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The impact of financial speculation on futures contracts price movements: A study of the US markets for dairy commodities

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Abstract

Research background: The study analyzes whether financial speculation destabilizes commodity prices in light of recent price volatility and spikes in agricultural commodities. The study delves deeper into the US dairy futures markets, which are less studied by other authors in their research and relatively new in comparison to other agricultural commodity markets. These dairy commodity futures contracts provide dairy businesses and farmers the chance to hedge against price risks, which are particularly crucial in uncertain economic times such as the post-2020 COVID-19 pandemic timeframe. The analysis makes use of the weekly returns on futures contracts for nonfat milk powder, butter, milk class III, and cheese that are obtained from the Chicago Mercantile Exchange (CME).

Purpose of the article: Conduct an empirical study to evaluate the effect of financial speculation on dairy product prices on US commodity markets, including the post-2020 timeframe.
Methods: Time series analysis is used in the investigation: the generalized auto-regressive conditional heteroskedasticity (GARCH) method, the Granger causality test, and the Augmented Dickey-Fuller (ADF) test.
Findings & value added: Our analysis's findings show that, even though most commodities experienced an increase in return volatility during the post-2020 period, there is no evidence for financial speculation being the cause of increased returns from dairy futures contracts. The research also suggests that financial speculation, in some cases, even lowers the volatility of dairy futures prices. Therefore, non-commercial market participants may help to distribute price risks, making these markets more liquid.

Introduction

High price volatility as well as price shocks in the markets for agricultural products lead to various problems. These are increased price risks for producers and traders of these products (Sifat *et al*., 2021); food crises (Yuan *et al*., 2020); slowed sustainable development of the agricultural system; and farmers' income stability (Baines, 2017). It is noteworthy that the prices of agricultural products have increased significantly over the last decades. The dairy products sector is particularly sensitive, where stable and uninterrupted production is important in order to ensure the quality of the dairy products (Wang *et al*., 2023), so special attention is paid to risk management, especially price risk and hedging opportunities (Białkowski & Koeman, 2018; Fernandez-Perez *et al*., 2022), given that there is little correlation between the volatility of dairy products and the commodities market as a whole (Fan *et al*., 2023).

Therefore, it is important to analyze what factors contribute to the destabilization of agricultural product prices, both when deciding which agricultural policy measures to apply and when regulating trade in these products and what instruments to use to manage price risks. The variability of product prices is determined by various factors, such as countries' economic indicators, the general macroeconomic environment, and general expectations for the future (Apergis *et al*., 2020). On the other hand, trade-related and financial market factors can also be emphasized. Financialization has resulted in much of the trading taking place in the global derivatives markets through futures, options, et cetera. Here, producers and traders of both dairy and other agricultural products hedge against the price risk inherent in their activities. Researchers analyze whether factors related to the performance of these markets affect product prices in the futures markets and ultimately in the spot markets (Basak & Pavlova, 2016; Bonnier, 2021; Borgards & Czudaj, 2022). Of special interest is speculation in the futures contract markets, usually identified by the volumes of those market participants who participate here for a purpose other than hedging against the price risk incurred in the production, processing, and trading of products—hedge funds et al. (Fan *et al*., 2022). A large body of research has analyzed this issue, but there is still no consensus on whether speculation destabilizes agricultural and other product prices: many authors provide no or mixed evidence of this impact (Lawson *et al*., 2021; Wimmer, 2021), whereas most recent research tends to provide affirmative evidence (Conrad, 2023; Breman & Storm, 2023). Even though dairy futures markets are fairly new, their importance is quickly growing as a way to solve problems in the dairy industry, to avoid price booms and spikes, and to make sure that the industry efficiently manages price risks, uncertainties, etc.

By using futures contract time series data from the Chicago Mercantile Exchange (CME) on four major dairy commodities from 1997 to 2022, this paper empirically investigates the effect of financial speculation on dairy products in the US commodity market. Research also includes the latest post-2020 time periods characterized by pandemic-induced crises, political instability, the war in Ukraine, growing energy prices, etc. that have the potential to make these dairy prices more volatile. On the one hand, the post-2020 time period can be associated with increasing levels of risk aversion (Boateng *et al*., 2022), whereas other authors point out increased price volatility and interconnectedness among financial markets starting in early 2020 (Zeng *et al*., 2023). In our study, we employ the Granger causality test for the causal effects of speculation on price movements and the GARCH model to test for its impact on conditional return volatility including the post-2020 timeframe.

The research provides several important findings. First, selected dairy commodities became more volatile in terms of return volatility during the post-2020 time period. Secondly, financial speculation, modeled as an exogenous factor, either has a weak effect or, in some cases, even reduces the volatility of dairy futures prices. This effect was also observed during the post-2020 time period, indicating that non-commercial market participants may indeed reduce economic turmoil-induced price shocks associated with high return volatility. Lastly, there is no evidence to support a causal relationship between the growth in non-commercial market participants (speculators) and higher returns from dairy futures.

