, which will should bring insights into the magnitude of the impact. Since the dependent variable is specified in logarithmic form, the coefficients should be interpreted as percentage changes.

3.2 Model with Bai and Perron test identified structural breaks

The second method we employ also involves taking the difference between world and domestic wheat and corn prices over time as the dependent variable. Next, we will run the model using only 11 seasonal monthly variables.

$$\ln(P_t^w - P_t^D) = \alpha + \sum_{m=1}^{11} \gamma^m \iota_t^m + \epsilon_t \quad (2)$$

To identify potential structural breaks within our model, statistical test known as the Bai and Perron will be employed to test for multiple unknown breakpoints. This test allows us to search for significant changes in the relationship between variables across different dates in the dataset, with a maximum of four breaks considered.

$$\ln(P_t^w - P_t^D) = \alpha + \beta_1 R_t^1 + \beta_2 R_t^2 + \beta_3 R_t^3 + \beta_4 R_t^4 + \sum_{m=1}^{11} \gamma^m \iota_t^m + \epsilon_t \quad (3)$$

After identifying the breakpoints (R_t^1 through R_t^4), the model is re-estimated by including new dummy variables that indicate the beginning of each identified point.

This approach allows us to examine the effect of the Grain Deal while also controlling for other structural breaks that may be present in the data.

Following the estimation of both the pre-determined model and the model with breakpoints, the residuals will be tested for autocorrelation using the Ljung-Box test. If autocorrelation is present, we will employ HAC (Heteroscedasticity and Autocorrelation Consistent) standard errors. HAC standard errors adjust for the presence of autocorrelation in the residuals, ensuring more accurate statistical inference.

In summary, our methodology combines two different modeling approaches to analyze the influence of the Grain Deal on domestic wheat and corn prices. By employing dummy variables, we capture specific dates and events related to the Grain Deal, while also considering seasonal trends and potential structural breaks.

Chapter 4

DATA

In this section, we examine the data used in our research, where we analyze the top two grain exports from Ukraine: wheat and corn. We gather two primary types of data: world international prices, represented by Euronext prices, and Ukrainian prices, specifically EXW prices, which are converted from hryvnias to dollars using the shadow dollar rate. The international and domestic grain prices data used in our research consists of daily observations, encompassing workdays from January 2, 2017 to December 30, 2022.

For Ukrainian prices, we EXW prices are used, which represent the price of the grain at the point of origin, excluding transportation and other additional costs. To convert these prices from the local currency, hryvnias, to dollars, we employ the shadow dollar rate. The shadow dollar rate refers to an unofficial exchange rate used to reflect the economic reality in situations where official exchange rates might not accurately represent market conditions.

Table 1 presents the statistics for domestic grain prices, specifically EXW prices for wheat and corn. The table includes descriptive measures for each variable, including the minimum, median, mean, maximum, number of observations (Obs), and the number of missing values (Na's).

It's important to note that since EXW prices are reported excluding Value Added Tax (VAT), adjustments were made to obtain the actual prices. Before March 2021, the applicable VAT rate in Ukraine was 20%, which was then reduced to 14%. To account for this change, the respective VAT rate is deducted from the EXW prices.

Table 1. Domestic grain prices

Variable	Min	Median	Mean	Max	Obs	Na's
Wheat	86.31	168.56	176.96	282.58	1565	69
Corn	86.31	138.82	154.86	256.68	1565	70

In our research, due to the presence of a significant number of missing values, we will utilize the abovementioned models from the methodology section for both the data with missing values and the data after interpolation.

Euronext prices refer to the market prices of commodities traded on the Euronext exchange. These prices are denominated in US dollars and serve as a benchmark for international grain markets. Table 2 presents the statistics for international grain prices.

Table 2. International grain prices

Variable	Min	Median	Mean	Max	Obs	Na's
Wheat	172.0	217.7	244.8	484.1	1565	0
Corn	171.5	199.4	229.5	424.8	1565	0

From the provided statistics in the tables, it is evident that the distribution of both international and domestic prices for wheat and corn is not normally distributed. The skewed nature of the distribution, particularly to the right, indicates a higher frequency of lower prices compared to higher prices.

This observation provides an additional reason for using logarithmic transformations in the analysis, beyond their easier interpretability.

