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The Impact of the War in Ukraine on the Development of Wheat and Rye Prices: An Analysis for the Period 2018-2024

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Abstract

The aim of the work is to assess the long-term development of wheat and rye prices in the period from 1 December 2018 to 1 April 2024 and to analyse the impact of the war in Ukraine on these prices. Analyses of the price development of these commodities are important for assessing economic stability and food availability. The prices are obtained by content analysis and then plotted in graphs. Using linear regression, it was found that the prices were not time dependent, Also, the prices of both commodities are found to be stable and very similar until the period of war in Ukraine. The latter had a significant impact on wheat and rye prices, with prices doubling after the start of the conflict. Subsequently, prices started to fall again, indicating market adaptation to the new conditions. Limitations of the study include the limited scope of the available data and the potential bias of the results due to the effects of other factors. Further research would benefit from including an extension of the analysis to include other influencing factors and increasing the frequency of data collection for more detailed analysis.

Keywords: Wheat, rye, price development, linear regression, war in Ukraine.

Introduction

Agriculture occupies a key position within the economic framework, as it provides a range of benefits for local communities. Its impact can be observed through various aspects, such as the provision of employment opportunities, income generation, and improvements in living standards, including ensuring food security (Mensah, 2023). For example, Fu et al.

(2023) argue that food security is highly important for all countries. In this context, agricultural price insurance represents an important tool for maintaining food security.

The stabilization of agricultural product prices is a key element in supporting social and economic development. Agriculture forms a fundamental pillar for many societies and economies; therefore, maintaining stable agricultural prices is essential for sustaining prosperity. Price fluctuations may occur in agriculture, and it is important to identify them, as they have a crucial impact on policy formulation and decision-making in agricultural production. These insights help to establish measures and strategies that influence agricultural prices, which in turn significantly affect agricultural markets and the overall economy (Wang et al., 2022).

Wheat is globally considered the most important cereal crop. It has enormous economic significance, as it is used for the production of bread, bakery products, and flour for households, and also serves as feed for livestock. Wheat is also utilized in healthcare due to its medicinal properties and nutritional composition (Ammar et al., 2023). This is supported by Gutierrez (2017), who states that wheat is globally significant for consumption, as it provides 20% of the world's calories and nutrients.

Rye is a very important cereal crop in many parts of Europe, and rye breeders are currently addressing the limited pool of genetic resources (Monteiro et al., 2016). It is also frequently used as a cover crop to improve soil health and as part of integrated weed management programs (Vollmer et al., 2020).

Rye plays an important agronomic, nutritional, and social role throughout human civilization. Over the past 50 years, rye grain yields have increased, though not sufficiently to offset the decline in cultivated area needed to maintain production. In this context, hybrid rye has significant potential due to its high yield performance and greater resistance to climate variability. The production area of hybrid rye has been increasing in recent years and is expected to continue growing. In the past decade, potential new markets for rye biomass have included applications such as biogas production and environmental sustainability initiatives. Although rye genomics lags behind other cereal crops, it has significantly contributed to understanding the evolution of the grass family through comparative genomic analyses. Over the past 50 years, advances in rye genomics and breeding have led to new and exciting research areas, particularly hybrid rye varieties, which outperform conventional synthetic varieties by 20–30% in both biomass and grain yield.

While rye may be considered a less important crop in terms of production, its contributions to cereal genomics have been substantial (Korzun et al., 2021).

The aim of this study is to evaluate the long-term development of wheat and rye prices in the period from December 1, 2018 to April 1, 2024, and to analyze the impact of the war in Ukraine on these prices.

In connection with this objective, the following research questions are defined:

RQ1: How did the prices of wheat and rye develop in the period from December 1, 2018 to April 1, 2024?

Answering this question provides an overview of how wheat prices in the Czech Republic evolved during the observed period.

RQ2: How did the war in Ukraine affect prices?

Answering this research question provides insight into the development of wheat and rye prices in the Czech Republic during the period from October 1, 2021 to March 1, 2024, and determines whether the war in Ukraine influenced these prices.

Data and methods

Data

To answer the first research question, it is necessary to obtain the prices of wheat and rye as of the first day of each month from December 1, 2018 to April 1, 2024. The data will be collected through content analysis from the websites of the State Agricultural Intervention Fund and the Czech Statistical Office. The data will then be recorded in tables using Microsoft Excel, and subsequently visualized in graphs.

