Agris on-line Papers in Economics and Informatics

Volume XIV Number 4, 2022

Could Exist a Causality Between the Most Traded Commodities and Futures Commodity Prices in the Agricultural Market?

Michal Čermák[1], Marie Ligocká[2]

[1] Department of Economics, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

[2] Department of Managerial Economics, Faculty of Business Administration, Prague University of Economics and Business, Czech Republic

Abstract

Nowadays, many financial and academic practitioners explore the area of high-frequency forecasting in new dimensions. Research on agricultural commodities is an important issue for food policy and security. This paper is focused on the causality between the spot prices and futures prices of the main traded agricultural commodities. Thus, the Granger causality was used to identify the relationship between spot and futures prices of commodities. Our results show the Granger causality between cash prices and futures prices of wheat and cocoa. However, there is also causality in the opposite direction in the case of wheat. Causality could be related, among other things, to a specific market position of the commodity, food policy, historical aspects, the sensitivity of the market, speculation activity, tax policy, and particular interconnection of the market with the energy commodities market. In the price process of cash and futures wheat prices, inventories and storage play an important role.

Keywords

Agricultural commodity, Granger causality, commodity futures, cash price, agricultural commodity interdependence, food policy.

Čermák, M. and Ligocká, M. (2022) "Could Exist a Causality Between the Most Traded Commodities and Futures Commodity Prices in the Agricultural Market?", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 4, pp. 11-25. ISSN 1804-1930. DOI 10.7160/aol.2022.140402.

Introduction

Nowadays, commodities are characterized as the most traded financial contracts around the world. Significant fluctuations in the main commodity prices occurred from 2006 to 2009, followed by a downtrend in the commodity markets due to economic crises (Huchet-Bourdon, 2011). There is a significance of price fluctuation in the capital and financial markets. There is a need to consider seasonality, storability, external shocks, and breaks in the agricultural commodity market. With all these variables, we have to deal.

The motivation to detect the causal relationship between spot and future prices comes from the need for financial practitioners and hedge funds to fix the price. Nowadays, uncertainty introduces the look with high importance. The theoretical background assumes that the cash-futures prices come from a strict relationship spot-forward. Contrary, the commodity market is not perfect. The imperfection consists of a lack of market information, investor sentiment, market friction, or new reactions. There should be an empirical investigation of this causal relationship in the last decade.

Many financial researchers and practitioners deal with volatility analysis among US, german and japan indices, see Reider (2009), Zhang et al. (2015), Poon (2005). One time we worked with price volatility, and research focused on the main agricultural commodities' price variability and dynamics. The pioneering research deals with asset price uncertainty; see Markowitz (1952). According to Zhang et al. (2015), there are problems and difficulties with visibility and patterns or any breaks within simulated data. The asset price dynamics changed 15 years ago due to the consideration of high-frequency data (Aït-Sahalia and Jacod, 2014). The price fluctuations are influenced by news or speculation activity among hedge funds. There are many applications

of why volatility forecasting is important. First of all, there is an interest in risk management. Secondly, according to Hull (2003), portfolio management has a significant impact consisting of assets, commodities, or derivatives. The need for long-term research activity in this field is based on volatile periods of commodity prices changing over time (Fama, 1965).

The article's main purpose is to evaluate if spillovers exist between the commodity market and the futures commodity market. However, as the current literature shows, there is a difference in the findings of individual authors. However, it is often discussed whether speculative activity in the future market can increase agricultural commodity prices. It still seems a largely controversial theme; there is a massive increase in trading in agricultural commodity derivatives, which has been related to the activities of many institutional money managers (Zuppiroli, 2015). However, Zuppiroli (2015) shows that speculations on commodity markets didn't affect the interaction of demand and supply in the food market. In conflict with Zuppiroli (2015) are the findings of Yang et al. (2005) and Hernandez and Torero (2010). Yang et al. (2005) indicate that increased futures trading volume caused an increase in the price volatility of commodities. This information supports the destabilizing effect of futures trading on agricultural commodity markets. Yang et al. (2005) explain why historically are most virulent markets with agricultural commodities. Moreover, Hernandez and Torero (2010) argue that spot prices are generally discovered in futures markets and that changes in futures prices lead to changes in spot prices more often than in reverse. Hernandez and Torero (2010) also claim that information flow from futures to spot markets has intensified in the past 15 years, probably due to the increase in the relative importance of electronic trading of futures contracts.

Different findings in contrast with Hernandez and Torero (2010) and Yang et al. (2005) determined Alquist and Gervais (2011) and Brunetti a Büyükşahin (2009). Alquist and Gervais (2011) show that changes in financial firms' positions do not predict oil-price changes, but that oil-price changes predict changes in positions. Findings also indicate that financial speculations did not cause price increases during 2007/2008. Further, the analysis of Alquist and Gervais (2011) suggests that there is no empirical evidence to suggest a strong relationship between speculators' positions and price changes. In addition, Brunetti and Büyükşahin (2009) indicate that speculation activity is not destabilizing because the analysis shows that it is not causing any price changes, but its effect is risk reduction. However, Brunetti and Büyükşahin (2009) argue that speculation does not seem to destabilize futures markets. They find that speculative trading activity has a beneficial effect on markets. Similar findings are presented by Pindyck (2001), who argued that previously published research detected that there might be expected that some portion of commodity price variation is not based on fundamentals but is instead the result of speculative trading or herd behavior. But in the analysis, Pindyck (2001) questioned this conclusion because it is possible to incorporate speculative behavior in the error terms of the model.

Opposite results compared with Brunetti and Büyükşahin (2009) and Pindyck (2001) detected by Ali and Gupta (2011) and Manogna and Mishra (2020). Ali and Gupta (2011) found a long-term relationship between futures and spot prices in agricultural commodities like maize, chickpea, black lentil, pepper, castor seed, soybean, and sugar. Then, the findings of Ali and Gupta (2011) show that futures markets have a stronger ability to predict subsequent spot prices for chickpea, castor seed, soybean, and sugar than maize, black lentil, and pepper, where bi-directional relationships exist in the short run. Similarly, Manogna and Mishra (2020) determined that price discovery exists in six analyzed futures commodity markets (soybean seed, coriander, turmeric, castor seed, guar seed, and chana). The Granger causality tests show that futures markets can predict spot prices more easily. And then, there exist mutual spillover effects on futures and spot markets by using the EGARCH volatility test. According to Manogna and Mishra (2020), the futures market is more efficient in the price discovery of agricultural commodities in India.

The same with Manogna and Mishra (2020) and Ali and Gupta (2011) are the results of Nath and Lingaredd (2008). Nath and Lingaredd (2008) indicate the volatility and prices of pulses were higher during the period of futures trading than before its introduction on markets and after the ban of futures contracts. Then opposite to Nath and Lingaredd (2008) are the findings of Stoll and Whaley (2015), who showed that commodity index investing is not speculation. Second, changes in commodity index investment do not cause futures prices to change; and third, the failure of the wheat futures price to converge to the cash price at the contract's expiration has not undermined

the futures contracts' effectiveness as a risk management tool. As Stoll and Whaley (2015) and Sashi (2007) determined, in wheat, turmeric, sugar, cotton, raw jute, and soybean oil, the nature of spot price volatility has remained the same with the onset of futures trading. However, in wheat and raw jute, there has been a weak destabilizing effect from futures to the spot with the onset of futures trading.

