

PRICE DEVELOPMENT OF WHEAT AND RAPESEED

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Abstract: The objective of the paper was to analyse the 2017-2022 time period using chronologically ordered time series with information on wheat and rapeseed prices. To assess the price development in the period under study, possible trends and seasonality. Furthermore, to confirm or refute dependence of agricultural commodity prices on the COVID-19 pandemic using correlation method. Three research questions were formulated and answered through these scientific methods. Descriptive analysis was used to process the chronologically ordered time series, graphs were used for visualization. Statistical indicators for mathematical expression such as mean, median, minimum and maximum were identified. In order to determine trend or seasonality, a trend line was plotted on graphs showing no statistically significant indicator which would confirm this. Correlation analysis showed low linear dependence between commodity prices and extreme events such as COVID-19.

Keywords: Wheat, rapeseed, descriptive analysis, correlation method, graph

1 Introduction

Volatility of commodity prices in the market is rising. Jankvic, Kovacevic, Jelocnik (2020) examine forecasts of future wheat price behaviour and make timely decisions on an appropriate price risk hedging strategy. There are many factors that can affect the price of wheat and rapeseed, including supply and demand, seasonal changes in production, news events, currency fluctuations and changes in trade policies. In recent years, world events such as the Covid-19 pandemic and the Russia-Ukraine war have also affected commodity prices.

The social demand for wheat is great. Wheat grain is used in the food industry and is a basic raw material for making bread, pasta and in confectionery. The main use of oilseed rape is in the production of a biobased component blended into diesel fuel. This product is called RME (rapeseed methyl ester). Rapeseed is one of the oldest and most widespread economic crops in the Czech Republic. Cultivation of rapeseed is very profitable for agricultural producers. These consequences are linked to the significant increase in rapeseed cultivation in response to increasing market demand.

Subsidies are one of the important factors influencing commodity prices. In the Czech Republic, farmers are governed by the State Agricultural Investment Fund (SAIF), an accredited paying agency that helps them to broker financial support from the European Union and national sources. Globally, however, subsidies are influenced by the Paris Agreement, which aims for a widespread transition to sustainability. In order to actually achieve these goals, subsidies can be introduced. Agriculture can benefit the climate and biodiversity, but it can also harm them. Agriculture therefore has an important role to play in the global transition to sustainability. Some agricultural resources appear to be environmentally friendly, but most appear to be ecologically destructive. Results show that agricultural subsidies must be substantially reduced and implemented more as complementary. Policy instruments such as quantity control instruments seem to be much more effective (Heyl et al. 2022)

World commodity markets are currently particularly unstable due to major health crises, political tensions, sanctions, rising demand and other global supply and demand factors. However, it should be noted that the volatility of world wheat prices has recently increased (Krasnovskiy et al. 2022). In addition to macro-environmental factors that determine prices, agricultural and other commodity markets are increasingly vulnerable to ever-increasing speculation on major commodity exchanges (Staugaitis and Vaznonis, 2022). One of the best-known commodity exchanges is the French Matif exchange that has a major influence on the price of agricultural commodities.

Imports of grain and oilseeds from Ukraine were 78.2 percent lower between February and July 2022. This was due to the Russia-Ukraine war. North America and Europe have benefited most from this trade diversion. The war has had a substantial impact on the countries directly involved in trade, but only a limited impact on global grain and oilseed markets in terms of quantities traded (Ahn, Kim, and Steinbach, 2023). There are many ways in which commodity prices can be predicted. Cariappa et al. (2020) forecasts prices based on the ARIMA model in countries with higher wheat production. Umar, Jareno a Escribano (2021) examined the joint and bivariate dependence of returns and volatility between different agricultural commodities and oil price shocks. Khan, Sharma a Ahmed (2022) model the dynamics of oil and agricultural commodity price linkages in linear and non-linear frameworks. Policy responses to Covid-19 that could have significantly affected the agricultural commodity market included, for instance, export restrictions, reduced consumption stocks or oil prices. Empirical analysis results suggest that the oil price decline may have contributed to the stability of the world grain market in the early 2020s, despite concerns that the supply chain would be disrupted. Export restrictions could significantly increase global prices, and such restrictions could also affect target commodities (Gutierrez, Pierre, and Sabbagh, 2022).

Energy is a significant part of production costs for a number of agricultural commodities. Previous studies have shown an intertwined relationship between oil prices and agricultural commodity prices, a relationship that may influence decision making of agricultural entities. Strong evidence of heterogeneity across time horizons and commodities has been found (Lundberg et al. 2021).