For the second research question (RQ2), which focuses on the impact of the war in Ukraine on prices, the same approach will be applied as for the first research question, with the only difference being the selected time period. The observed period will be from October 1, 2021 to March 1, 2024.

Methods

To answer the first research question concerning the development of wheat and rye prices in the period from December 1, 2018 to April 30, 2024, the method of linear regression will be used. This method allows for the mathematical expression of the relationship between time and the prices of these commodities. The regression coefficients and their errors will

be calculated using Microsoft Excel through the Data Analysis tool, where regression will be selected. The most important outputs will be the p-values, which indicate whether the effect is statistically significant, and the R^2 value, which determines how well the model explains the variability in commodity prices.

It is also possible to use the method of least squares to determine a linear function, which effectively describes the relationship between time and price. This linear regression model has the following form (UJEP, 2024):

$$y = k * x + q \tag{1}$$

where:

y – price of wheat or rye,

x – time index,

k – regression coefficient representing the rate of price change,

q – regression coefficient representing the initial price.

The regression coefficients k and q are calculated using the following formulas (UJEP, 2024):

$$k = \frac{n * (\sum_{i=1}^{n} x_i y_i) - (\sum_{i=1}^{n} x_i) * (\sum_{i=1}^{n} y_i)}{n * (\sum_{i=1}^{n} x_i^2) - (\sum_{i=1}^{n} x_i)} \tag{2}$$

$$q = \frac{(\sum_{i=1}^{n} x_i^2) * (\sum_{i=1}^{n} y_i) - (\sum_{i=1}^{n} x_i) * (\sum_{i=1}^{n} x_i y_i)}{n * (\sum_{i=1}^{n} x_i^2) - (\sum_{i=1}^{n} x_i)} \tag{3}$$

The correlation coefficient, whose value lies within the interval ⟨-1, 1⟩, will be used to determine the degree of linear dependence between time and the prices of wheat and rye. The closer the result is to 1 or -1, the stronger the dependence.

Based on the estimated regression coefficients k and q, it is possible to determine the expected development of prices. The formula for its calculation is as follows (UJEP, 2024):

$$r_{xy} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}} \tag{4}$$

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} \tag{5}$$

Furthermore, the standard errors of the regression coefficients k and q would be calculated. These intervals make it possible to express the uncertainty of the estimates and provide a more accurate picture of the development of wheat and rye prices. The formulas for their calculation are as follows (UJEP, 2024):

$$\sigma_k = \sqrt{\frac{S_0}{(n-2)*\left[\sum_{i=1}^{n} x_i^2 - \frac{1}{n}*(\sum_{i=1}^{n} x_i)^2\right]}} \qquad \sigma_q = \sqrt{\frac{S_0 * \frac{1}{n} * \sum_{i=1}^{n} x_i^2}{(n-2)*\left[\sum_{i=1}^{n} x_i^2 - \frac{1}{n}*(\sum_{i=1}^{n} x_i)^2\right]}} \tag{6}$$

$$S_0 = \left(\sum_{i=1}^{n} y_i^2\right) - \frac{1}{n} * (\sum_{i=1}^{n} y_i)^2 - k * \left[\sum_{i=1}^{n} x_i\, y_i - \frac{1}{n} * \left(\sum_{i=1}^{n} x_i\right) * \left(\sum_{i=1}^{n} y_i\right)\right] \tag{7}$$

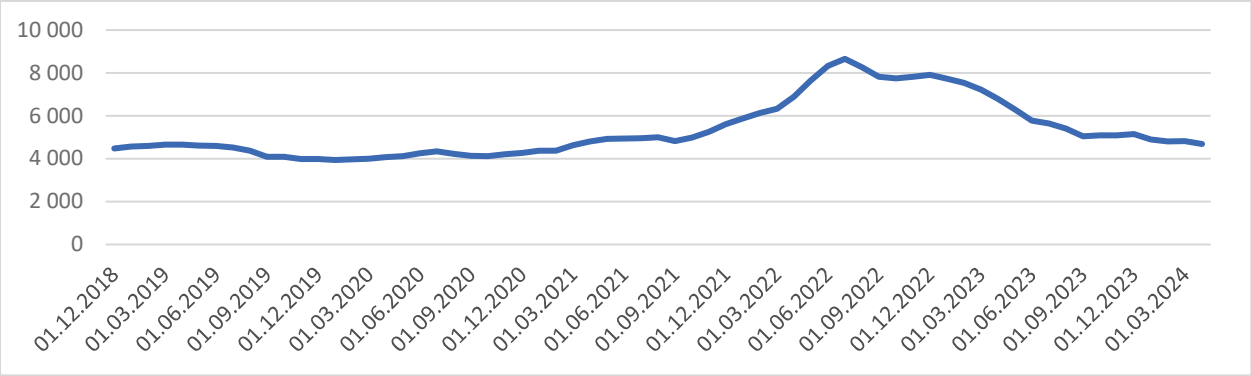
The confidence interval of the estimated regression coefficients, and thus their accuracy, depends on these deviations and the chosen probability level P. The Student's t-coefficient t_p, (n−1) has parameters n−1 and P = 95% (UJEP, 2024).