In addition to Sashi (2007), a certain degree of interconnectedness of markets is also evident in Kang et al. (2017), who analyzed the dynamics of return and volatility spillover indices. Kang et al. (2017) found that the correlation between commodity futures market returns increased significantly during crises. One of the basic findings is the occurrence of two-way spillovers of returns and volatility across commodity futures markets. They also found more pronounced trends in their levels in the post-crisis period. These findings can be essential for investment decisions and trading strategies. Adämmer and Bohl (2018) also emphasize the interconnectedness of the markets. They determined the impact of the futures market on spot prices and pointed out that more significant trading activity in the futures market did not have a more significant impact on spot prices. Similar findings can be seen in Bouri et al. (2021), pointing to the fact that the connectedness of volatility varies over time and is affected by uncertainty and the macroeconomic situation (e.g., interest rates, level of real GDP).

While Dimpfl et al. (2017) confirmed that the futures market contributes less than 10% to the formation of the spot price, Dimpfl et al. (2017) emphasize that in the long run, speculation in futures markets adversely affects the commodity market. Likewise, the results of Xu (2018) and Xu (2019) did not support a causal structure between the individual variables but demonstrated a long-run equilibrium relationship. In contrast, Samak et al. (2021), Tiwari et al. (2020), and Pradhan et al. (2021) demonstrate the connection between spot and futures markets of agricultural commodities. According to Samak et al. (2021), information flows and investor sentiment from the futures market to the spot price market. However, Tiwari et al. (2020) refer to industrial inputs as the originator of volatility transmission.

Materials and methods

This paper investigates the data consisting of 2,455 trading days for each commodity. The analysis for the daily time series is run. The timeframe of research is based on the years 2012–2020. represents the future commodity price and spot cash closing prices of different commodities – Wheat, Corn, Soybeans, Cocoa, Coffee, and Sugar. All the data are obtained from the database Stooq and Investing. The EViews software for the analysis is used. For the statistical analysis, the logarithmic returns are calculated therefore:

$$r_t = \left(ln \frac{P_t}{P_{t-1}} \right) \quad (1)$$

where P_t is the closing price of the commodity and P_{t-1} is one lagged (prior day).

The Augmented Dickey-Fuller test and Phillip-Peron test are employed to examine the presence of the unit root within data. The use of the Dickey-Fuller test is positively evaluated, for example, by Haug and Basher (2011), who states that it has the highest and most stable force for typical final sample sizes due to the likely data generation processes encountered by practitioners. On the other hand, for example, Choi (1992) shows that, especially for the aggregate data, the Phillip-Perron tests appear to be more powerful than the augmented Dickey-Fuller test. Due to a different view of the strength of unit root tests, we use both tests, whose results are presented in Table 1. In the case of the presence of non-stationarity of the observed data, the logarithmic returns are made. It leads the transition from one period to the next (Tillman, 1973). If the data exhibits non-stationary, thus the regression analysis does not reflect the real spillover effect. Table 1 displays the unit root analysis. In both cases of the test, the null hypothesis is rejected. The null hypothesis is the presence of unit root at level 0.01of confidence. The results of the Augmented Dickey-Fuller unit root test and the Phillips-Perron test in Table 1 also demonstrate that both tests could identically evaluate the used time series stationarity. The results show that time series (logarithmic returns) are stationary at the level.

According to Appendix 1, descriptive statistics is employed to analyze the main characteristics of time series, both spot price, and futures commodity prices. Except for the sugar futures price, all commodities exhibit heavier tails. Thus the time series do not have symmetric distribution. The casual relationship is used for the spillover analysis of logarithmic returns (Granger, 1969). The Granger methodology investigates if the changes in one time series casual the change in another. There is an assumption that the past values

Commodity	Type of unit root test	Cash price of commodities (returns)	Price of commodity futures (returns)
Wheat	ADF	-52.5808* (0)	-47.7303* (0)
	PP	-52.8231* (0)	-47.7428* (0)
Corn	ADF	-29.0256* (0)	-53.6819* (0)
	PP	-141.2100* (0)	-54.0621* (0)
Soybeans	ADF	-26.4103* (0)	-46.5939* (0)
	PP	-161.8327* (0)	-46.5982* (0)
Cocoa	ADF	-51.2335* (0)	-49.0617* (0)
	PP	-51.2039* (0)	-49.0569* (0
Coffee	ADF	-51.7969* (0)	-49.7318* (0)
	PP	-51.8948* (0)	-49.6960* (0)
Sugar	ADF	-17.9662* (0)	-2.6376*** (0)
	PP	-50.5757* (0)	-2.5845*** (0)

Note: *, **, *** means significance at 1 %, 5 %, and 10 % levels. ADF symbolizes the Augmented Dickey-Fuller unit root test, and PP presents the Phillips-Perron unit root test. (0) means stationary at the level, and (1) means stationary at the first difference.

Source: Authors' calculation (based on data available from Stooq and Investing)

Table 1: Results of Augmented Dickey-Fuller and Phillips-Perron unit root test statistic.

of the time series X can predict the future values of Y with consideration of all relevant information. Vice versa, it can be valid if values of Y Granger-cause of the importance of X. This concept is introduced by two OLS regression equitations (Gujarati, 2009):

$$X_t = \alpha_0 + \sum_{i=1}^{m} \mu_i X_{t-1} + \sum_{j=1}^{m} \delta_j Y_{t-j} + u_{1t} \quad (2)$$

$$Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_{t-1} + \sum_{j=1}^{m} \beta_j X_{t-j} + u_{2t} \quad (3)$$

where X (futures prices of commodities) and Y (cash prices of commodities) represent the stationary variables, and parameter m is lag length for both X and Y. The u_{1t} and u_{2t} are uncorellated error terms. Therefore we run the Granger analysis test represented with hypothesis H_0:

$$H_0: \beta_1 = \beta_2 = .. = 0 \quad (4)$$

It means that X's values do not Granger-cause Y's values. We can construct the alternative hypothesis:

$$H_1: \beta_j \neq 0 \quad (5)$$

In the case of rejection, the null hypothesis, it is evident that $\beta_j \neq 0$ for j. In summary, this fact approves the Granger causality evidence.

