

Dynamic Effects of Wheat Prices in Context of the Russian-Ukrainian War

Dynamické efekty cien pšenice v kontexte rusko-ukrajinskej vojny

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Abstract

The war in Ukraine greatly affects the world price of wheat, as before the war Ukraine was the fifth largest exporter of wheat in the world, and as a result of the conflict, wheat exports have decreased dramatically. The world wheat price peaked in May 2022 when India, the world's second-largest exporter, imposed an embargo on wheat exports due to rising domestic prices. The Slovak market also reacts to the world price of wheat. The article aims to evaluate the development of wheat prices in Slovakia, in the European Union, and in the world in the context of the Russian-Ukrainian conflict using descriptive time series statistics and also to examine the impact of the development of wheat prices in the world and in the European Union on the development of food wheat prices in Slovakia using Pearson and Spearman correlation coefficient. Subsequently, a prediction of the development of these prices for the period of the following 12 months is compiled using the average growth coefficient.

Keywords: *Ukraine war conflict - World wheat price – Commodity market – Volatility – Inflation – Global food crisis*

JEL Classification: Q2, Q11

Humanity is going through the biggest global food crisis since World War II. Climate change is increasingly affecting agricultural production and combined with the effects of two events that hit the whole world shortly after each other – the COVID-19 pandemic and the Russian invasion of Ukraine; have caused the population suffering from hunger to rise to 783 million (LIN F. et al., 2023). These events significantly worsened the physical and price availability of cereals, including wheat. Lockdown during the COVID-19 pandemic disrupted supply chains and major exporters, such as Romania and Russia, decided to limit wheat exports. The limited supply of wheat put pressure on world prices (FALKENDAL T. et al., 2021).

However, the war in Ukraine affected the supply and prices of wheat much more significantly than the lockdown. In the first half of 2022, the prices of fertilizers, fuel and energy grew intensively, which increased the costs of wheat production. This increase in prices was primarily caused by the sanctions imposed on Russia (ARNDT C., DIAO X., DOROSH P., PAUW K., THURLOW, J., 2023). Fertilizer prices rose further when Russia, which accounts for 18% of the world's nitrogen fertilizer trade, subsequently banned fertilizer exports (LABORDE D., MAMUN A., 2022). However, wheat prices also increased due to a reduction in its supply on the world market. After the outbreak of the war in Ukraine, Russia blocked Ukrainian ports in the Black Sea for several months and 20-30 mil. tons of grain remained in warehouses. Russia thus tried to block Ukrainian exports (RUNARSSON I., 2022). Before the war, Ukraine was the fifth largest exporter of wheat, with up to 65% of its exports going to developing countries (EUROPEAN COUNCIL, 2023). The situation was further aggravated by the Russian embargo

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on the development of some cereals, including wheat, during March - June 2023. Before the war, Russia was the largest exporter of wheat in the world (EVENETT S.J., MUENDLER M.A., 2023). India, the world's second-largest exporter of wheat, banned wheat exports in May 2022 due to rising domestic prices. This caused an even greater increase in wheat prices, as many countries depended on India during the blockade in the Black Sea ports (RITTER T., MOCKSHELL J., BLANCO M., 2023).

The global food crisis has worsened significantly as a result of these export bans, and food security concerns have grown. The countries of sub-Saharan Africa and Southeast Asia suffered mainly from the lack of wheat. The world has been hit by an enormous increase in prices. In May 2022, cereal prices increased by almost 60% compared to the beginning of 2020 (FAO, 2023). The European Union decided to help developing countries, as well as the Ukrainian economy, and created solidarity lanes through which goods flowed from Ukraine to the EU and back. In this way, 60% of Ukrainian grain intended for export (70.9 million tons) was transported. The remaining 40% was exported thanks to the Black Sea Grain Initiative (EUROPEAN COMMISSION, 2023). The UN managed to secure Ukraine's agreement with Russia in July 2022 to export commercial food and fertilizers from three key Ukrainian Black Sea ports. Thanks to renewed exports from Ukraine, wheat prices fell. However, Russia did not extend this agreement after its end on 17 July 2023 (GOYAL R., STEINBACH S., 2023). That night, Russian drones attacked grain warehouses in Black Sea ports. Wheat futures prices immediately reacted to the situation with a jump of 8.5%. This increase did not last long, as Russia surprisingly began to replace shortages in wheat supply with its exports, thanks to which wheat futures fell to a three-year low (SAVAGE S., 2023).