To answer the third research question, the same procedure will be applied using Microsoft Excel; however, only wheat and rye prices for each month in the period from October 1, 2021 to March 1, 2024 will be used.

Results

After obtaining the prices of food wheat and rye from data analysis provided by the State Agricultural Intervention Fund, where prices are expressed in Czech crowns per ton, the focus was placed on the period from December 1, 2018 to April 1, 2024. The data are collected as of the first day of each month. The prices are then recorded in tables, and these tables are subsequently used to create graphs for visualizing price developments over the observed period.

Graph 1: Development of Food Wheat Prices [CZK/t], 01/12/2018–01/04/2024

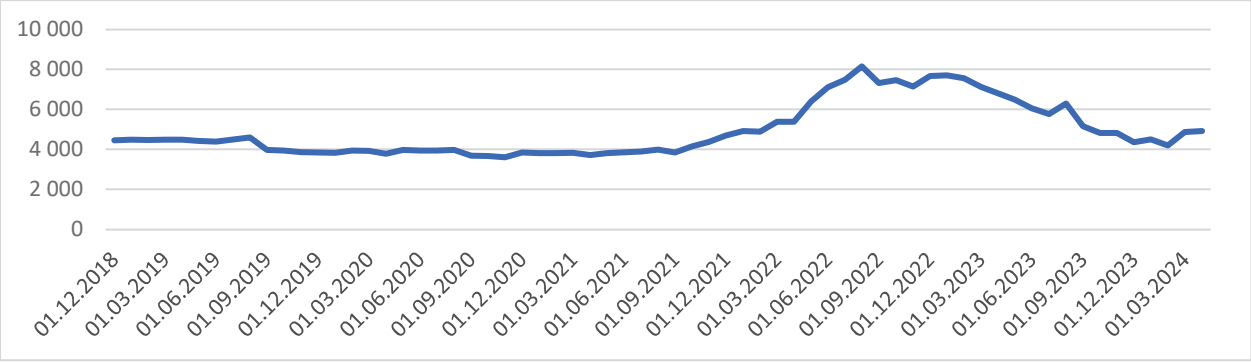


Source: Author's own elaboration based on (State Agricultural Intervention Fund, 2024).

Graph 1 shows the development of food wheat prices over the observed period. The average price of this commodity is 5,342 CZK/t. The lowest price was recorded on January 1, 2020, at 3,949 CZK/t, which represents a significant difference compared to the highest recorded price of 8,654 CZK/t on July 1, 2022 – more than double the lowest value.

It is evident from Graph 1 that the price developed relatively steadily until 2021, when it first exceeded 5,000 CZK/t at the end of the year. From that point onward, the price continued to increase. At the beginning of 2022, the increase became significantly steeper; however, from 2023 onward, the price of the commodity began to decline again and is now almost at the same level as before 2021.

Graph 2: Development of Food Rye Prices [CZK/t], 01/12/2018–01/04/2024



Source: Author's own elaboration based on (State Agricultural Intervention Fund, 2024).

Graph 2 illustrates the development of the price per ton of food rye over the same period. The average price is slightly lower than that of food wheat, amounting to 4,955 CZK/t. The lowest price was recorded on November 1, 2020, at 3,617 CZK/t.

A significant increase in the price of this commodity occurred a few months later than in the case of wheat, specifically in March 2022. The price rose sharply until August 2022 and then

began to gradually decline. However, it returned to its original level only in October 2023, and since then, the price has not exceeded 5,000 CZK/t.

During this period of price fluctuation, the highest price of food rye was recorded at 8,150 CZK/t, representing an even larger increase than in the case of food wheat.