Before calculating the empirical estimations, it is presented the development of the main important factors that affect commodity markets. The graphs in Appendix 2 show that wheat prices were most influenced in 2014, 2016, 2017, and 2018. Prices of corn, sugar, and soybeans were most affected in 2020. The prices of coffee were most volatile, mainly in 2014, 2019, and 2020. The cocoa prices oscillated throughout the analyzed period, but most in 2017, 2019, and 2020. However, a significant event in the commodity market in May 2012 was the rise in soybean, wheat, and maize prices due to the drought that hit the US, with a more modest increase in prices for coffee and sugar. A good harvest in the southern hemisphere contributed to the stabilization of prices in 2012. In 2013, the decline in food commodity prices related to the forecast of a new harvest (e.g., wheat) appeared to be important, while in energy crops (soybeans, maize), prices rose in July 2013 due to favorable weather reports. However, the price of sugar fluctuated near a minimum of more than three years; the same was true for coffee. The outlook at the end of 2013 was the expectation of a slight increase in prices for corn, wheat, and coffee, while the price of soybeans was to fall. These were related to lower demand from developing countries, lower incentives to hold commodities as hedges against inflation, and expectations of a slowdown in monetary easing in developed countries (CNB, 2021).

The beginning of 2014 was marked by a continuing trend of shifting growing demand from developed countries. In February 2014, the price of wheat, corn, coffee, and soybeans began to rise due to fears of damage to this year's crop in the USA

due to severe frosts and bad weather in Brazil. On the other hand, the more than a three-month decline in sugar prices came to a halt. Agricultural tensions in Ukraine also began to show political tensions. The factor that will dampen rising prices was expected to be the expected strengthening of the US dollar and the tightening of US monetary policy, which should lead to an outflow of investment from commodity markets. This outflow occurred in April 2014 and the transfer of investment to the stock markets. In the second half of 2014, the impact of high wheat yields in the Black Sea region became apparent, and, compared to 2013, growing conditions for maize and soybeans in the USA improved due to favorable weather. In general, expectations of a good global harvest have led to a fall in agricultural commodity prices, as has the intensity of the political conflict in Ukraine and concerns about the harvest. The mild winter in Europe and the cold summer in the US led the USDA to forecast a rich harvest, which pushed grain prices to four-year lows. However, rainy weather in Western Europe disrupted the fall in prices. However, grain prices in the USA were affected by uncertainty about the future production of alcohol from grain and corn. The price of soybeans was influenced by growing competition from palm and rapeseed oil. Coffee and sugar prices also rose (drought in Brazil and growth in ethanol production there). Especially at the end of the year, agricultural commodity prices were negatively affected by rainy weather in the USA, Russia, and Ukraine, which slowed down the harvest of cereals and soybeans. There were also fears of cold weather in the US and restrictions on exports from Russia. The price of corn was significantly affected by growing production and demand for ethanol, and the price of soybeans was affected by high exports from the USA (CNB, 2021).

At the beginning of 2015, fears of production outages and high stocks of some commodities in the USA subsided. The weather in South America began to improve, which was reflected in agricultural commodity prices. The price of soybeans started to fall, mainly due to good weather in Brazil and forecasts of record USDA global production. The price was also depressed by the larger sown areas of North America, the Middle East, and North Africa; it offset the decline in planted regions of Russia. The price of wheat has risen temporarily due to low temperatures in the US and fears of crop damage. Other factors included the strengthening exchange rate of the US dollar, expectations of high global yields, and lower demand for biofuels (low oil prices). In mid-2015, sugar prices rose due to the strengthening of the Brazilian currency and expected higher exports from India. Cocoa prices have increased due to a reduction in the Ghana harvest estimate. In the second half of the year, the price of agricultural commodities was affected by the weather and higher demand; especially due to the humid weather, corn and soybeans began to rise. The price of soybeans was also affected by the devaluation of the Chinese renminbi. At the end of 2015, the price of soybeans reached a more than eight-year low. The reason was high production in Brazil and a record harvest in the USA. Sugar prices also rose sharply due to dry weather and lower yields in India, China, and the EU. The price of corn has been pushed down by estimates of higher harvests and falling fuel prices (CNB, 2021).

Significant events in the markets for agricultural commodities in 2016 can be described as the decline in sugar and cocoa prices at the beginning of the year due to the estimate of a good harvest; a similar trend was also evident for grains. The negative effects on commodity prices began to show in April 2016. The rise in sugar prices was linked to the strengthening of the Brazilian real and the decline in exports from Thailand due to dry weather, while rains in Brazil slowed the sugar cane harvest. The strengthening of the Brazilian currency has also impacted coffee prices. In the case of grains, the drought in Brazil appeared to be problematic, with a negative impact on the maize crop, and rains in Argentina negatively affected the soybean crop. The drought in the USA also affected the harvest of these commodities. Since August 2016, the USA's weather improvement has been reflected in the expectation of a rich harvest of soybeans and corn. There has also been an increase in the sown area of grains. Larger wheat harvests in Russia, Kazakhstan, and Ukraine were also reflected in the decline in grain prices. At the same time, the negative impact was evident on the price of coffee. There was a strike of carriers in Colombia and the threat of the frost crop in Brazil. Sugar prices reflected lower production in Brazil and expectations of lower production in India, which led to the price reaching a four-year high (CNB, 2021).

In the first half of 2017, grain prices were affected by expectations of lower yields, also due to drought in the main growing areas. In addition, lower wheat production was expected in India and Kazakhstan, and higher demand for maize

in China and Mexico. In the case of sugar prices, prices increased due to an estimate of lower production in India (dry weather). The persistent oversupply caused a significant increase in the price of cocoa. Soybean prices were affected by the rich harvest in the USA and Brazil. At the end of April, the price of wheat began to rise due to frosts in growing areas of North America (frosts on the US Central Plains). During the year, the prices of cocoa, sugar, and coffee continued to fall sharply. The price of sugar and coffee began to show a weakening of the Brazilian reality in connection with political instability in the country. In the case of sugar, an important factor was that most of the harvest would be used for sugar production and less for ethanol. The price of soybeans fell due to an estimate of a good harvest. In the second half of 2017, the price of grain was affected by unfavorable weather in some areas (drought in Australia and Argentina and floods in Southeast Asia). Still, at the end of the year, the high global stocks of these commodities had a stabilizing price. The price of sugar started to rise in August 2017 due to the strengthening Brazilian real and the reduction of the local ethanol tax (CNB, 2021).

In 2018, agricultural commodity prices tended to stagnate as a result due to high stocks and the global harvest. However, some fluctuations have been observed in cocoa prices, which are highly volatile over the period. It was due to the weather in the main growing areas (Ghana and Côte d'Ivoire). The weather affects the quality of cocoa, and tree infections leading to pruning are also a problem. USD fluctuations and support programs also have some implications. Wheat and corn prices in 2018 were affected by strong demand and a slight decline in production, while crop growth was expected for soybeans due to a good harvest in Argentina.

In most cases, the first half of 2019 was associated with a decline in agricultural commodity prices, reflecting the existence of high global supply prospects of a rich harvest. In the second half of 2019, grain, sugar, and coffee prices began to rise, citing dry weather concerns in Canada, Australia, and Russia and floods in some areas of the United States that threatened the supply and quality of commodities. In the end, coffee, cocoa, and sugar prices also started to rise more significantly. In 2020, price developments varied considerably, with agricultural commodity prices being affected by Covid-19 measures with markets becoming highly speculative due to supply constraints, high demand, and supply uncertainty. Depending on changes in agricultural commodity prices, the speculative activity of financial investors and, thus, the volatility of yields on the futures market may also have taken place (CNB, 2021).