Fortunately, the food security of the European Union is not directly threatened, as the EU is a net exporter of food and Ukraine accounts for only 4.9% of agri-food imports into the EU. Even Slovakia is not dependent on the import of agricultural products from Ukraine and Russia. However, the conflict in Ukraine affects both the EU and Slovakia secondarily through rising prices and dependence on Russian gas supplies (SPPK, 2023). Political instability in the regions of Africa and Asia caused by threats to food security represents another risk for Europe (HUDECOVÁ K., RAJČANIOVÁ M., 2023).

Methodology

The aim of the article is to evaluate the development of wheat prices in Slovakia, in the European Union and in the world in the context of the Russian-Ukrainian conflict. We focus on monthly prices during the period 2019-2023. For 2023, price data is available till September. The source of values for average purchase prices of food wheat in Slovakia are market reports published on the website of the Agricultural Paying Agency – Agricultural Market Information of Slovakia [PPA - ATIS]. Data on average monthly soft wheat prices for the Member States of the European Union and countries of the world are published on the price panels on the website of the European Commission in the section Agriculture and Rural Development. The European Commission publishes here a monthly summary of prices for the most representative agricultural commodities and food products. As for European Union prices, during 2019 they are published as the EU-28 average, i.e., including the United Kingdom and, after Brexit, since January 2020 for the EU-27, i.e., excluding the United Kingdom. The data on world prices were taken from the FAO database by the European Commission. Price values for Slovakia, the European Union and the world are quoted in euros per tonne of wheat.

We analyse wheat prices by various statistical methods, which include descriptive analysis, calculation of chain and base indices, calculation of the Pearson and Spearman coefficients. After ex-post analysis, we make predictions for the next twelve months using an average growth coefficient.

As part of descriptive analysis, we will focus on determining the minimum and maximum values for individual time series, calculating the arithmetic and geometric mean, median, standard deviation, and coefficient of variation.

Standard deviation (s) shows the extent to which the individual measured values are around the mean. The smaller the standard deviation, the closer the measured values are around the mean.

$$s = \sqrt{\frac{1}{N} \sum_{i=1}^N (X_i - \bar{X})^2}$$

Where:

n - number of observations,

X_i - value of observation i when $i=1, 2, \dots, N$,

\bar{X} - mean of observations (RIMARČÍK M, 2007).

The coefficient of variation (CV) is a relative measure of variability and shows the range of variability of the data in the sample relative to the population diameter. In finance, the coefficient of variation makes it possible to determine to what extent volatility is expected compared to the expected amount.

$$CV = \frac{s}{\bar{X}} * 100$$

Where:

s - standard deviation,

[2]

\bar{X} - mean of observations (ABDI H., 2010).

We are examining the change in wheat prices since the outbreak of the war in Ukraine using base and chain indices. Using the base index, we examine the change in prices from month to month from February 2022 to September 2023 compared to the period just before the war, i.e. January 2022. Using a chain index, we examine the price change from the previous month, focusing on the period January 2022 - September 2023.

The magnitude of the correlation between time series of wheat prices in Slovakia, the EU and the world is analysed using the correlation matrix which contains Pearson coefficients for each pair of examined variables. We also calculate Spearman rank correlation coefficient for these pairs.

Pearson product-moment correlation coefficient (r_p) measures the linear correlation between the variables X and Y. It represents a value on a scale from -1 to 1, with negative numbers indicating negative correlation and positive numbers indicating direct correlation. A value of -1 represents a perfect indirect correlation, and a value of 1 represents a perfect direct correlation. If the coefficient is equal to zero, the variables are not correlated at all.

$$r_p = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{[\sum(X_i - \bar{X})^2][\sum(Y_i - \bar{Y})^2]}}$$

Where:

[3]

X_i, Y_i - values for observation i by variables X and Y when $i=1, 2, \dots, N$,

\bar{X}, \bar{Y} - mean of variables X and Y.