Figure 1 and Figure 2 illustrate the time trends of wheat and corn prices, respectively, including both international and domestic prices. Additionally, vertical dotted lines are incorporated into the plots to represent significant events. The left vertical line signifies the beginning of the full-scale invasion, while the right vertical line represents the first ship leaving port within the Grain Deal initiative on August 1st.

Missing data points can be observed in the domestic prices plot during the period between the middle of February 2022 and the first week of June. However, reference points are present, allowing us to discern the pattern of domestic prices decreasing. Given these reference points, we assume and interpolate the missing values using linear interpolation, which estimates missing values by taking the average of the values immediately before and after the missing value, assuming a linear relationship between those points.

The plots also reveal the pre-invasion trend of increasing prices, which subsequently becomes more volatile in the years leading up to the invasion. Increasing volatility can be attributed to various factors, including the impact of the COVID-19 pandemic. The pandemic disrupted global supply chains and had significant effects on agricultural markets, leading to increased price fluctuations and market uncertainties.

Table 3 presents the statistics for the dependent variable, which is the difference between world and domestic Ukrainian prices for wheat and corn. The maximum difference for wheat is 327.11, while for corn, it is 272.55. Both of these peaks occur at the beginning of the full-scale invasion.

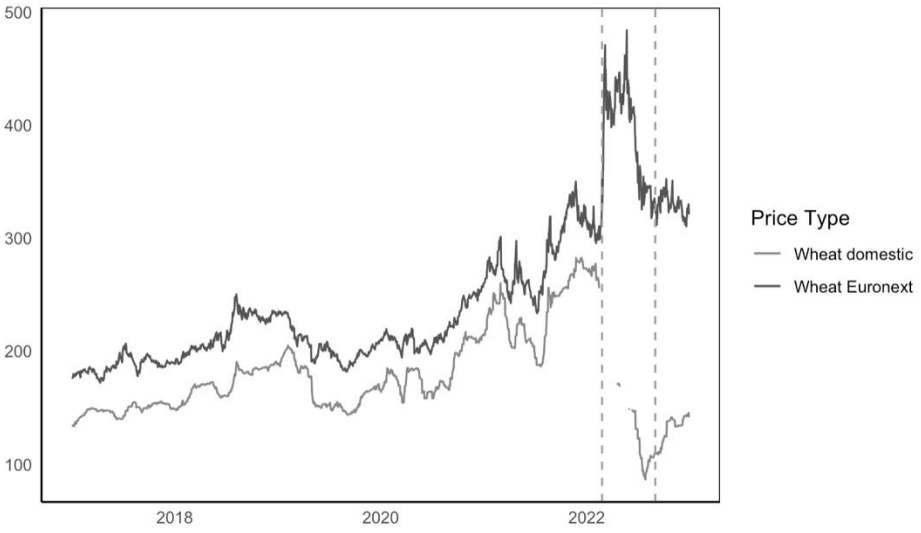

Figure 1. Wheat prices

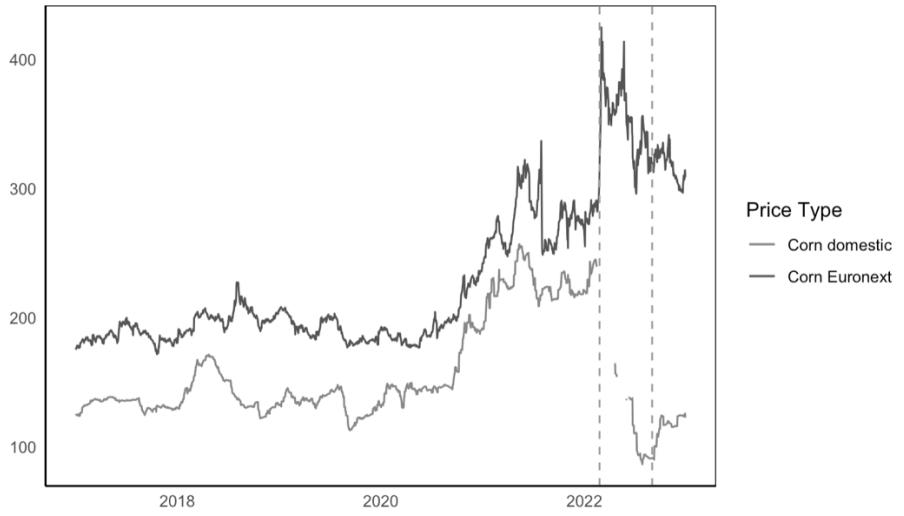

Figure 2. Corn prices

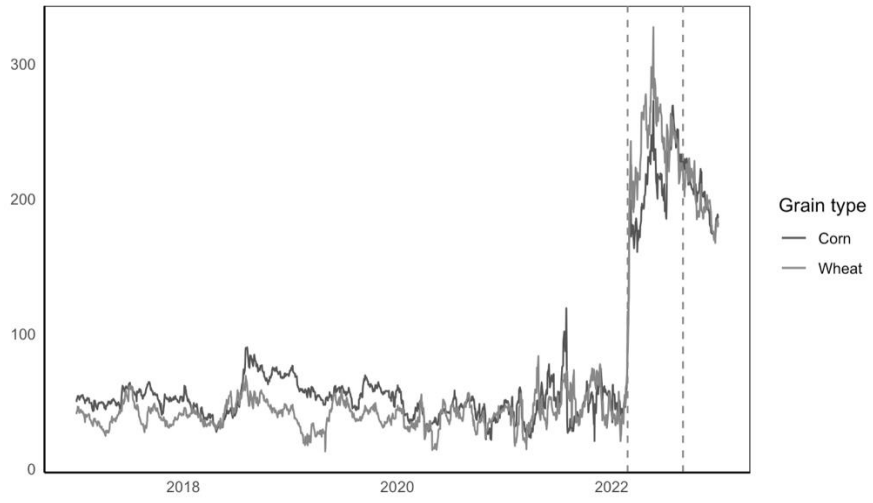

Figure 3. Gap between world and domestic grain prices

When examining the plots, we can observe a pattern in this variable. Prior to the war period, over time, the difference between world prices and Ukrainian prices shows a trend of decreasing, indicating a decrease in transfer costs. This decreasing trend suggests an optimization process in which the costs associated with transporting and trading grains were being reduced.

Table 3. Gap between international and domestic grain prices

Variable	Min	Median	Mean	Max	Obs
Wheat	13.01	42.61	67.03	327.11	1565
Corn	20.71	53.08	73.43	272.55	1565

The plots and statistics indicate that after the invasion, the gap between world and Ukrainian prices increased and became more volatile. While it appears to decrease

following the Grain Deal, it appears insufficient to fully offset the disruptive effects of the war.

To further explore this aspect, we examined the monthly exports of wheat and corn from Ukraine. Although this piece of data is not directly included in the regression analysis due to its monthly frequency and the potential introduction of endogeneity (if included as independent variables), it still offers valuable insights into the shipment patterns and help visualize the effects of the Grain Deal.

Figure 4 presents the monthly exports in million metric tons for corn and wheat from 2017 to the end of 2022.