The aim of this paper is to assess how wheat and rapeseed prices have been affected by Covid-19 and the Russia-Ukraine war, to determine how volatile the prices are over the specified period (2017-2022) and whether prices vary according to seasonality and trends. Thus, the following research questions were formulated:

Question 1 (RQ1): How did the price of wheat and rapeseed develop between 2017 and 2022?

Question 2 (RQ2): How does seasonality affect the price of wheat and rapeseed?

Question 3 (RQ3): How have the events of Covid-19 and the Russia-Ukraine war affected the price of wheat and rapeseed?

2 Literary research

Information concerning the relationship between the cost of production and the market price of wheat allows farmers to predict the market price trend and reduce business risks in the farm. They will decide whether to sell before harvest, immediately after harvest or store the wheat and sell it later. If the market price of wheat reaches the level of operating costs, farmers will stop selling and store their products in anticipation of higher prices in the near future. The results of the analysis indicate a strong positive correlation between operating costs and the market price of wheat. This indicator makes it possible to predict the future behaviour of the wheat price and timely determine on an appropriate price risk hedging strategy (Jankovic, Kovacevic, Jelocnik, 2020). Jankovic, Kovacevic, Jelocnik (2020) study the prediction of future wheat price behaviour to decide on an appropriate price risk hedging strategy in a timely manner. Umar, Jareno, and Escribano (2021) studied the joint and bivariate dependence of returns and volatility between different agricultural commodities and oil price shocks. They propose to use a vector autoregression methodology with fresh time-varying parameters (TVP-VAR). In addition, they pay special attention to the most important periods of economic turbulence in the last 20 years such as the dot-com bubble, the global financial crisis, and the COVID-19 pandemic crisis. The main results show the directional interdependency of returns and

volatility for crude oil risk shocks is higher than that for crude oil demand shocks and, conversely higher than that for crude oil supply shocks. The overall link between returns and volatility varies over time and increases during periods of economic crisis. Khan, Sharma and Ahmed (2022) modelled the dynamics of crude oil and agricultural commodity price links in linear and non-linear frameworks.

Advanced econometric approaches, namely autoregressive distributed lag and nonlinear autoregressive distributed lag models, were used for symmetric and asymmetric impacts of crude oil prices on agricultural commodity prices. The results show that in the aggregate analysis, crude oil prices have an asymmetric impact on 10 groups of agricultural commodities in the long run while the disaggregated analysis shows that crude oil prices have a long-term positive elasticity of 29 out of 37 agricultural commodity prices.

An empirical assessment was provided for the impact of volatility of the world's agricultural commodity price indices on economic processes in industrialized countries (the United States and the European Union countries). The results showed a positive dependence of the US GDP trend on the growth of worldwide prices of raw materials. A similar result was obtained for the industrial production indicators in both countries under review. In the evaluation of the agricultural raw materials in the world's commodity market, the prices of sugar and rice were identified to fluctuate the most. However, it should be noted that the volatility of world prices of wheat has recently increased (Krasnovskiy et al. 2022). Staugaitis and Vaznonis (2022) analyzed the impact of financial speculation on agricultural and other commodity prices and volatility of returns. They use daily returns on wheat, soybeans, corn, and oats from the Chicago Mercantile Exchange as well as two other commodities (crude oil and gold) to compare the magnitude of this effect. In addition to traditional time series analysis tools, they use the threshold generalized autoregressive conditional heteroskedasticity (TGARCH) technique to measure this effect. They also present a model using seasonal dummy variables to see whether the financial speculation effect on returns volatility varies across seasons as seasonality plays an important role in returns dynamics for agriculture. They concluded that either there is no relationship between the increase in short-term speculation and agricultural commodity price volatility or the relationship is at best questionable.

An attempt has been made to forecast monthly wholesale prices of wheat using the ARIMA model in spatially separated markets in India using historical data. The prices of wheat exhibited a distinct seasonality captured through monthly price indices. It was identified that prices were highest in the harvest season and lowest in the post-harvest season. The forecast prices estimated by the ARIMA model are higher in countries with low or negligible wheat production and lower in countries with higher wheat production. The predictive performance of the models was further supported by measures such as RMSE, MAPE and MAE with 95% confidence intervals (Cariappa et al. 2020).