Figure 1: Regression of Food Wheat and Rye Prices for the Period 01/12/2018–01/04/2024

Regression statistics	
Multiple R	0,560094439
R Square	0,31370578
Adjust Square R	0,302636519
Standard Error	1128,45394
Observations	64

ANOVA

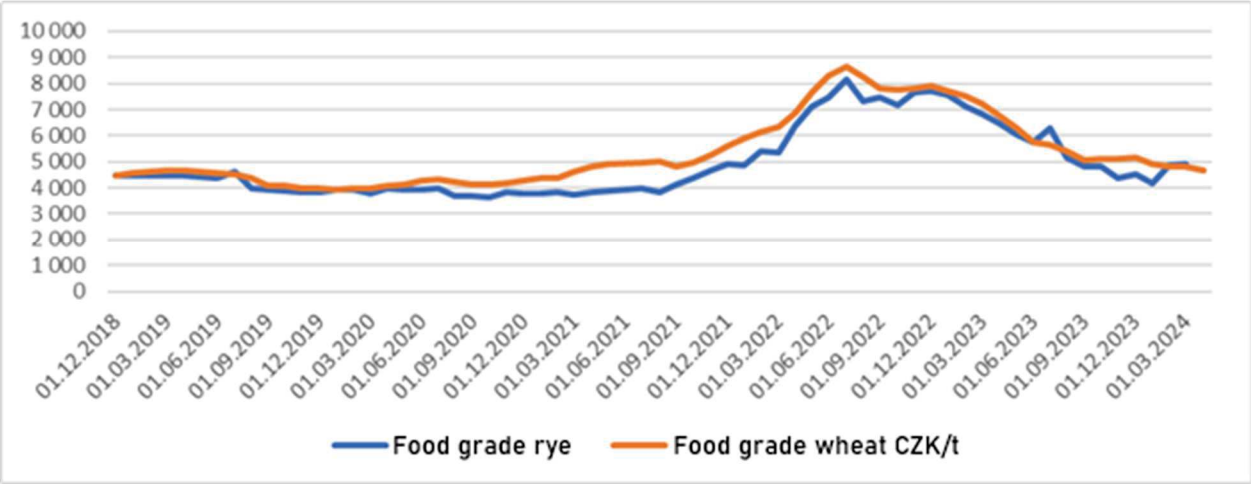
	Variance	*SS*	*MS*	*F*	*Significance F*
Regresion	1	36088725,45	36088725,45	28,34026257	1,49201E-06
Residual	62	78951314,3	1273408,295		
Total	63	115040039,8			

	Coeffiecients	*Standard error*	*t Stat*	*Value P*	*Lower 95%*	*Higher 95%*	*Lower 95,0%*	*Higher 95,0%*
Limit	-52612,01034	10887,23368	-4,832449811	9,23361E-06	-74375,28036	-30848,7	-74375,3	-30848,7
Time	1,304978396	0,245132778	5,323557323	1,49201E-06	0,814964955	1,794992	0,814965	1,794992

Source: Author's own elaboration based on (State Agricultural Intervention Fund, 2024).

After listing the prices of food wheat and rye for each month from December 1, 2018 to March 1, 2024, the data analysis showed that the model explains 56% of the variability in commodity prices, and the p-value was 0.000009234. Therefore, price is not statistically dependent on the time period, as there are other factors that influence it much more significantly.

Graph 3: Comparison of the Development of Food Wheat and Rye Prices [CZK/t], 01/12/2018–01/03/2024

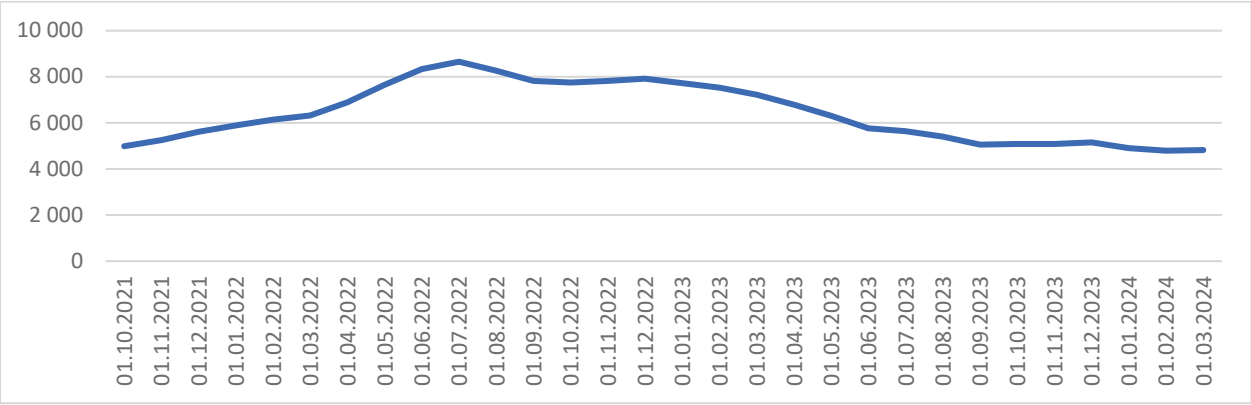


Source: Author's own elaboration based on (State Agricultural Intervention Fund, 2024).