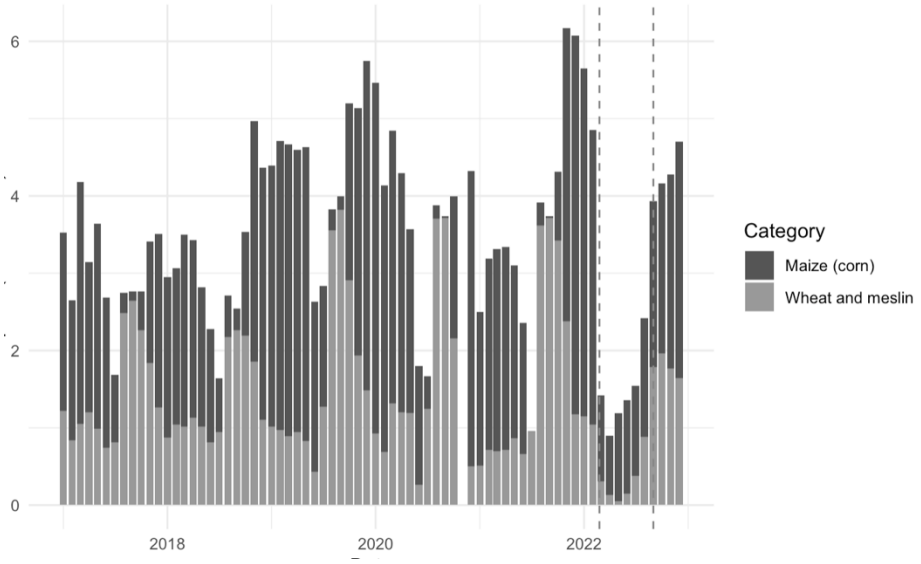

Figure 4. Monthly exports in million metric tons. Data source: UN Comtrade

The distinct seasonality observed in the shipment patterns of wheat and corn exports can be attributed to the unique characteristics of their respective harvesting seasons and global demand patterns. Wheat exports are the highest during the months of August to October, while corn exports are higher during winter months.

Both wheat and corn experienced an increasing trend in shipments over time before the war period but as Russia invaded Ukraine, there was a rapid decline in wheat exports, almost reaching zero. Corn exports experienced a comparatively smaller decrease during that period. The grain during this time was transported via trucks, trails, and the Danube river port, which is highly limited in capacity.

After the signing of the Grain Deal, indicated by a vertical line on the graph, a sharp increase in both corn and maize exports can be observed. However, the wheat exports, during the usual peak shipment period (August to October), remained significantly lower than previous trends.

Given the substantial increase in exports, the persistence of low domestic prices for corn and wheat raises a key concern. This suggests that the transfer costs associated with signing of Grain Deal have not decreased considerably, which is central focus of this research.

Chapter 5

ESTIMATION RESULTS

In this section of the master thesis, we present the estimation results obtained by implementing the model described in the methodology section. Our approach involves two main steps. First, we estimate a linear regression model with predetermined structural breaks based on specific events. Second, we employ the Bai and Perron test to identify any significant breakpoints and subsequently estimate the model with an alternative set of breaks.

5.1 Model with predetermined structural breaks: Estimation results

The estimation results for the first models are presented in Table 4. The independent variables include dummy variables for the invasion, Grain Deal, and Suspension - period when Russia suspended its participation in the initiative. It also includes 11 dummy variables representing different months.

Coefficient results show a significant effect of 1.82 indicating that the invasion increased the price difference by 182% for wheat. When the missing values are dropped, the coefficient remains similar at 1.73%. For corn, the magnitude of the war's impact on the price difference is slightly lower, with coefficients of 1.46% for interpolated data and 1.44% for dropped data. All of these coefficients are statistically significant.

The estimation results indicate that the Grain Deal coefficient exhibits a significant negative effect on the price differences between world and domestic prices. For interpolated data, the coefficient is -0.25 for wheat and -0.09 for corn, suggesting

that the Grain Deal reduced the price difference by approximately 25% for wheat and 9% for corn.

When the missing values are dropped, the coefficients for both wheat and corn remain statistically significant, but at slightly different confidence levels. The coefficient for wheat, with a value of -0.16, remains significant at a 95% confidence level. On the other hand, the coefficient for corn, with a value of -0.08, is slightly less significant at a 90% confidence level.

Table 4. Estimation results

	Wheat (Na's interpolated)	Wheat (Na's dropped)	Corn (Na's interpolated)	Corn (Na's dropped)
(Intercept)	3.69 ***	3.69 ***	3.95 ***	3.95 ***
	(0.02)	(0.02)	(0.02)	(0.02)
Invasion	1.82 ***	1.73 ***	1.46 ***	1.44 ***
	(0.02)	(0.03)	(0.02)	(0.03)
Grain Deal	-0.25 ***	-0.16 ***	-0.09 **	-0.08 .
	(0.03)	(0.04)	(0.03)	(0.04)
Suspension	0.02	0.02 (	0.06	0.06
	(0.16)	0.15)	(0.16)	(0.16)
Jan	0.01	0.01	0.01	0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Feb	-0.19 ***	-0.20 ***	-0.13 ***	-0.13 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Mar	-0.23 ***	-0.24 ***	- 0.21 ***	-0.20 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Apr	-0.18 ***	-0.19 ***	-0.25 ***	-0.25 ***
	(0.03)	(0.03)	(0.03)	(0.03)