Ayyildiz (2022) studied how concerns about the COVID-19 pandemic had affected grain prices globally. The global fear index (GFI) and sub-price indices were used to identify the impact of COVID-19 induced fear on grain prices. Considering an asymmetric relationship between the variables, a non-linear model with a distributed autoregressive lag was used to determine this relationship. The model results show that in the long run, the agricultural commodity prices responded to positive (negative) effects in the GFI by price increase (decrease) and that the effect of a GFI increase on agricultural commodity prices was greater than the effect of a GFI decrease.

For the purpose of the paper, the time series analysis was chosen, namely descriptive time series analysis for research questions 1 and 2. This analysis will allow to monitor and follow price changes over time, fluctuations in the time series and possible trends. Correlation analysis was chosen for research question 3. Document content analysis will be used to collect

secondary data for all research questions. Visual analysis (graph) was chosen to ensure a perspicuous representation.

3 Data and methods

Data collection methods

Considering the first research question and the second research question, information on wheat and rapeseed prices in the 2017-2022 period will be used from www.kurzy.cz (Kurzy.cz, 2023) for wheat data collection, and www.eagri.cz (Eagri.cz, 2023) for rapeseed data collection. The average monthly price figures of both agricultural commodities in CZK per 1 tonne will be applied. They are included in Annex 1.

As for the third research question, data on the increments of COVID-19 positive patients will be used for the period under review, while the pandemic did not break out until 2020, so the period before will be supplemented with zero values. Specifically, the average monthly increments will be monitored on the basis of data taken from the "Onemocnění aktuálně" website, which is the official website of the Ministry of Health of the Czech Republic (MOH, 2023). The data are included in Annex 2 table.

Data processing methods

In relation to the first research question and the second research question, the data will be processed in Microsoft Excel 2013. Descriptive analysis will be used to process chronologically ordered time series with information on wheat and rapeseed prices. A graph will be used for visual representation. Statistical indicators for mathematical expression such as mean, median, minimum and maximum will be used to obtain the mean of variability and range of the data. A graph will be plotted using a curve in order to show whether seasonality affects the price of wheat and rapeseed and to answer the second research question.

As regards the third research question, correlation method will be used to determine whether there is a statistically significant relationship between development of agricultural commodity prices and the Covid-19 pandemic. The CORREL function will be used to calculate the correlation coefficient ranging from -1 to 1. A value of 0 means that there is no linear dependence between the variables. A positive value of 1 means that there is direct functional linear dependence between the variables, with one variable increasing and the other one increasing as well. A negative value of 1 (i.e. -1) means that there is indirect functional linear dependence between the variables, with one variable increasing and yet the other one decreasing. The closer the value of the correlation coefficient is to one or minus one, the stronger the relationship is. Values around zero mean that the values have no relationship.

Next, there will be a comparison of the test statistic using the correlation coefficient and the amount of data with the so-called critical value. A significance level of 5% will be considered and looked up in the Student's distribution of tables.

The test statistic will be calculated according to the following where r is the correlation coefficient value and n is the number of values (Neubauer, Sedlačík and Kříž, 2016).

In relation to the third research question, the following hypothesis is stated:

H0: Extreme events affect the price of wheat and rapeseed.

H1: Extreme events do not affect the price of wheat and rapeseed.

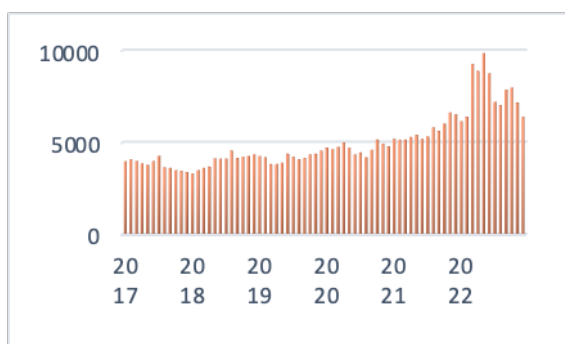
Having applied the selected methods, the following results are expected: Statistical description of the time series of wheat and rapeseed prices. Graphical representation of the development of wheat and rapeseed prices. Statistical description of the time series of agricultural commodity prices depending on seasonality. Graphical representation of the development of agricultural commodity prices depending on seasonality. The degree of correlation between agricultural commodity prices and the Covid-19 pandemic incidence.

The expected results are as follows:

According to the processed data, the prices of wheat and rapeseed for the 2017 – 2022 period will be found. Owing to the methods used, it will be possible to prove that the prices of the selected agricultural commodities are affected by seasonality, and it will be provable that unpredictable events such as the COVID-19 pandemic have affected the prices of wheat and rapeseed.