Graph 3 shows a very similar price development for these commodities. Food wheat generally reaches higher prices, and the price increase occurred a few months earlier than in the case of food rye. In the case of rye, more pronounced price fluctuations can also be observed.

Graphs 4 and 5 illustrate the development of food wheat and rye prices in Czech crowns per ton (CZK/t) over different time periods. Both graphs cover the period from October 1, 2021 to March 1, 2024, which includes the onset of the war in Ukraine in February 2022.

Graph 4: Development of Food Wheat Prices [CZK/t], 01/10/2021–01/03/2024

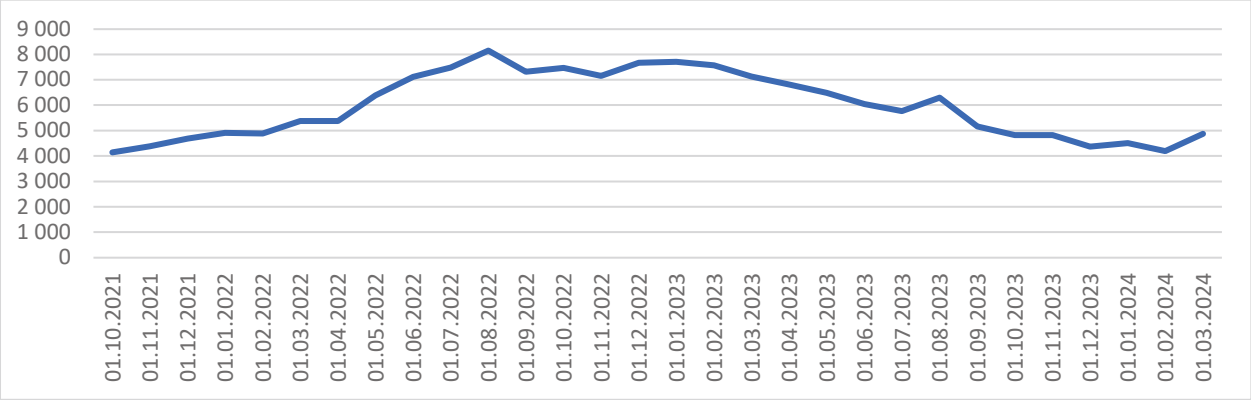


Source: Author's own elaboration based on (State Agricultural Intervention Fund, 2024).

In the case of food wheat, illustrated in Graph 4, the price starts just below 5,000 CZK/t and gradually increases until February 2022. The price then peaks in June 2022 at nearly 9,000 CZK/t. From the beginning of 2023, however, the price gradually declines and stabilizes

around 5,000 CZK/t at the beginning of 2024, which is a level comparable to prices before 2021.

Graph 5: Development of Food Rye Prices [CZK/t], 01/10/2021–01/03/2024



Source: Author's own elaboration based on (State Agricultural Intervention Fund, 2024).

Graph 5, which illustrates rye prices, shows a similar trend. The price of rye starts at around 4,000 CZK/t and rises to approximately 5,000 CZK/t by the beginning of 2022. From March 2022, there is also a sharp increase in price, reaching a peak in June 2022 at around 8,000 CZK/t.

After June 2022, rye prices fluctuate between 7,000 and 8,000 CZK/t, and from the beginning of 2023, they gradually decline. By the end of the observed period, the price once again resembles the level recorded before 2021.

Discussion

RQ1: Development of wheat and rye prices in the period 01/12/2018–01/04/2024

The analysis of food wheat and rye price development over the period from December 1, 2018 to April 1, 2024 showed that the model explains 56% of the variability in commodity prices and that prices are not statistically dependent on the time period, as they are influenced more strongly by other factors. The analysis also revealed several important trends.