Spearman rank correlation coefficient (r_s) is the nonparametric version of the Pearson correlation coefficient. Spearman's correlation determines the strength and direction of the monotonic relationship between your two variables rather than the strength and direction of the linear relationship between your two variables, which is what Pearson's correlation determines. Like the Pearson coefficient, the Spearman coefficient takes values from -1 to 1, with values near zero representing a weak correlation and values near extremes representing a strong negative or positive correlation.

$$r_s = 1 - \frac{6 \sum d_i^2}{N * (N^2 - 1)}$$

Where:

$d_i - X'_i - Y'_i$; is the difference between each pair of the ranked variables,

i - paired score,

n - number of observations

[4]

Kendall rank correlation coefficient (τ) is a nonparametric measure with help of which we can compute the statistical dependence between two ranked quantities. It is an alternative to the Spearman correlation coefficient.

$$\tau = \frac{n_c - n_d}{\frac{1}{2} N(N - 1)}$$

[5]

Where:

n_c - number of concordant pairs (when both $x_i > x_j$ and $y_i > y_j$ or both $x_i < x_j$ and $y_i < y_j$),

n_d - number of discordant pairs (when both $x_i > x_j$ and $y_i < y_j$ or both $x_i < x_j$ and $y_i > y_j$) (XIAO C., YE J., ESTEVES R.M, RONG C., 2015).

The average growth coefficient is the geometric mean of the growth coefficient thanks to which we can predict future development of wheat prices. The growth coefficient represents a multiple of the average growth of the given element compared to the previous period.

$$\bar{k} = \sqrt[N-1]{k_2 k_3 \dots k_N} = \sqrt[N-1]{\frac{X_N}{X_1}}$$

Where:

$k_{2,3}$ - growth coefficients in dates 2 and 3,

k_n - growth coefficient in date N,

N – number of observations (LITSCHMANNOVÁ M., 2011)

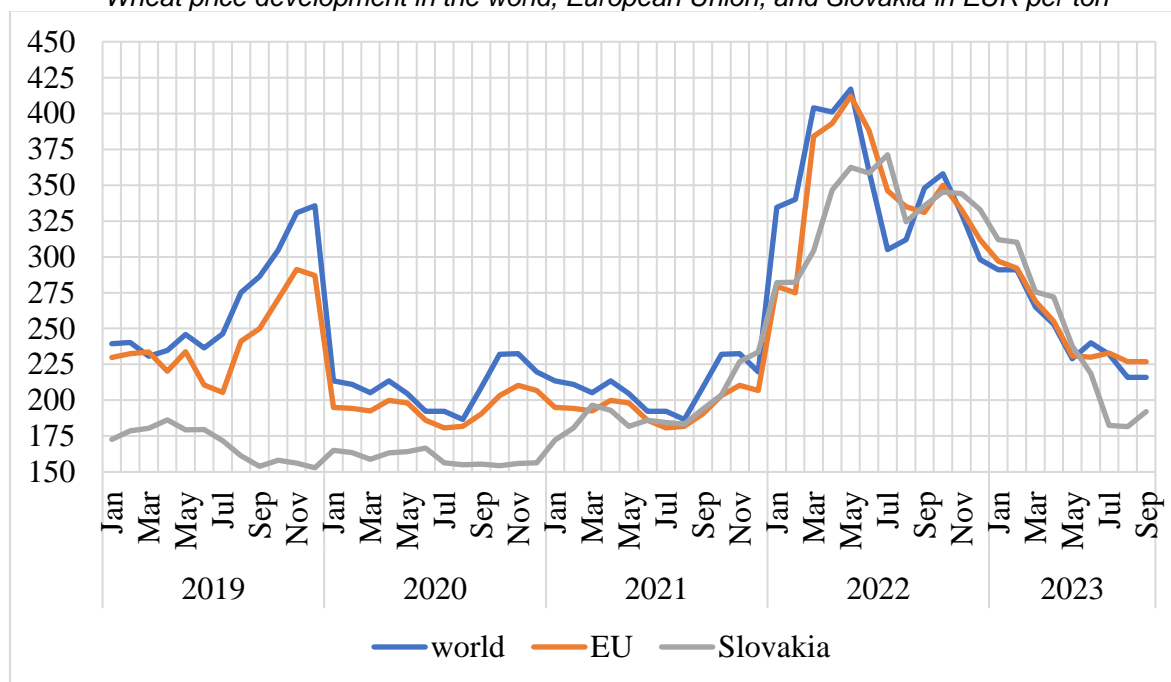
[6]

Research Results

In our research, we will first focus on the development of wheat prices in the world, in the EU and in Slovakia. Graph 1 shows the evolution of monthly prices from shortly before the war in Ukraine to the present, and Table 1 presents descriptive statistics for each time series.