Results and discussion

First, the correlation coefficients between spot prices and futures prices of selected commodities were calculated. As the results in Table 2 show, none of the presented correlation coefficients were not statistically significant. It indicates that there is no linear relationship between the analyzed variables. According to these findings, it is evident that the co-movements of variables need to be sufficiently strong.

Wheat	-0.0207
Corn	0.0136
Soybeans	0.0288
Cocoa	0.0320
Coffee	0.0004
Sugar	0.007645

Note: *, **, *** means significance at 1 %, 5 %, and 10 % level.

Source: Authors' calculation (based on data available from Stooq and Investing)

Table 2: Correlation coefficients between the price of commodity futures and the cash price of commodities.

Then, it was necessary to identify the optimal lag length. The Akaike information criterion, the Schwarz Criterion, and the Hannan–Quinn information criterion is commonly used to determine the optimal delay. As findings in Table 3 show, it seems most appropriate to use an optimal lag length of one day based on the Akaike information criterion, the Schwarz Criterion, and the Hannan–Quinn information criterion.

In Table 4, there are test statistics of Granger causality. The causality effect is detected between the cash price of wheat and the futures price at the significance level of 0.05. There is also evident causality in the opposite direction going from the futures prices of wheat to spot prices of wheat at the significance level of 0.01. In other words, the Granger causality exists between a wheat commodity's cash price and futures price. The second case where causality between spot prices and futures prices is found is with cocoa, at the significance level of 0.01. In other cases, the causality relationship was not proved.

Commodity	Lag	LogL	Sequential modified LR test statistic (at 5 % level)	Final prediction error	Akaike information creiterion	Sxchwarz information criterion	Hannan-Quinn information criterion
Wheat	0	-9433.618	N/A	12.4979	8.2013	8.2063*	8.2031
	1	-9418.192	30.8120*	12.3744*	8.1913*	8.2063	8.1968*
Corn	0	-12461.19	N/A	151.0601	10.6934	10.6983	10.6952
	1	-12156.98	607.6475*	116.7568*	10.4358*	10.4506*	10.4412*
Soybeans	0	-10697.19	N/A	77.9685	10.0320	10.0373	10.0340
	1	-10412.37	568.8425*	59.9190*	9.7687*	9.7846*	9.7745*
Cocoa	0	-8977.807	N/A	9.2583	7.9012	7.9063*	7.9031
	1	-8965.858	23.8647*	9.1938*	7.8942*	7.9094	7.8998*
Coffee	0	-9710.427	N/A	16.8030	8.4973	8.5023*	8.4991
	1	-9700.841	19.1466*	16.7210*	8.4924*	8.5074	8.4979*
Sugar	0	-27074.63	N/A	63844318	23.6477	23.6527	23.6495
	1	-21416.90	11300.63*	457808.4*	18.7099*	18.7249*	18.7154*

Note: * indicates lag order selected by the criterion.
Source: Authors' calculation (based on data from Stooq and Investing).

Table 3: Determination of optimal lag length.

Null Hypothesis	F-Statistic	Probability	Causality
Futures price of wheat =/=> Cash price of wheat	7.2132*	0.0073	+
Cash price of wheat =/=> Futures price of wheat	4.3110**	0.0380	+
Futures price of corn =/=> Cash price of corn	0.0660	0.7973	-
Cash price of corn =/=> Futures price of corn	0.2553	0.6134	-
Futures price of soybeans =/=> Cash price of soybeans	0.3873	0.5337	-
Cash price of soybeans =/=> Futures price of soybeans	0.4135	0.5203	-
Futures price of cocoa =/=> Cash price of cocoa	2.5442	0.1108	-
Cash price of cocoa =/=> Futures price of cocoa	6.7221*	0.0096	+
Futures price of coffee =/=> Cash price of coffee	0.2179	0.6406	-
Cash price of coffee =/=> Futures price of coffee	0.5510	0.4580	-
Futures price of sugar =/=> Cash price of sugar	0.2326	0.6296	-
Cash price of sugar =/=> Futures price of sugar	0.1023	0.7491	-

Note: *, **, *** denotes significance at 1 %, 5 %, and 10 % level. Symbol + means the existence of a causal relationship between analyzed variables, and symbol denotes no causal relationship between selected factors.
Source: Authors' calculation (based on data from Stooq and Investing).

Table 4: Results of Granger Causality Test for prices of commodity futures and cash price of commodities.

There is evidence of non-causality among these commodities in predicting power spot and futures commodity prices. However, the wheat commodity futures prices are applicable for research on spot prices. Our results are similar to Sashi (2007), who determined a weak destabilizing effect from futures to the spot prices in the case of wheat, while for the other commodities analyzed. The possibility of a causal relationship between spot prices and futures prices is also identified by Kang et al. (2017), Adämmer and Bohl (2018), and Manogna and Mishra (2020). On the other hand, the absence of a causal relationship between spot prices and futures prices for some of the analyzed commodities is consistent with the findings of Dimpfl et al. (2017), Xu (2018), Xu (2019), and Zuppiroli (2015).

There could be some reasons for the causality between wheat's spot prices and futures prices. The role could be historical because wheat belongs to the most traded agricultural commodities. Wheat is connected with the beginnings of trading on futures markets because it was the first commodity used as the underlying asset for futures contracts. The fact that wheat belongs to the most traded agricultural commodities could reflect that increasing speculations on financial markets can be

transmitted to markets with real assets and effected this market. The wheat market appears to be more sensitive than other agricultural commodities markets, as indicated, for example, in 2009 by the fact that the price of wheat reached its peak earlier than the prices of other commodities. Greater sensitivity could be related to the interconnectedness of the energy commodities market, as part of the wheat produced is sugar and partly ethanol. It means that there could exist a spillover effect due to these facts. The other reason for significant causality may be in the field of important convergence between the cash market price and wheat futures price. The wheat commodity has a difficult role in the world. For instance, it has a complicated market structure because of the wheat grown. In the futures wheat market, 20 local contracts are listed worldwide. According to the CME Group, there are many fluctuations and disconnects between cash and futures prices. It can be reasoned in the field of the power of U.S wheat stocks. The same concept for wheat price discovery can come from storage and different expiration contracts in the futures market.

One of the most reasons for a causal effect among wheat spot and derivative markets could also be in food security, respectively, food policy. That's because wheat is the most important commodity used for human nutrition. The concept of food security is defined as a state in which all people always have access, both physically and financially, to a safe and nutritionally rich diet. Such nutrition aims to satisfy nutritional needs and dietary preferences (as defined by the FAO, 2015). The world community has had a significant impact over the past decade on providing nutrition for the population. However, more than 800 million people worldwide suffer from hunger and face problems caused by malnutrition (FAO, 2015). The Food and Agricultural Organization (FAO, 2015) has identified four pillars of food safety access, availability, efficiency, and stability. Food availability is measured by the overall food supply, while access to food is based on household income. However, these conditions are necessary, but more is needed for food stability. For example, research on several factors that affect food prices has been conducted by Haile et al. (2014). Food price stability can be involved in several ways:

- Fluctuations in the harvest of agricultural commodities (market effects and storage costs).
- Changes in real income with an impact on access to food.
- The impact of natural disasters or pandemics.
- For each such factor, changes in food prices signal a change in the stability of food security. Conversely, high prices may indicate the problem of rising prices in general. The specifics of these areas in the wheat market may be the reason for the causality between spot and futures prices of wheat.