4 Results

Graph 1 – Average monthly wheat prices in 2017-2022



Source: Authors.

The average price of wheat in the period from 2017 to 2022 is CZK 4,997 per tonne. In May 2022, the price of wheat reached its maximum (CZK 9,847 per tonne), whereas the minimum price was CZK 3,307 per tonne in January 2018. According to the graph, the biggest price fluctuation was in 2022. It was caused by the Russia-Ukraine war that started in February 2022 when wheat prices doubled.

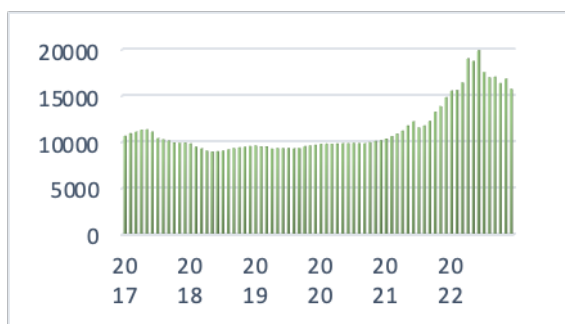
Table 1 – Wheat price statistics in 2017-2022

	2017	2018	2019	2020	2021	2022
mean	3,788	3,996	4,173	4,682	5,603	7,741
minimum	3,380	3,307	3,821	4,189	5,144	6,136
maximum	4,262	4,556	4,556	5,144	6,614	9,847
median	3,822	4,115	4,207	4,703	5,365	7,533

Source: Author

The statistical indicators of wheat prices in the above table, i.e. the mean, minimum, maximum and median, clearly show the prices, also indicating an extreme increase in 2022. From 2017 to 2021, the price trend was slightly upward and gradual.

Graph 2 - Average monthly rapeseed prices in 2017-2022



Source: Authors.

The average price of rapeseed between 2017 and 2022 is CZK 11,389 per tonne. In June 2022, the price of rapeseed amounted to its maximum (CZK 19,887 per tonne), whilst the minimum price was CZK 8,927 per tonne in May 2018. It can be seen from

the above graph that the biggest price fluctuation was in 2022, which was caused by the Russia-Ukraine war.

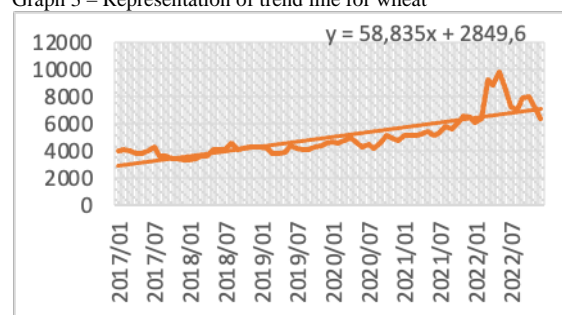
Table 2 - Statistical indicators of rapeseed prices in 2017-2022

	2017	2018	2019	2020	2021	2022
mean	10,573	9,284	9,431	9,884	12,031	17,132
minimum	9,885	8,927	9,265	9,767	10,342	15,534
maximum	11,348	9,799	9,651	10,162	14,811	19,887
median	10,519	9,300	9,411	9,841	11,741	16,897

Source: Author

The statistical indicators of rapeseed prices in the above table, i.e. the mean, minimum, maximum and median, clearly show the prices. In 2018, a noticeable price decrease can be observed. From 2018 to 2020, the price of rapeseed was stable and had a slight upward trend. In 2021, the price increased noticeably and the extreme increase came again in 2022.

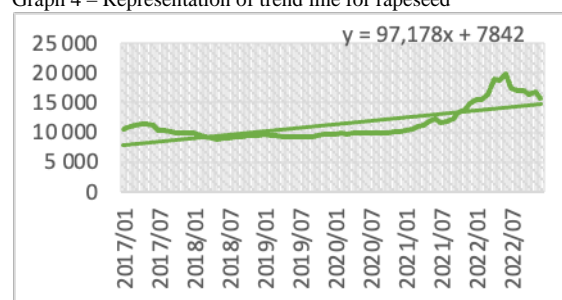
Graph 3 – Representation of trend line for wheat



Source: Authors.

A considerable rise in the wheat price from 2017 to 2022 can be seen on the linear trend line. The equation is expressed using the following formula: $y = 58.835x + 2849.6$. Given the irregular development of wheat prices and the variance compared to the straight line, trend or seasonality cannot be considered a statistically significant indicator to confirm this fact.