Graf 1 Vývoj ceny pšenice vo svete, v Európskej únii a na Slovensku v EUR/t

Wheat price development in the world, European Union, and Slovakia in EUR per ton



Source: PPA – ATIS and European Commission

Tab. 1 Descriptive characteristics of time series of wheat prices for the period of years 2019 - 2023

| | Mean | Min | Max | St. dev. | Coef. of variance |
|----------|--------|--------|--------|----------|-------------------|
| world | 257.4 | 186.6 | 417 | 60.17 | 23.37% |
| EU | 245.31 | 180.7 | 412 | 61.86 | 25.22% |
| Slovakia | 218.48 | 152.88 | 371.16 | 69.52 | 31.82% |

Source: PPA – ATIS and European Commission; own calculations

Graph 1 shows the turbulent development of wheat prices in Slovakia, the EU, and the world. From January to July 2019, wheat prices remained more or less stable, moving only slightly. However, from July to December 2019 there was a sharp increase in the price of wheat in the world and the EU, on the contrary, in Slovakia the price decreased slightly. The world price in December 2019 hit 335.7 EUR/t and the EU price at 286.9 EUR/t, both above average. In Slovakia, surprisingly, in December 2019 the price was the lowest of the entire reporting period, as it was at the level of 152.88 EUR/t. In January 2020, the price in the EU and the world fell by leaps and bounds. It remained at a relatively low level until the end of 2021. There were slight fluctuations during this period, such as the increase in the world and European price in October 2020, but compared to December of the previous year, this increase was much smaller. In July 2020, the price of wheat in the EU was at its lowest, at 180.7 EUR/kg, and then in August 2020 the world price of wheat reached its low (186.6 EUR/t). However, January 2022 saw a jump in all wheat prices, which still escalated in March. However, both the world and European prices reached their maximum in May 2022. During this period, prices were almost double the average and more than double the value of summer 2020. On world markets, buyers received a ton of wheat for 417 euros, and on European markets for 412 euros. The price in Slovakia reacted belatedly and reached its peak in July of that year, when one tonne of wheat was sold for 371.16 euros. After a sharp drop from the peaks, there was a resurgence in October 2022 and, between that point and the end of the projection horizon, prices were already gradually declining and falling below average. Developments at the end of the period under review suggest that these prices could stabilise in the short term.

Table 1 shows that the average price of wheat for 2019-2023 is the highest in the world (257.4 EUR/t) and vice versa the lowest in Slovakia (218.48 EUR/t). Although the price of wheat in the European Union is slightly lower than the world price, there is a more significant difference between it and the price of wheat in Slovakia. Chart 1 also shows that the price of wheat in Slovakia was significantly lower than the global and EU prices during 2019 and 2020, but a reversal occurred in March 2021 and became above the EU average. By the end of 2021, it was roughly on par with the European and global prices, however, the events at the beginning of 2022 did not have as much impact on it as prices in the EU and globally. However, in July 2022, the effects of events in the increase in the price of wheat were still belatedly felt in Slovakia. Until May 2023, prices in Slovakia were slightly higher than in the EU and the world, but from that point on they fell more sharply and were again at a lower level than European and world prices. As for prices in the EU, they mostly followed global price developments, being lower than global prices until May 2022, but at the same level or higher for the remainder of the projection horizon. For the last three months, prices in the EU have remained at a higher level than in the world.

The standard deviation indicates that the observed prices deviate from the average values by more than EUR 60/t, while for Slovakia it is almost at the level of EUR 70/t. World wheat prices and EU wheat prices have very similar standard deviation values.