The fact that national governments are responsible for ensuring a certain degree of food security and living conditions for citizens could have some impact (Bellemare, 2015). Food policy is a politically sensitive issue in the context of the growing trend of urbanization of the world's population. Based on research (Béné et al., 2015), there are recommendations for working with increased commodity price volatility through specific food policy objectives. The sensitivity of rising food prices to political results, for example, in elections, has been demonstrated. Examples are known where the increase in food prices has led to societal protests in Haiti (in 2008) and Algiers (in 2011); for example, in 2007/2008 as well, rising food prices led to social protests in Bangladesh (Bellemare, 2015). Once food prices become a sensitive policy issue, there will be a rapid response from international organizations, such as the OECD, to limit the extreme rise in price volatility. However, a significant share of these responses to rising food prices had a partial effect (Martin and Anderson, 2012). One of the main reasons for the failure of these joint actions is the growing integration of local agricultural markets into global structures. It is a situation where the traditional agricultural market is fully integrated into various financial markets. It makes it difficult to identify the sources of increased volatility. The conventional concept of supply and demand in the agricultural commodity market has less of a defining feature for price fluctuations. Important factors in the agricultural market that play a role are energy commodity prices, interest rates, monetary policies of central banks, speculation and investment, trade restrictions, or lack of information (Martin and Anderson, 2012). In the case of wheat, price volatility could also be reflected in the causality because wheat commodity volatility was a crucial problem at the time. There are periods with high price fluctuation and evidence of the leverage effect (Cermak, 2017). With the increasing wheat cash price, there is a tendency to change the commodity price volatility in the same direction.

The second commodity that shows Granger

causality between spot prices and futures prices is cocoa. The reason for demonstrating Granger causality between spot prices and cocoa futures prices could be that cocoa is a potential commodity that can be used for industrial processing. Tulashie et al. (2022) found that the chemical characteristics in oil extraction from cocoa nibs were below the recommended standards acceptable for industrial applications. Additionally, the oil was found to be highly stable despite thermal extraction. The potential for using cocoa in the industry could influence speculation on the development of cocoa prices to a greater extent. A large concentration of cocoa bean production in a certain area could appear as an important factor. According to Faostat (2022), 68% of cocoa beans are produced in Africa. It means that market supply is significantly influenced by factors affecting African production, for example, the age of cocoa trees, climatic conditions, level of technology, etc. (Wessela and Quist-Wessel, 2015). It is related to the fact that cocoa is a crucial raw material for further processing, especially for the production of chocolate. Price fluctuation is, therefore, significantly influenced by the demand for final cocoa products. External factors, such as weather or price shocks, are the main reasons for the growth in the use of futures contracts (International cocoa organization, 2022).

Granger causality was reflected for cocoa in the high dependence of the producer on the given commodity and the related importance for the national economy (source of income, jobs). It applies, for example, to Indonesia, the 3rd largest cocoa producer in the world (Adelina, Hasyim, and Wibowo, 2020). In addition, according to Rubbaniy et al. (2022), cocoa can be considered a "safe haven" for short-term investors in both futures and spot markets, especially during the Covid-19 pandemic. Conversely, this relationship does not apply to investors using a long-term horizon. Another factor could be the possibility of export taxes on cocoa, as these taxes could affect the integration of domestic and international markets, which may be a source of greater market uncertainty (Duron et al., 2022).

On the market with other analyzed agricultural commodities, there didn't have to be a causal relationship between spot prices and futures prices of analyzed agricultural commodities since commodity price changes may not be affected by financial market turbulence. There is no speculation on the financial markets for some agricultural commodities to the same extent as for wheat. Another reason may be that other agricultural commodity markets are not as sensitive as the wheat market and are not linked to the energy commodity market as wheat. There are differences between the information absorbed by the financial market and the real asset markets. It could be reflected even more strongly in these commodities. The location of commodity cultivation is also an important criterion, i.e., how a given commodity is widespread worldwide. It could also be linked to the tendency of farmers to secure. Another important factor may be the degree to which food policy is addressed. There may be distortions in the markets for the other agricultural commodities analyzed, for example, because of various support programs.

Conclusion

The objective of this paper was to examine if the causal relationship between spot prices and futures prices in main traded commodities exists. The Granger causality was used for data daily (wheat, corn, sugar, coffee, cocoa, and soybeans) in 2012 – 2020. Our results show that the Granger causality exists among cash prices and futures prices of wheat and that there is also causality in the opposite direction. There can be several reasons for this finding. These reasons may include the following. First, there is an issue with food policy or security as its subarea. All the examined commodity prices, including wheat commodities, do not have a crucial effect on food nutrition like wheat. According to the findings, the possible explanation can be related to the importance of the commodity wheat, like a worldwide good traded at major commodity exchanges and in the field of specific convergence and market structure.

We then detected Granger causality between spot prices and cocoa futures prices. It could be reflected in the position of the commodity on the market and in industry, barriers to international departure through taxes and customs duties, or macroeconomic factors. In the case of other commodities, no causal link was found between spot prices and fur prices. These results may have been due to less sensitivity of the markets, less level of hedging, the effect of speculation in the markets, the level of concentration of cultivation of commodities, and interconnectedness of the financial market with the market of real assets.

These results are important and useful

for agricultural policymakers, investors, and financial practitioners. From a practical point of view, these findings can be used to create and simulate scenarios of various portfolios where the inclusion of agricultural commodities is considered. In terms of price volatility among the monitored commodities, the results are helpful regarding the causal influence of price movements.

Acknowledgements

Publication of this paper was supported by the institutional support "VŠE FPH IP300040" and by IGA PEF ČZU (Interní grantová agentura PEF ČZU) "20171031". The support is greatly acknowledged.

Corresponding authors
Ing. Michal Čermák
Department of Economics, Faculty of Economics and Management
Czech University of Life Sciences Prague, Kamýcká 129, 165 00, Prague - Suchdol, Czech Republic
Phone: +420 224382089, e-mail: cermak@pef.czu.cz

References

[1] Adämmer, P. and Bohl, T. M. (2018) "Price Discovery dynmaics in European agricultural markets", *Journal of Futures Markets*, Vol. 38, No. 5, pp. 549-562. ISSN 0270-7314. DOI 10.1002/fut.21891.

[2] Adelina, S., Wilbowo, R. P. and Hasyim, H. (2020) "Analysis of the Export Determinants of Indonesian Cocoa with Gravity Model Approach", *International Journal of Research and Review*, Vol. 7, No. 10, pp. 66-75. ISSN 2349-0788.