Graph 4 – Representation of trend line for rapeseed

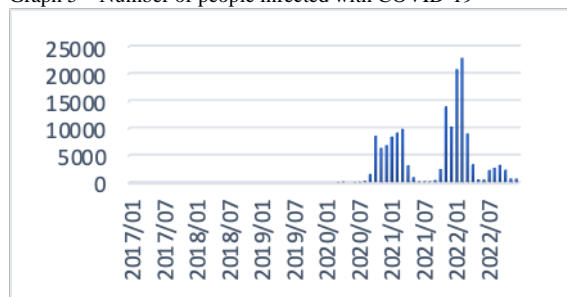


Source: Authors.

There is a noticeable rise in the price of rapeseed on the linear trend line between 2017 and 2022. The equation is expressed using the following formula: $y = 97.178x + 7842$.

Again, given the irregular development of rapeseed prices and the variance compared to the straight line, trend or seasonality cannot be considered a statistically significant indicator to confirm this fact.

Graph 5 – Number of people infected with COVID-19



Source: Authors.

In 2020, the global pandemic COVID-19 broke out. In order to determine whether there is a statistical relationship between the prices of agricultural commodities (wheat and rapeseed) and the numbers of people infected with COVID-19, the following will be applied: correlation coefficient, test statistic and critical value.

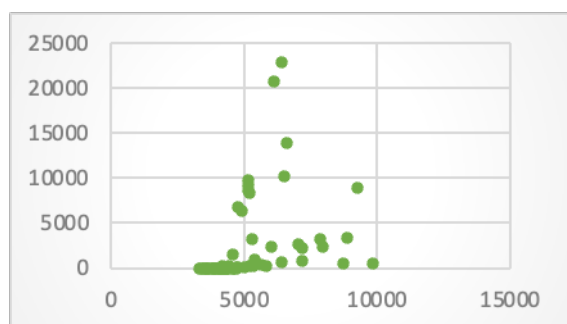
Table 3 – Correlation values of wheat and rapeseed prices with the number of COVID-19 infections

	wheat / COVID-19	rapeseed / COVID-19
correlation coefficient	0.384338	0.373491
test statistic	3.483	3.369
critical value	1.994	1.994

Source: Author

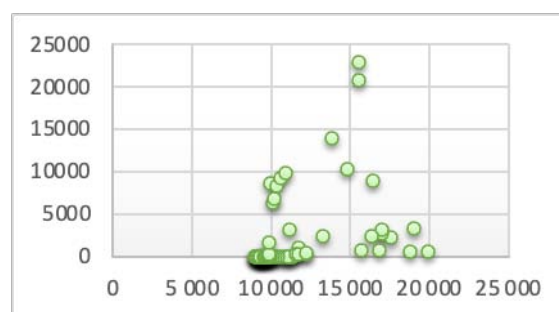
Based on the processed data, there was linear dependence between the price of agricultural commodities and the number of COVID-19 infected. There is a positive relationship between the variables, which means that when one variable increases, the other variable increases as well. However, the correlation coefficient value is quite low, hence the dependence is very weak. When comparing the absolute test statistic value and the critical value, the correlation was found to be significant. The test statistic value is greater than the calculated critical value.

Graph 6 – Correlation diagram of wheat price and number of COVID-19 infected



Source: Authors.

Graph 7 – Correlation diagram of rapeseed price and number of COVID-19 infected



Source: Authors.

With regard to the collected and processed data, the aforementioned hypothesis (H0: Extreme events affect the price of wheat and rapeseed) was confirmed. The correlation analysis showed low linear dependence between wheat and rapeseed prices and extreme events.

5 Discussion

Based on the results obtained, it is possible to answer the previously mentioned research questions:

How did the price of wheat and rapeseed develop between 2017 and 2022?

When compared to the 2015 average (=100%), the agricultural price index showed an increase of 48.1% in November 2022, while the total crop production index increased by 50.2% in comparison with the 2015 average. Regarding wheat used in the food industry, the average price in November 2022 was 7,911 CZK/t, with the price increasing by 2,306 CZK/t compared to November 2021. As for feed wheat, its price increased by 2,246 CZK/t compared to the same period last year and reached 7,470 CZK/t in November 2022 (szif.cz, 2023).

The wheat price related to the period under review (2017-2022) has an upward trend. At the beginning of 2017, the price per tonne of wheat was CZK 3,968, whereas at the end of 2022, the price amounted to CZK 6,393. The overall average price of wheat per tonne in the aforementioned period is CZK 4,997. In 2022, the price reached its maximum (CZK 9,847). In this period, the Russia-Ukraine war started, which influenced the price development. Ukraine is one of the main grain producers in Europe.