The coefficient of variation confirms what we can see on the chart, that the volatility of all examined prices is quite high over the period under review. It is highest in Slovakia, the standard deviation here is up to 31.82% of the average. For prices in the EU, it is 25.22% and in the world, it is 23.37%. At the same time, however, it should be noted that the fact that Slovakia has the highest coefficient of variation does not mean that price fluctuations are most frequent there. However, even though Slovak prices are more stable than European and world prices, the standard deviation in Slovakia is the highest, due to the lowest average, as during the first half of the period under review prices were significantly lower compared to the EU and the world.

The chain and base indices for each time series are summarised in Table 2.

Tab. 2 Chain and base indexes of time series of wheat prices (December 2021=100)

| | world | | EU | | Slovakia | |
|----------|-------------|------------|-------------|------------|-------------|------------|
| | chain index | base index | chain index | base index | chain index | base index |
| Jan 2022 | 1.52 | 1.52 | 1.35 | 1.35 | 1.21 | 1.21 |
| Feb 2022 | 1.02 | 1.55 | 0.98 | 1.33 | 1.00 | 1.21 |
| Mar 2022 | 1.19 | 1.84 | 1.40 | 1.86 | 1.08 | 1.30 |
| Apr 2022 | 0.99 | 1.83 | 1.02 | 1.90 | 1.14 | 1.48 |
| May 2022 | 1.04 | 1.90 | 1.05 | 1.99 | 1.05 | 1.55 |

| | | | | | | |
|----------|------|------|------|------|------|------|
| Jun 2022 | 0.86 | 1.64 | 0.94 | 1.88 | 0.99 | 1.53 |
| Jul 2022 | 0.85 | 1.39 | 0.89 | 1.67 | 1.04 | 1.59 |
| Aug 2022 | 1.02 | 1.42 | 0.97 | 1.62 | 0.87 | 1.39 |
| Sep 2022 | 1.12 | 1.58 | 0.99 | 1.60 | 1.03 | 1.44 |
| Oct 2022 | 1.03 | 1.63 | 1.06 | 1.69 | 1.03 | 1.48 |
| Nov 2022 | 0.92 | 1.50 | 0.95 | 1.61 | 1.00 | 1.47 |
| Dec 2022 | 0.90 | 1.36 | 0.94 | 1.51 | 0.97 | 1.43 |
| Jan 2023 | 0.98 | 1,32 | 0.95 | 1.44 | 0.94 | 1.34 |
| Feb 2023 | 1.00 | 1.32 | 0.98 | 1.41 | 0.99 | 1.33 |
| Mar 2023 | 0.91 | 1.21 | 0.92 | 1.30 | 0.89 | 1.18 |
| Apr 2023 | 0.95 | 1.15 | 0.95 | 1.23 | 0.99 | 1.16 |
| May 2023 | 0.91 | 1.04 | 0.91 | 1.12 | 0.87 | 1.02 |
| Jun 2023 | 1.05 | 1.09 | 1.00 | 1.11 | 0.92 | 0.94 |
| Jul 2023 | 0.97 | 1.06 | 1.01 | 1.13 | 0.83 | 0.78 |
| Aug 2023 | 0.93 | 0.98 | 0.97 | 1.10 | 1.00 | 0.78 |
| Sep 2023 | 1.00 | 0.98 | 1.00 | 1.10 | 1.06 | 0.82 |

Source: PPA – ATIS and European Commission; own calculations

Based on the chain index values in Table 2, we can conclude that the largest increase in wheat prices occurred during January 2023 compared to the previous month. The world price has risen by as much as 52% over the period. The price in the EU increased by 35% and the price in Slovakia by 21%. The second largest month-on-month increase in the global price occurred in March 2022, when the price increased by 19%. In the EU, price increases were more pronounced in March than in January, as prices rose by as much as 40% in March. However, the price in Slovakia increased by only 8% in the given period, its increase was delayed only in April (14%). Later, a significant price increase was recorded only in September 2022 and only at the world price (12%).