The remaining portions of the study are structured as follows. The literature on speculation in commodity markets and its effects is reviewed in Section II. In Section III, the methods and variables are covered. Section IV compares the empirical findings with the conclusions of earlier research. Section V discusses the empirical findings. The final section offers concluding observations, limitations, and recommendations for further study.

Literature review

Speculation can be defined as the short-term buying and selling of an asset with the purpose of profiting from price movements. The effect of speculation on agricultural and other product prices has been extensively analyzed in the works of other authors; for example, it is argued that speculation, in addition to helping to introduce new information to markets, can also provide liquidity to those markets (Fan *et al*., 2022; Brunetti *et al*., 2016). In studies on futures commodity markets, speculation, unlike in other markets, is usually associated with the ratio between commercial and non-commercial market participants. Commercial market participants are traders who are themselves producers and manufacturers of physical products and who seek to hedge against price risks experienced in their underlying businesses. Hedging pressure theory states that speculators earn risk premiums by taking price risk from commercial participants in these markets (Ekeland *et al*., 2019). Non-commercial market participants — also called speculators — take short or long positions and thus correct the discrepancy between demand and supply to hedge against rising or falling prices. On the other hand, some of these speculations are excessive when the volume of non-commercial positions is greater than necessary to eliminate these discrepancies, and the index of speculative activity, also known as the Working T index (Working, 1960), is often used by other authors to measure the effects of speculation in commodity futures markets (Etienne *et al*., 2018; Guo *et al*., 2022; Long & Guo, 2022).

Since the beginning of 2000, the processes related to the liberalization, globalization, and financialization of derivatives markets have led to a significant increase in the volume of non-commercial positions in global commodity markets (Basak & Pavlova, 2016; Kang *et al*., 2023). Since commodity futures contracts are standardized, have low carrying costs, almost perfect or semi-perfect market competition, and are in continuous demand, they attract a lot of speculators. Finally, in 2007, the crisis led to extremely volatile prices and price jumps in the markets for agricultural products. This has led to considerable debate as to whether speculation in these markets has driven these changes. For example, behavioral theories state that speculators behave differently than regular commercial participants in these markets (Huchet & Fam, 2016; Xiao *et al*., 2023). If product prices do not correspond to their fundamental value, this ultimately leads to bubbles in markets. For example, during periods of crisis, macroeconomic uncertainty may increase the speculative nature of trading markets (Apergis *et al*., 2020; Xiao & Wang, 2022).

However, the reverse effect is often emphasized (Etienne *et al*., 2018; Wellenreuther & Voelzke, 2019), or even that non-commercial market participants can stabilize prices (Bohl & Sulewski, 2019). On the other hand, the authors mainly delve into energy products or grain markets (Wimmer *et al*., 2021). Other markets have been little studied, often showing negative effects of speculation (Algieri & Leccadito, 2019). Therefore, it is necessary to further analyze the dairy product markets, which have not been sufficiently analyzed by others. It is emphasized that although prices and their dynamics are explained by fundamental factors, their impact can be exacerbated by speculation (Palazzi *et al*., 2020). The authors also take into account seasonality (Silveira *et al*., 2017), the impact of prices of energy products (Behmiri *et al*., 2019), intercorrelations during the crisis period (Umar *et al*., 2021), carrying costs (Samak *et al*., 2020), etc.

Various methods are widely used in the works of the authors on commodity markets and the impacts of speculation. These are various time elution methods: the Granger causality test (Wellenreuthe & Voelzke, 2019); the Diks-Panchenko test (Palazzi *et al*., 2020). Other authors also use GARCH methods to analyze variability, including their modifications EGARCH (Czudaj, 2019), TGARCH (da Silveira *et al*., 2017), DCC GARCH (Ulusoy & Onbirler, 2017), stochastic volatility modeling (Du & Dong, 2016), and HAR models (Brunetti *et al*., 2016).

On the other hand, little research has yet analyzed recent data covering the post-2020 period to determine whether speculation has increased price volatility during times of market distress. Based on these observations, the research methodology and its main aspects are presented below.

Research method

In our research, the Granger causality test is used to investigate causal relationships between speculation and dairy commodity returns, and the GARCH model is used to model price or return volatility. The main hypotheses of the research are:

H1. *Financial speculation causes returns from dairy futures contracts*.

H2. *Financial speculation has an impact on the volatility of dairy futures returns*.

The dependent variable, returns from dairy futures contracts, reflects the price volatility and price risks. The logarithmic difference in nearby futures contract closing prices between periods t and t-1 is used to calculate returns on product futures similarly to research by other authors (da Silveira *et al*., 2019).