[3] Aït-Sahalia, Y. and Jacod, J. (2014) "*High-Frequency Financial Econometrics*", Prinston: Prinston University Press. ISBN 9780691161433. DOI 10.23943/princeton/9780691161433.001.0001.

[4] Ali, J. and Gupta, K. B. (2011) "Efficiency in agricultural commodity futures markets in India: Evidence from cointegration and causality tests", *Agricultural Finance Review*, Vol. 71, No. 2, pp. 162-178. ISSN 0002-1466. DOI 10.1108/00021461111152555.

[5] Alquist, R. and Gervais, O. (2011) "*The Role of Financial Speculation in Driving the Price of Crude Oil*", IFPRI Discussion Paper 2011-6, July 2011. [Online]. Available: https://www.bankofcanada.ca/wp-content/uploads/2011/07/dp2011-06.pdf [Accessed: Oct. 5, 2021].

[6] Bellemare, M. F. (2015) "Rising food prices, food price volatility, and social unrest", A*merican Journal of Agricultural Economics*, Vol. 97, No. 1, pp. 1-21. ISSN 0002-9092. DOI 10.1093/ajae/aau038.

[7] Béné, C., Barange, M., Subasinghe, R., Pinstrup-Andersen, P., Merino, G., Hemre, G. I. and Williams, M. (2015) "Feeding 9 billion by 2050–Putting fish back on the menu", *Food Security*, Vol. 7, No. 2, pp. 261-274. ISSN 1876-4517.

[8] Huchet-Bourdon, M. (2011) "*Agricultural Commodity Price Volatility*", OECD Food, Agriculture and Fisheries Papers No. 52, June 2011. [Online]. Available: http://dx.doi.org/10.1787/5kg0t00nrthc-en [Accessed: June 5, 2022].

[9] Bouri, E., Lucey, B., Saeed, T. and Xuan, V. V. (2021) "The realized volatility of commodity futures: Interconnectedness and determinants", *International Review of Economics and Finance*, Vol. 73(C), pp. 139-151. ISSN 1059-0560. DOI 10.1016/j.iref.2021.01.006.

[10] Brunetti, C., Büyükşahin, B. and Harris, J. H. (2009) "*Is Speculation Destabilizing?*", U.S. Commodity Futures Trading Commission Working Paper, Apr. 2009. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.357.8949&rep=rep1&type=pdf [Accessed: Oct. 12, 2021].

[11] Choi, I. (1992) "Effects of data aggregation on the power of tests for a unit root", *Economics Letters*, Vol. 40, No. 4, pp. 397–401. ISSN 0165-1765. DOI 10.1016/0165-1765(92)90133-J.

[12] Cermak, M. (2017) "Leverage Effect and Stochastic Volatility in the Agricultural Commodity Market under the CEV Model", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 65, No. 5, pp. 1671-1678. ISSN 1211-8516. DOI 10.11118/actaun201765051671.

[13] Česká národní banka (CNB) (2021) "*ČNB – Globální ekonomický výhled*", ČNB, 2021. [Online]. Available: https://www.cnb.cz/cs/menova-politika/gev/ [Accessed: Oct. 16, 2021] (In Czech).

[14] Dimpfl, T., M. Flad and Jung, R. C. (2017) "Price discovery in agricultural commodity markets in the presence of futures speculation", *Journal of Commodity Markets*, Vol. 5, pp. 50-62. ISSN 2405-8513. DOI 10.1016/j.jcomm.2017.01.002.

[15] Duron, M. J. J., Manalo, M. P. I., Reyes, A. M. and Rosete, M. A. L. (2022) "Trading Policy Analysis of Cocoa in Indonesia", *International Journal of Social and Management Studies*, Vol. 3, No. 1, pp.32-61. ISSN 2775-0809. DOI 10.5555/ijosmas.v3i1.85.

[16] Fama, E. F. (1965) "The Behavior of Stock-Market Prices", *The Journal of Business*, Vol. 38, No. 1, pp. 34-105. ISSN 0021-9398.

[17] FAOSTAT (2022) "Statistics in 2022", FAO, 2022 [Online]. Available: https://www.fao.org/statistics/en/". [Accessed: Nov. 16, 2022].

[18] Food Agricultural Organization (FAO) (2015) "The state of food insecurity in the world 2015: meeting the 2015 international hunger targets: taking stock of uneven progress". Advances in Nutrition, 2015. [Online]. Available: http://ambassadors-env.com/en/files/a-i4646e.pdf [Accessed: 25 Nov. 2021].

[19] Granger, C. W. J. (1969) "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods", *Econometrica*, Vol. 37, pp. 424-438. ISSN 0012-9682. DOI 10.2307/1912791.

[20] Gujarati, D. N., and Porter, D. C. (2009) "*Basic econometrics (international edition)*", New York: McGraw-Hills Inc. ISBN 00-712-7625-4.

[21] Haile, M., Kalkuhl, M. and von Braun, J. (2014) "Agricultural supply response to international food prices and price volatility: a cross-country panel analysis", *2014 International Congress*, August 26-29, 2014, Ljubljana, Slovenia 182725, European Association of Agricultural Economists. DOI 10.22004/ag.econ.182725.

[22] Haug, A. A. and Basher, S. A. (2011) "Linear or nonlinear cointegration in the purchasing power parity relationship?", *Applied Economics*, Vol. 43. No. 2, pp. 185-196. ISSN 1466-4283. DOI 10.1080/00036840802403656.

[23] Hernandez, M. and Torero, M. (2010) "*Examining the Dynamic Relationship between Spot and Future Prices of Agricultural Commodities*", IFPRI Discussion Paper 00988, June 2010. [Online]. Available: https://core.ac.uk/download/pdf/6270326.pdf [Accessed: Oct. 3, 2021].

[24] Hull, J. (2003) "*Options, futures*", 5th ed. Upper Saddle River: Prentice Hall, c. Prentice Hall finance series. ISBN 01-300-9056-5.

[25] Investing.com - Stock Market Quotes & Financial News (2021) "*Investing.com*", Investing.com, 2021. [Online]. Available: https://www.investing.com [Accessed: Sep. 6, 2021].

[26] International Cocoa Organization (2022) "*Statistics*", ICCO. [Online]. Available: https://www.icco.org/statistics/ [Accessed: Nov. 15, 2022].

[27] Kang, H. S., McIver, R. and Yoon, M.-S. (2017) "Dynamic spillover effects among crude oil, precious metal, and agricultural commodity futures markets", *Energy Economics*, Vol. 62(C), pp. 19-32. ISSN 0140-9883. DOI 10.1016/j.eneco.2016.12.011.

[28] Manogna, R. L. and Mishra, A. K. (2020) "Price discovery and volatility spillover: an empirical evidence from spot and futures agricultural commodity markets in India", *Journal of Agribusiness in Developing and Emerging Economies*, Vol. 10, No. 4, pp. 447-473. ISSN 2044-0839. DOI 10.1108/JADEE-10-2019-0175.