TABLE 4 - Continued

May	-0.10 ***	- 0.13 ***	-0.11 ***	-0.14 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Jun	0.14 ***	0.15 ***	-0.02	0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Jul	0.18 ***	0.20 ***	0.09 **	0.09 **
	(0.03)	(0.03)	(0.03)	(0.03)
Aug	0.11 ***	0.11 ***	0.01	0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Sep	0.07 *	0.07 **	0.07 *	0.07 *
	(0.03)	(0.03)	(0.03)	(0.03)
Oct	0.09 **	0.09 **	0.01	0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Nov	0.01	0.01	-0.01	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)
N	1565	1496	1565	1495
R^2	0.89	0.86	0.84	0.81

Note: Dummies for structural differences and seasonality were used. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '.' 1

After conducting the Ljung -Box test on the interpolated data, the null hypothesis of no autocorrelation is rejected, indicating the presence of autocorrelation in the model. To account for this issue, the HAC (Heteroscedasticity and Autocorrelation Consistent) method was employed to obtain robust standard errors, as shown in Table 5.

In both the wheat and corn models, the coefficient for the Invasion variable remained statistically significant at a 99% confidence level, indicating a significant effect of the war on the price differences between world and domestic prices.

For wheat, the coefficient for the Grain Deal variable also remained significant, suggesting a 25% decrease in the price difference after the introduction of the deal. However, in the corn model, the coefficient for the Grain Deal variable became statistically insignificant, with the t-value decreasing from 3 to 0.81. This implies that the Grain Deal did not have a significant impact on the price difference in corn.

Table 5. Corrected residuals with HAC

	Wheat (Na's interpolated)	Corn (Na's interpolated)
(Intercept)	3.69 ***	3.95 ***
	(0.02)	(0.07)
Invasion	1.82 ***	1.46 ***
	(0.08)	(0.06)
Grain Deal	-0.25 *	-0.09
	(0.10)	(0.11)
Suspension	0.02	0.06
	(0.05)	(0.06)
N	1565	1565
R^2	0.89	0.86

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '.' 1

5.2 Bai and Perron test breakpoint-identified models: Estimation results

In order to further explore potential structural breaks in the data, models for both grain types with only seasonal dummy variables as independent variables are estimated. The dataset is subsetted to begin from January 2020 to reduce the number of potential breakpoints. The Bai and Perron test was then applied to identify any significant breakpoints.

For the logarithm of wheat prices, logarithm of corn prices, and untransformed wheat prices as dependent variables were detected no breakpoints that could be associated with the Grain Deal. However, for untransformed corn prices, a breakpoint was found on 2022-07-12, which was 10 days before the deal was officially signed. Even though this break was before the formal signing, the initiative was already publicly discussed, which could have caused a potential market impact even before the formal signing. Hence, it was decided to take this point as the potential structural break.

Additional breakpoints identified by the test include 2022-02-18 (around the start of the invasion), 2021-07-15, and 2021-02-11. These reference points were used to re-estimate the models (Table 6) for both the logarithm of wheat and corn variables.

Table 6. Breakpoints model with corrected residuals

	Wheat	Corn
(Intercept)	3.57 ***	3.70 ***
	(0.09)	(0.07)
R1	0.18 .	0.13 .
	(0.11)	(0.07)

TABLE 6 - Continued

R2	-0.09	0.06
	(0.13)	(0.08)
R3	1.64 ***	1.37 ***
	(0.15)	(0.11)
R4	-0.24	0.09
	(0.14)	(0.12)
Jan	-0.02	0.06
	(0.11)	(0.08)
Feb	-0.25 *	-0.12
	(0.11)	(0.10)
Mar	-0.17	-0.14
	(0.18)	(0.17)
Apr	-0.00	-0.14
	(0.16)	(0.10)
May	-0.13	0.10
	(0.20)	(0.13)
Jun	0.09	0.14
	(0.11)	(0.11)
Jul	0.20 *	0.24 *
	(0.08)	(0.11)
Aug	0.20 **	-0.05
	(0.07)	(0.17)
Sep	0.01	0.01
	(0.10)	(0.10)
Oct	0.10	0.00
	(0.10)	(0.07)

TABLE 6 - Continued

Nov	0.12	-0.08
	(0.12)	(0.09)
N	766	766
R^2	0.92	0.92

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '.' 1

After incorporating four breakpoint dummy variables in the models, namely R1 on 2021-02-11, R2 on 2021-07-15, R3 on 2022-02-18, and R4 on 2022-07-12, the presence of autocorrelation was still observed, similar to the previous models. To address this issue, the HAC method was employed to adjust the standard errors, resulting in the updated results presented in Table 6. The adjustment for autocorrelation led to lower t-values for three out of the four reference points, except for the war coefficient.