Base indices point to the fact that the global and European price of wheat in May 2022 reached almost double the price of December 2021. At the price in Slovakia, an increase of only 55% was recorded, later in July by 59% compared to the base period. Subsequently, prices began to gradually fall. The price in Slovakia was the first to reach the pre-conflict level in June 2023, when it was even 6% below the base value. The world price fell below the base value in August 2023 and the price in the EU is still 10% higher at the end of the projection horizon than in December 2021.

Tables 3, 4, and 5 contain data on the Pearson, Spearman, and Kendall correlation coefficients between each pair of the variables studied.

Tab. 3 Correlation matrix with Pearson coefficients

| | world | EU | Slovakia |
|----------|----------|----------|----------|
| world | 1 | 0.953378 | 0.742254 |
| EU | 0.953378 | 1 | 0.849584 |
| Slovakia | 0.742254 | 0.849584 | 1 |

Source: PPA – ATIS and European Commission; own calculations

Tab. 4 Correlation matrix with Spearman coefficients

| | world | EU | Slovakia |
|----------|----------|----------|----------|
| world | 1 | 0.953619 | 0.493014 |
| EU | 0.953619 | 1 | 0.574207 |
| Slovakia | 0.493014 | 0.574207 | 1 |

Source: PPA – ATIS and European Commission; own calculations

Tab. 5 Correlation matrix with Kendall coefficients

| | world | EU | Slovakia |
|----------|----------|----------|----------|
| world | 1 | 0.822055 | 0.354637 |
| EU | 0.822055 | 1 | 0.431704 |
| Slovakia | 0.354637 | 0.431704 | 1 |

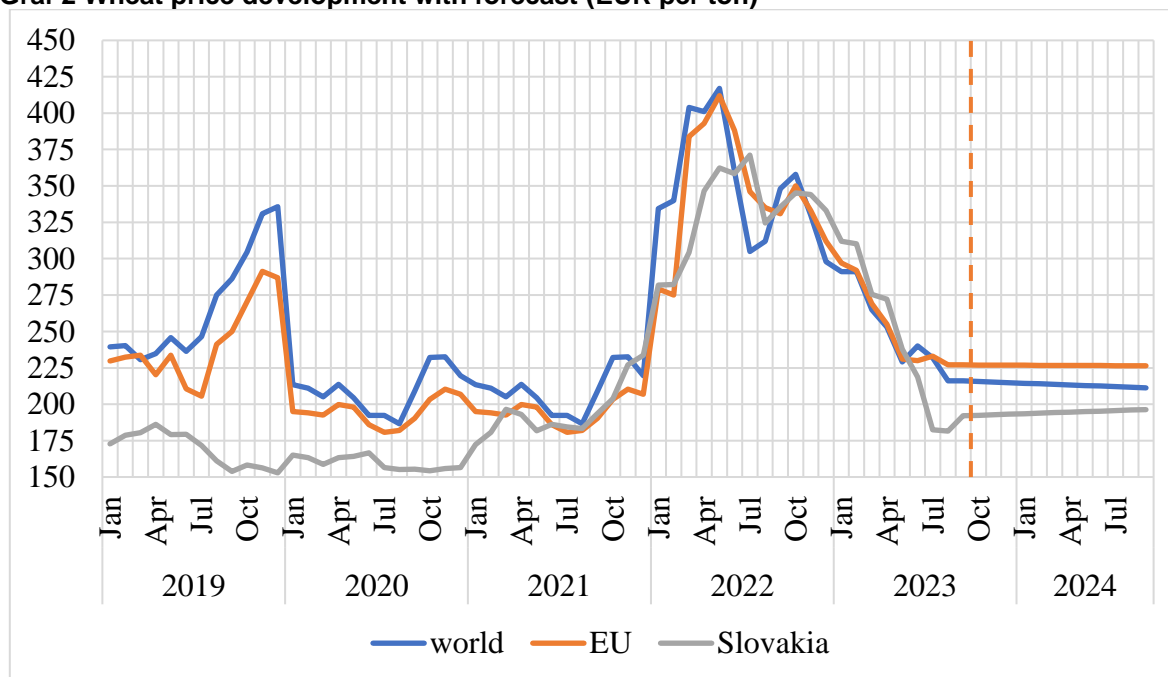
Source: PPA – ATIS and European Commission; own calculations