[29] Markowitz, H. (1952) "Portfolio Selection", *The Journal of Finance*, Vol. 7, No. 1, pp 77-91. ISSN 0022-1082. DOI 10.1111/j.1540-6261.1952.tb01525.x.

[30] Martin, W. and Anderson, K. (2012) "Export restrictions and price insulation during commodity price booms", *American Journal of Agricultural Economics*, Vol. 94, No. 2, pp. 422-427. ISSN 0002-9092.

[31] Nath, G. C. and Lingareddy, T. (2008) "Impact of Futures Trading on Commodity Prices", E*conomic and Political Weekly*, Vol. 43, No. 3, pp. 18-23. ISSN 0012-9976. DOI 10.2307/40276919.

[32] Pindyck, R. S. (2001) "The Dynamics of Commodity Spot and Futures Markets: A Primer", *The Energy Journal*, Vol. 22, No. 3, pp. 1-29. ISSN 0195-6574. DOI 10.5547/ISSN0195-6574-EJ-Vol22-No3-1.

[33] Poon, S.-H. (2005) "*A practical guide for forecasting financial market volatility*", Hoboken, NJ: Wiley. 200 p. ISBN 978-0-470-85613-0.

[34] Pradhan, R. P., Hall, J. H. and du Toit, E. (2021) "The lead–lag relationship between spot and futures prices: Empirical evidence from the Indian commodity market", *Resources Policy*, Vol. 70(C). ISSN 0301-4207. DOI 10.1016/j.resourpol.2020.101934.

[35] Reider R. (2009) "Volatility Forecasting I: GARCH Models, Time Series Analysis and Statistical Arbitrage Notes", New York University, New York.

[36] Rubbaniy, G., Khalid, A. A., Syriopoulos, K. and Samitas, A. (2022) "Safe-haven properties of soft commodities during times of Covid-19", *Journal of Commodity Markets*, Vol. 27, p. 100223. ISSN 2405-8513. DOI 10.1016/j.jcomm.2021.100223.

[37] Samak, N., Hosni, R. and Kamal, M. (2020) "Relationship between spot and futures prices: The case of global food commodities", *African Journal of Food, Agriculture, Nutrition and Development*, Vol. 20, No. 3, pp. 15800-15820. ISSN 1684-5374. DOI 10.18697/ajfand.91.18620.

[38] Sashi, G. S. (2007) "Influence of Commodity Derivatives on Volatility of Underlying Asset", *ICFAI Journal of Derivatives Markets*, Vol. 4, No. 3, pp. 26-39. ISSN 0972-9119.

[39] Stoll, H. R. and Whaley, R. E. (2010) "Commodity Index Investing and Commodity Futures Prices", *Journal of Applied Finance*, Vol. 20, No. 1, pp. 7-46. ISSN 1534-6668.

[40] Stooq (2021) "*Stooq*", Stooq, 2021. [Online]. Available: https://stooq.com/ [Accessed: Sep. 6, 2021].

[41] Tillman, J. A. (1973) "The Efficiency of Taking First Differences in Regression Analysis: A Note", *Economic and Social Review*, Vol. 4, No. 4, pp. 543-549. ISSN 0012-9984.

[42] Tiwari, A. K., Nasreen, S., Shahbaz, M. and Hammoudeh, S. (2020) "Time-frequency causality and connectedness between international prices of energy, food, industry, agriculture and metals", *Energy Economics*, Vol. 85(C), p. 104529. ISSN 0140-9883. DOI 10.1016/j.eneco.2019.104529.

[43] Tulashie, S. K., Dodoo, D., Appiah, G., Kotoka, F. and Adukpoh, K. E. (2022) "Oil produced from Ghana cocoa bean for potential industrial applications", *Industrial Crops and Products*, Vol. 177, pp. 114426. ISSN 0926-690. DOI 10.1016/j.indcrop.2021.114426.

[44] Wessel, M. and Foluke Quist-Wessel, P. M. (2015) "Cocoa production in West Africa, a review and analysis of recent developments", *NJAS – Wageningen Journal of Life Sciences*, Vol. 74-75, pp. 1-7. ISSN 1573-5214. DOI 10.1016/j.njas.2015.09.001.

[45] Xu, X. (2018) "Causal structure among US corn futures and regional cash prices in the time and frequency domain", *Journal of Applied Statistics*, Vol. 45, No. 13, pp. 2455-2480. ISSN 0266-4763. DOI 10.1080/02664763.2017.1423044.

[46] Xu, X. (2019) "Price dynamics in corn cash and futures markets: cointegration causality, and forecasting through a rolling window approach", F*inancial Markets and Portfolio Management,* Vol. 33, pp. 155-181. ISSN 1934-4554. DOI 10.1007/s11408-019-00330-7.

[47] Yang, J., Balyeat, B. R. and Leatham, D. J. (2005) "Futures Trading Activity and Commodity Cash Price Volatility", *Journal of Business Finance & Accounting*, Vol. 32, No. 1, pp. 297-323. ISSN 0306-686X. DOI 10.1111/j.0306-686X.2005.00595.x.

[48] Zhang, Y., Yao, T. and He, L. (2015) "*Forecasting crude oil market volatility: can the Regime Switching GARCH model beat the single-regime GARCH models?*". [Online]. Available: https://arxiv.org/abs/1512.01676 [Accessed: Dec. 10, 2021].

[49] Zuppiroli, M. (2015) "Recent Developments in Agri-food Commodity Prices and the Impact of Financial Speculation", *Progress in Nutrition*, Vol. 17, No. 1, pp. 23-35. ISSN 1129-8723.

Appendix

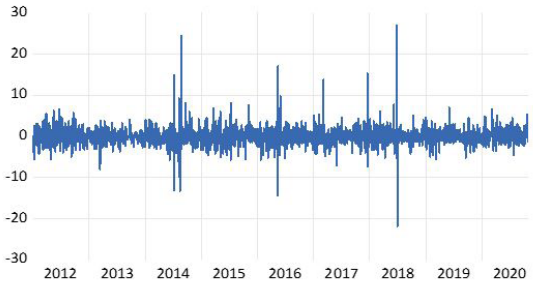
Variable	Price of wheat futures	Cash price of wheat	Price of corn futures	Cash price of corn	Price of soybeans futures	Cash price of soybeans
Mean	-0.0093	0.0058	-0.0245	0.0029	-0.0055	-0.0114
Median	-0.0519	0.0000	0.0000	0.0000	0.0186	0.0000
Maximum	6.6272	23.9149	25.0288	227.9300	5.4957	232.2664
Minimum	-6.7077	-24.5738	-26.8620	-230.3398	-12.5420	-228.6311
Std. Dev.	1.6190	2.1830	1.7796	6.9023	1.2258	7.0934
Skewness	0.2896	0.5878	-1.2435	-0.5034	-0.7544	0.7385
Kurtosis	4.0844	26.1158	56.8393	1042.649	10.0284	1014.446
(continued)						
Variable	**Price of cocoa futures**	**Cash price of cocoa**	**Price of coffee futures**	**Cash price of coffee**	**Price of sugar futures**	**Cash price of sugar**
Mean	0.0092	-0.0002	-0.0249	-0.0347	-1284.457	-0.0201
Median	0.0236	0.0000	-0.0275	0.0000	-1219.888	-0.0700
Maximum	19.2511	12.2363	11.7892	22.3992	-697.5694	811.3441
Minimum	-19.7491	-13.4124	-7.6331	-44.0641	-2323.845	-818.7789
Std. Dev.	1.7893	1.6998	2.0584	1.9901	328.5009	24.3291
Skewness	0.0769	-0.2562	0.2709	-4.8060	-0.7137	-0.4176
Kurtosis	16.2977	13.1275	4.5716	126.1574	2.8858	1100.897