The price of rapeseed in November 2022 was CZK 16,821/t, which was an increase of CZK 2,967/t compared to the same period in 2021 (szif.cz, 2023).

Overall, rapeseed has similar price development to wheat in the 2017-2022 period. At the beginning of the period, the price was CZK 10,631, whilst at the end of 2022, it reached CZK 15,720. There is an upward trend as well. In 2022, there was an extreme price increase for wheat as well due to the Russian invasion of Ukraine, when the price climbed up to 19,887 CZK. The average price over the period under review is CZK 11,389.

How does seasonality affect the price of wheat and rapeseed?

Staugaitis and Vaznonis (2022) also present a model using season dummy variables to see if the effect of financial speculation on return volatility varies across individual seasons, as seasonality plays an important role in return dynamics regarding agriculture. They conclude that either there is no relationship between the increase in short-term speculation and agricultural commodity price volatility or the relationship is at best questionable.

Seasonality affects the price of rapeseed and wheat since these crops are seasonal and are only harvested at certain times of the year. Considering rapeseed, harvesting usually takes place

between August and October and the price usually decreases as market supply increases during and after harvest. On the other hand, if there are harvest problems, such as droughts or floods, the price of rapeseed may increase due to reduced supply. As for wheat, harvesting usually takes place between May and August. Prices usually fall with the increasing amount of harvested wheat on the market and afterwards as well. However, if there are harvest problems such as drought or diseases, the price of wheat may increase due to reduced supply. Overall, the seasonality of rapeseed and wheat prices is therefore mainly driven by market supply. Higher supply usually leads to lower prices, whereas lower supply leads to higher prices. However, the seasonality of wheat and rapeseed prices was not statistically demonstrated in the period under review. This may indicate that these commodities are produced in abundance, both from own and imported sources.

How have the events of Covid-19 and the Russia-Ukraine war affected the price of wheat and rapeseed?

Ayyildiz (2022) examined how concerns about the COVID-19 pandemic have affected grain prices globally. The global fear index (GFI) and sub-price indices were used to determine the impact of COVID-19 induced fear on grain prices. Assuming an asymmetric relationship between the variables, a non-linear model with a distributed autoregressive lag was used to determine this relationship. Based on the model results, it was found that in the long run, agricultural commodity prices responded by increasing (decreasing) to positive (negative) influences in the GFI, and that the effect of an increase in the GFI on agricultural commodity prices was greater than the effect of a decrease. Correlation analysis showed low linear dependence between wheat price, rapeseed price and extreme events in the period between 2017 and 2022. The analysis showed that COVID-19 had an impact on the price of wheat and rapeseed.

6 Conclusion

The aim of this paper was to find out price development of agricultural commodities (wheat, rapeseed) over the 2017-2022 period, trace the development, fluctuations and possible trends or seasonality with the use of descriptive analysis, and by applying correlation analysis, to determine whether the COVID-19 pandemic has affected prices of the selected commodities. It was found that the prices of both agricultural commodities were on an upward trend. The largest price fluctuation was due to the Russian invasion of Ukraine in 2022. It was illustrated on the above linear trend line that there is no statistically significant indicator that would show a trend or seasonality in relation to the price development of agricultural commodities over the period under review. Low correlation dependence of commodity price development on the COVID-19 pandemic was demonstrated.

In recent years, the development of wheat and rapeseed prices has been influenced by a number of factors such as changes in market supply and demand, the impact of weather on harvests, the development of oil and other commodity prices, political and economic factors and many others. As regards the period between 2017 and 2022, grain prices fluctuated depending on these factors, but remained relatively stable on average. Overall, it can be stated that the development of wheat and rapeseed prices in recent years has shown that the grain market is highly influenced by various factors, but has nevertheless remained at a relatively stable level. It should be noted that grain prices are very important not only for farmers but also for the overall economy as they have an impact on food prices as well as prices of other commodities.

The objective of the paper was met and all previously formulated research questions were answered using the related scientific methods employed. The research was limited to the time span of 2017-2022, examining only wheat and rapeseed as the selected agricultural commodities. If other criteria were selected, the findings could have been different. Possible future research based on the research conducted could be to compare the results already obtained with results from a larger time span, perhaps

the period after the end of the Russia-Ukraine war and COVID-19.

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Primary Paper Section: A

Secondary Paper Section: AG