The analysis of the adjusted results indicates that the war had a consistent and significant effect on increasing the price gap between world and domestic prices for both wheat and corn. Specifically, the war is associated with a 164% increase in the price gap for wheat and a 137% increase for corn, both at a 99% confidence level. Although the t-value of 1.64 in absolute terms suggests relatively weaker significance for wheat, the effect of the Grain Deal on reducing the price difference is evident. The introduction of the Grain Deal resulted in a 24% decrease in the price difference for wheat when considering the reference points identified by running the Bai and Perron test on the log corn model.

In contrast, the p-value of 0.42 for the Grain Deal coefficient in the corn model indicates that there is insufficient evidence to reject the hypothesis that the deal narrowed the price gap for corn. Therefore, the results suggest that the Grain Deal

had a positive impact on reducing the price difference for wheat, but there is not enough evidence to support its effect on corn.

In our estimation process, we observed consistently high R-squared values across all the models we estimated, ranging from 0.81 to 0.92. The models with breakpoints determined using the Bai and Perron test showed the highest R-squared values of 0.92 for both models, which signifies that a larger proportion of the variation in the dependent variable was accounted for by the independent variables.

However, it is important to acknowledge the limitations of the model used, such as the assumption of linearity in a non-linear relationship and the non-stationarity of the data. These limitations should be considered when interpreting the results. Nevertheless, the analysis provides valuable insights into assessing average impact of the economic shock caused by the war and the outcome of the Grain Deal on the grain markets.

Overall, the findings demonstrate the consistent effect of the war across all models investigated. The Grain Deal is found to have influenced domestic prices for wheat, namely, the logistics costs, leading to a decrease in the price difference. However, for corn, results indicate that the impact of the Grain Deal was not significant.

Chapter 6

CONCLUSIONS AND POLICY RECOMENDATIONS

Based on the analysis conducted, the findings indicate that the war had a significant effect on increasing the gap between world and domestic Ukrainian prices for wheat and corn. The estimated war effect ranged from approximately 160% to 180% for wheat and around 137% to 146% for corn. These findings highlight the disruptive impact of the war on the grain markets and the associated increase in transfer costs.

Furthermore, the analysis revealed that the Grain Deal had a significant positive effect on wheat, reducing the price gap by approximately 25%. This suggests that the implementation of the Grain Deal helped improve the situation by mitigating the transfer costs associated with wheat exports. However, for corn, the results were insignificant, indicating that the Grain Deal may not have had a significant impact on narrowing the price gap for this commodity.

The limited impact of the Grain Deal on domestic prices could potentially be attributed to the uncertainties and delays in negotiations and trade arrangements with Russia, which may have hindered the implementation of the deal, leading to disruptions in the supply chain and delays in shipments. These challenges in trade logistics and market uncertainties could impact the effectiveness of the Grain Deal in influencing domestic prices.

Further research in this area could explore the interactions between trade dynamics, policy implementation challenges, and market outcomes to gain a deeper understanding of the underlying factors influencing price dynamics.

Given the current extreme situation in Ukraine, providing precise policy recommendations becomes challenging, as the impact of policies may be limited

under such circumstances. The risk of the agreement being broken by Russia adds to the uncertainties. Additionally, Ukraine has suffered significant economic losses, limiting the implementation of high-cost policies without substantial financial support from allies.

However, in light of these challenges, some general policy considerations can be recommended. First, it is crucial to continue to strengthen international partnerships and alliances to secure financial aid, technical expertise, and diplomatic support from allies during this critical period. Collaborating with international partners to ensure access to essential agricultural resources, such as seeds, fertilizers, and machinery, is essential. In the future, promoting the adoption of innovative farming practices and technologies that enhance production efficiency and resilience might help mitigate the challenges. Investing in comprehensive plans for post-war agricultural recovery, focusing on infrastructure rehabilitation, land restoration, and economic revitalization, especially in the most affected regions, is crucial for long-term stability and growth.

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