Source: Authors' calculation (based on data available from Stooq and Investing)

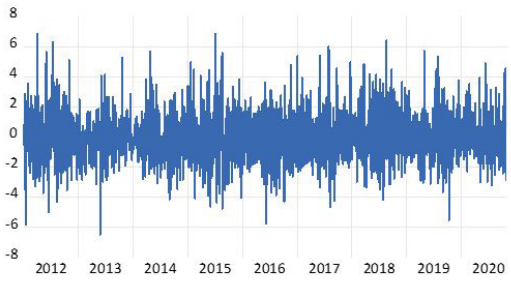
Appendix no. 1 Descriptive statistics of future prices and cash prices of analyzed commodities.

Wheat

Cash price of wheat

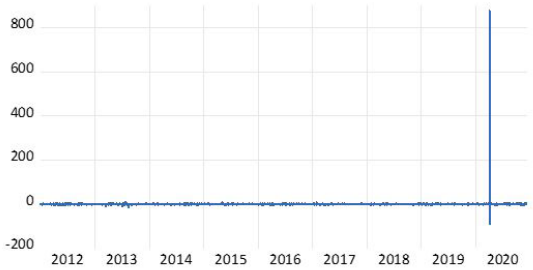


Price of wheat futures

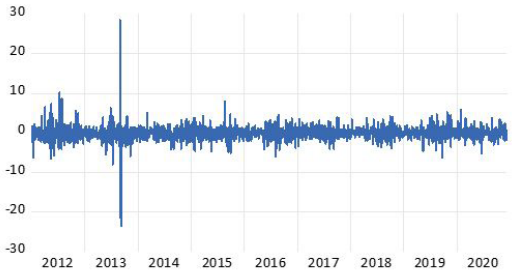


Corn

Cash price of corn

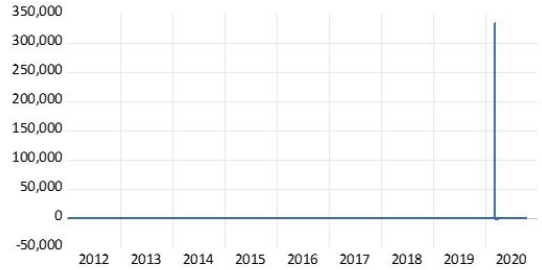


Price of corn futures

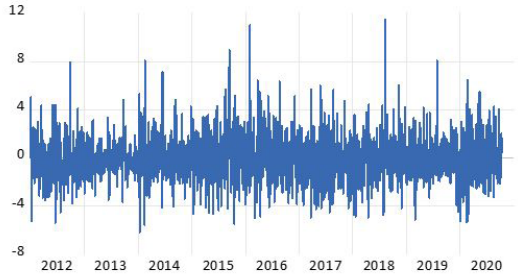


Sugar

Cash price of sugar

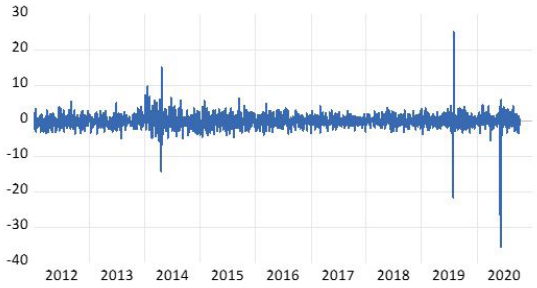


Price of sugar futures

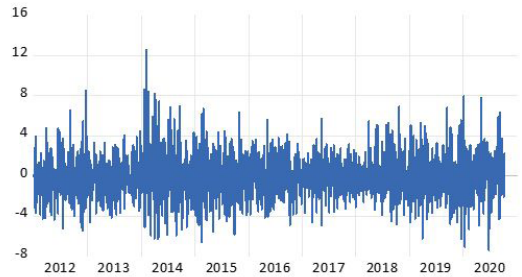


Coffee

Cash price of Coffee



Price of coffee futures

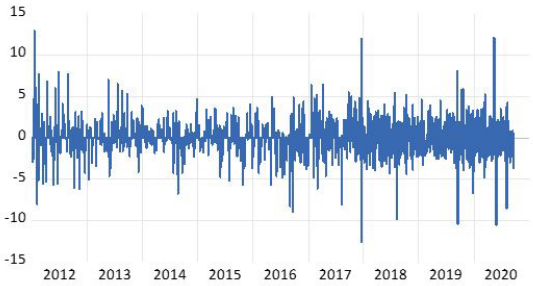


Source: Authors' calculation (based on data available from Stooq and Investing)

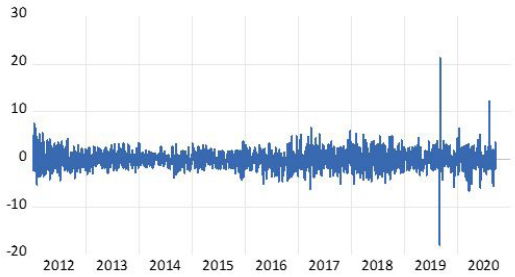
Appendix no. 2: Development of future prices and cash prices of analyzed commodities (change in %) (To be continued).

Cocoa

Cash price of cocoa

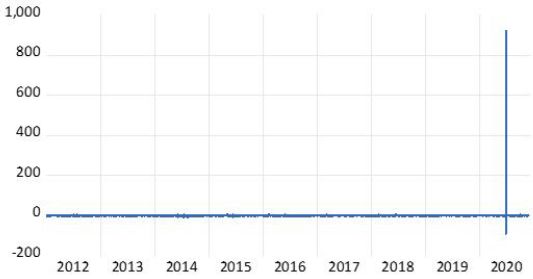


Price of cocoa futures

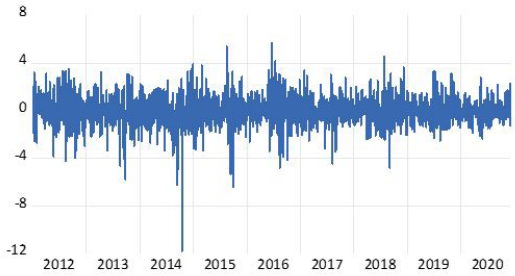


Soybeans

Cash price of soybeans



Price of soybeans futures



Source: Authors' calculation (based on data available from Stooq and Investing)

Appendix no. 2: Development of future prices and cash prices of analyzed commodities (change in %) (Continuation).