The price of food wheat remained relatively stable until 2021, when it began to gradually increase. A more significant rise was observed at the beginning of 2022, with a peak in June 2022, when the price reached nearly 9,000 CZK/t. This was followed by a gradual decline, and by the end of the observed period, the price stabilized at around 5,000 CZK/t. This development suggests that the wheat market was influenced by various factors, including global economic conditions and specific events.

Similarly, the price of food rye remained stable until the beginning of 2022. A sharp increase was recorded from March 2022, with a peak in June 2022 at around 8,000 CZK/t. After this peak, the price fluctuated between 7,000 and 8,000 CZK/t and began to gradually decline from the beginning of 2023. By the end of the observed period, the price stabilized at approximately 4,500 CZK/t. This trend indicates that the rye market responded to similar factors as the wheat market, although price fluctuations were somewhat more pronounced.

Simotová et al. (2023) analyzed wheat and rapeseed prices for the period 2017–2022 and reached similar conclusions, namely that the prices of these commodities were variable over time, without strong long-term trends or clear seasonal patterns.

RQ2: How did the war in Ukraine affect prices?

The war in Ukraine, which began in February 2022, had a significant impact on the prices of food wheat and rye. Immediately after the outbreak of the conflict, a dramatic increase in prices of both commodities was observed. Ukraine is one of the largest exporters of wheat and rye, and disruptions in its supply had an immediate and substantial effect on prices.

Wheat prices began to rise sharply from February 2022 and peaked in June 2022. This rapid increase can be directly linked to supply disruptions from Ukraine and subsequent concerns about global availability of this commodity. After reaching the peak, prices gradually declined, which may indicate that the market adapted to new conditions, for example through increased production in other regions or the identification of alternative suppliers.

Rye prices followed a similar pattern to wheat prices, with a sharp increase from March 2022 and a peak in June 2022. As with wheat, this increase can be attributed to disruptions in production and exports caused by the war in Ukraine. After reaching the peak, prices fluctuated and then began to decline, suggesting a similar market adaptation as in the case of wheat.

The results clearly show that the war in Ukraine had a significant and immediate impact on the prices of food wheat and rye. The sharp increase in prices immediately after the outbreak of the conflict reflects supply disruptions and global concerns regarding the availability of these commodities. The subsequent decline in prices suggests that the market gradually adapted to new conditions, which may have included increased production in other regions or the identification of alternative suppliers. By the end of the observed period, prices stabilized at levels comparable to those before the war, indicating the market's ability to adjust and restore equilibrium even during global crises.

Martin and Minot (2022) reached similar conclusions in their study on the development of agricultural commodity prices, confirming that food crises in Ukraine doubled the overall increase in global wheat prices.

Conclusion

The aim of this study was to evaluate the long-term development of food wheat and rye prices in the period from December 1, 2018 to April 1, 2024 and to analyze the impact of the war in Ukraine on these prices. These objectives were successfully achieved.

The analysis of commodity price development over the observed period from December 2018 to April 2024 revealed that the model explains 56% of the variability in commodity prices and that prices are not statistically dependent solely on the time period. This indicates that, in addition to time trends, there are other variables that significantly influence these prices, such as economic conditions or climatic factors.

Significant trends in the data showed that the prices of food wheat and rye were relatively stable until the end of 2021, a period characterized by slight fluctuations without major volatility. From the end of 2021, however, prices began to gradually increase. This increase was not immediate. A sharp rise in prices was observed from March 2022, which can be primarily attributed to the impact of the war in Ukraine. The conflict had a direct effect on supply chains and logistics, leading to an immediate increase in prices due to uncertainty and limited availability of commodities. The subsequent decline in prices following this sharp increase suggests that markets began to adapt to the new conditions.

The war in Ukraine therefore had a clear and dramatic impact on the prices of food wheat and rye. It was found that immediately after the outbreak of the conflict, prices of both commodities increased by up to twofold, representing an extraordinary shock to the market. As mentioned above, prices subsequently declined, which may indicate a certain degree of normalization and adaptation of market participants to the new conditions. Overall, it can be concluded that the analysis not only confirmed the impact of the war but also demonstrated the ability of the market to adapt to such significant changes. Although prices returned to lower levels, they remain influenced by various factors that continue to shape them.

Recommendations for further research include expanding the analysis to incorporate additional factors influencing wheat and rye prices, such as climatic or political factors. It

would also be useful to increase the frequency of data collection, for example to a daily or weekly basis, in order to enable more detailed analysis. Furthermore, conducting a comparative analysis with regions not affected by the war, or with pre-war periods, would help to better understand the specific impacts of the war in Ukraine.

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