Tables 3, 4, and 5 show that there is a very strong positive correlation between world wheat prices and wheat prices in the European Union. The values of the first two coefficients – Pearson product-moment correlation coefficient and Spearman rank correlation coefficient – are approximately 0.95. The high value of the Pearson coefficient confirms a strong linear correlation, and the high value of the Spearman coefficient indicates an almost perfect association of rank. The relationship between these variables is very well explained by the monotonous function. The Kendall coefficient is slightly lower (0.822055). In the case of the pair, the price of wheat in Slovakia and the price of wheat in the EU, although the linear correlation is slightly weaker, still shows high values. However, the value of the Spearman coefficient is only 0.574207. The Kendall coefficient even shows only a mean correlation between these variables. This means that the relationship between wheat prices in the EU and Slovakia is harder to explain by its monotonous function. Finally, among wheat prices in the world and in Slovakia, the linear correlation is the weakest, but even here the Pearson coefficient shows 0.742254, which is a strong positive correlation. However, the value of both the Spearman and Kendall coefficients does not even reach the level of 0.5, and therefore we can only state about a medium correlation.

On the basis of price data during the period under review, we calculated the average growth coefficient of the observed wheat prices. The average coefficient of price growth in the world is 0.9982 and thus, on average, world wheat prices fell very slightly month-on-month (by 0.18%). Prices in the EU have an average growth coefficient of 0.9998, i.e. prices fell only marginally month-on-month. On the contrary, Slovak prices showed an upward trend, with an average growth coefficient of 1.0019, which means an increase of 0.19%.

Using average growth coefficients for each price series, we calculated predictions for the 12 months following September 2023 and processed the results in Graph 2.

Graf 2 Wheat price development with forecast (EUR per ton)



Source: PPA – ATIS and European Commission; own calculations

Graph 2 shows that based on predictions, World and European prices are expected to decrease. In September 2024, according to the prediction, world prices should be at the level of 211.35 EUR/t and prices in the EU at 226.41 EUR/t. However, the Slovak price will increase and should reach the level of 196.39 EUR/t in September 2024.

Discussion

The situation in world commodity markets was tense even before the outbreak of war in Ukraine. In December 2021, Russia limited the export of nitrogen and phosphate-based fertilizers for 6 months, which increased their world price and indirectly affected the prices of crops. Fuel prices also rose, and these factors, combined with the tense political situation, pushed up wheat prices. Already in January 2022, the world price of wheat reached its maximum value since 2011 (BENTON T.G. et al., 2022). The graph of the development of wheat prices, which we created based on the available data, also pointed to a sharp increase in all monitored prices in January 2022.

Another price jump in world prices occurred right after the invasion of the Russian troops in Ukraine. The correlation between the war in Ukraine and the price of wheat is -60.1%, so there is a strong indirect correlation (NOVOTNÁ L., ROWLAND Z., JANEK S., 2023). The ongoing Russian-Ukrainian conflict causes wheat prices to rise by around 2% in all countries except Ukraine, as the amount of supply on the world market has decreased. In Ukraine, on the contrary, these prices fell by up to 26.6% due to export restrictions and excess supply on the Ukrainian market (DEVADOSS S., RIDLEY W., 2023). The low prices of imported Ukrainian wheat and flour represent a threat to the competitiveness of European farmers, including Slovak ones. To compensate for these losses, the European Union allocated 5.24 million euros for Slovakia to support farmers affected by the import of agricultural commodities from Ukraine (EUROPEAN COMMISSION, 2023). 5 countries of the European Union, which include Slovakia, nevertheless decided to extend the ban on the import of Ukrainian grain to protect the interests of their farmers. However, they will enable the transfer of grain through their territory to other parts of the world (EUROPEAN PARLIAMENTARY RESEARCH SERVICE, 2023).

However, increasing the availability of Ukrainian wheat on the world market can lower the world price and, through it, also national prices. The Black Sea Grain Initiative, thanks to which Ukrainian ships could once again export grain from Black Sea ports, reduced wheat prices by 7.9% and also reduced the economic costs of the war in Ukraine by \$21.48 billion (POURSINA D., ALEKS SCHAEFER K., HILBURN S., JOHNSON T., 2023). This agreement was concluded on 27/07/2022 and the Russian temporary ban on wheat exports to Eurasian Economic Union countries ended on 30/06/2022. These facts had a positive impact on wheat prices in the summer of 2022. Unfortunately, India still insists on banning wheat exports, except for some countries such as Nepal and Bhutan, to which deliveries of certain quantities of wheat are allowed based on government agreements (ROSE A., CHEN Z., WEI D., 2023).

In 2023, we can observe a gradual decrease in the price of wheat, but further developments are questionable. Research conducted using multilayer perceptron networks estimated that the US Wheat Future prices compared to February-March 2022, when it was at the level of 1400 USD/t, prices will decrease by 600-800 USD/t by the end of 2025 (NOVOTNÁ L., ROWLAND Z., JANEK S., 2023). The future development of wheat prices is significantly influenced by the development of fertilizer and energy prices. The OECD developed a scenario analysis where it found that a 1% increase in fertilizer prices would increase agricultural commodity prices by 0.2%. In the horizon of up to one year, he expects high nominal prices of cereals (OECD, 2023).

Conclusions

The war conflict in Ukraine has a significant impact on wheat prices and availability. It threatens food security primarily in developing countries in Africa and the Middle East, but also increases the cost of wheat in developed countries, including Slovakia.

The analysis of the development of average monthly wheat prices in EUR/t in the world, in the European Union, and in Slovakia showed that after relatively low price fluctuations in 2020 and 2021, there was a sharp increase in all examined prices at the beginning of 2022. In January, the month-on-month increase in world prices by 52% was caused by the increase in the prices of industrial fertilizers, which was caused by the restriction of their export from Russia and also by the tense geopolitical situation. Shortly after the Russian invasion of Ukraine, the world price of wheat increased by another 19%. A significant problem was the blockade of the Black Sea ports, due to which Ukraine could not export more than 30 mil. t of wheat and the lack of supply put pressure on prices. Another swing came

in May 2022 when India banned wheat exports to protect domestic prices. This caused an increase in the world price by 4% until the world price of wheat reached a maximum value of 417 EUR/t. The price of EU wheat most of the time copied the world price, and the European price also reached its maximum in May 2022 at the level of 412 EUR/t. The price of wheat in Slovakia reacted late and reached its maximum value only in July of the given year, at a time when world and European prices were already falling. In Slovakia at that time, the price of wheat was at the level of 371.16 EUR/t. From May 2022, the price began to fall and in July it experienced a slump thanks to the conclusion of an agreement between Ukraine and Russia to allow the export of grain from Black Sea ports. From the fall of 2022 to September 2023, the surveyed prices gradually decreased until they reached the level before the war. Thanks to the calculation of basic indices, we found that the world price fell below the level of December 2021 in August 2023, the Slovak price even as early as June 2023. However, the average price of wheat in the EU countries is still 10% above the value from December 2021. During the monitored period, the coefficient of variation showed high values, which points to the high volatility of the examined prices. Prices in Slovakia showed the greatest volatility, up to 31.82%. World prices were the least volatile (23.37%).

We examined the magnitude of the correlation between individual pairs of examined prices by calculating three different correlation coefficients. All correlation coefficients were the highest for the pair of world prices - European prices and, conversely, the smallest for the pair of world prices - Slovak prices. Pearson's coefficient showed the largest values for all pairs. All values were above 0.5, indicating a strong positive linear correlation. However, with Spearman's and Kendall's coefficients, the values for the pair of world prices - Slovak prices were between 0.3 and 0.5, which represents a moderately large correlation. We can state that wheat prices in the European Union are significantly influenced by world prices and Slovak prices by prices in the EU. However, the influence of world prices on Slovak prices is less pronounced.

Based on the average growth coefficient, we created predictions for the period October 2023 - September 2024. A decrease in world and European prices is expected. On average, the world price will decrease by 0.18% month-on-month and the European price by 0.02%. In September 2024, according to the prediction, world prices should be at the level of 211.35 EUR/t and prices in the EU at 226.41 EUR/t. However, the Slovak price will increase by 0.19% on average month-on-month and should reach the level of 196.39 EUR/t in September 2024.

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