To measure financial speculation in dairy commodities markets, we use the Working T index of excess speculation (Working, 1960). We use this index as an independent variable. In futures market research, the Working's T index is used to determine the extent to which non-commercial positions (speculators' positions) outnumber commercial positions (dairy producers' and consumers' positions) (Formula 1). This index's value must be greater than one. If it equals 1, all market positions are considered commercial (no speculation).

$$T_t = \begin{cases} 1 + \frac{NS_t}{CL_t + CS_t} & \text{if}(\mathrm{CS_t} \geq \mathrm{CL_t}), \\ 1 + \frac{NL_t}{CL_t + CS_t} & \text{if}(\mathrm{CL_t} > CS_t). \end{cases} \tag{1}$$

where:
T_t the financial speculation (Working T) index;
NS_t short non-commercial positions;
NL_t long non-commercial positions;
CS_t short commercial positions;
CL_t long commercial positions;
t the time period.

The time series are then given descriptive statistics and tested to see if they are stationary. It is crucial when analyzing time series that they exhibit stable statistical features and distributions such as autocorrelation, mean, and variance. The unit root Dickey-Fuller (ADF) test, which is common in this sort of research (Wang *et al*., 2022), will be used to determine whether the time series of futures variables are stationary. We use the Augmented Dickey–Fuller (ADF) test if the data in our study is stationary (h0: unit root is present; h1: alternate hypothesis). The ADF test is based on an auto-regressive time series model with a constant and a trend (Dickey & Fuller, 1979).

The Granger causality test is then used to investigate the causal relationship between the given speculation index and the prices of dairy products or the return on futures contracts for those products if the time series in absolute terms of prices does not meet the condition of stationarity. The Granger causality test is easy to explain, as it uses only two variables and their lagged values. However, the traditional Granger model is only appropriate for linear connections between variables and needs a well-specified specification of time lags. Once a linear connection is observed, more complex forms can be used to analyze this relationship further. Using Granger's (1969) methodology, it is tested which time series can better explain the other time series for the given number of time lags. The Granger causality test is written as two autoregressive equations (Formulas 2 and 3). The first equality in the model ensures that the speculation index is not driving futures contract prices or returns (Formula 2). The model's second equation evaluates whether prices or futures returns are driving the speculation index (Formula 3). For comparison reasons, we chose to use two time lags. Then we test which variable explains the other with smaller p-values. In addition, there can be situations when no statistically significant effects for both time series are found or when the impact is statistically significant for both time series (feedback relationships).

$$\mathrm{Y}_t = \alpha_0 + \sum_{i=1}^{j} \alpha_{1i} Y_{t-i} + \sum_{i=1}^{j} \alpha_{2i} X_{t-i} + \varepsilon_t. \tag{2}$$

$$X_t = \beta_0 + \sum_{i=1}^{j} \beta_{1i} X_{t-i} + \sum_{i=1}^{j} \beta_{2i} Y_{t-i} + \omega_t. \quad (3)$$

where:
Y_t the return on dairy product futures contracts;
X_t the index of speculative activities (Working T);
$\beta_{0,1,2}$, $\alpha_{0,1,2}$ model parameters;
ε_t, ω_t residual errors;
i the time lag;
j number of time lags;
t the time period.

The hypotheses for the Granger causality test are as follows: h1 speculation does not cause returns; h2 returns does not cause speculation.

Futures return time series, similar to other financial assets, typically rely on previous squared observations and variances to model present variation. Therefore, GARCH modeling is widely employed in studies of financial markets (Wang *et al.*, 2022). However, GARCH models can be unstable and inaccurate if the underlying data is excessively volatile or lacks observation. As a result, our study is limited to four dairy futures, and we use GARCH modeling to see how speculative variables affect return conditional volatility. Based on the methodology described by Bollerslev (1986) with 1 period AR lags GARCH, we define our model GARCH (1,1). The model consists of mean (Formula 4) and variance equations (Formula 5). The residual error represents innovation and its impact on price and return volatility. The variance effect reflects the clusters of time series.

$$R_t = \alpha_0 + \alpha_1 R_{t-1} + u_t. \quad (4)$$

$$h_t^2 = \beta_0 + \beta_1 u_{t-1}^2 + \beta_2 h_{t-1}^2 + \beta_3 T_{t-1}. \quad (5)$$

where: R_t is an autoregressive process with parameters α_0, α_1 and an error term u_t with a variance of h^2. The conditional variance h_t^2 is provided in the variance equation, where β_0 is the constant, $\beta_1 u_{t-1}^2$ is the ARCH effect, $\beta_2 h_{t-1}^2$ is the GARCH effect, $\beta_3 T_{t-1}$ is the speculation index (Working T).

The hypotheses are as follows: h1 speculation does not increase the volatility of returns from dairy futures contracts.

Following that, we look to see if the p-values of the GARCH model parameters are less than 0.05, indicating statistically significant volatility clustering, exogenous variables, and so on. The Hannan–Quinn information criterion, the Akaike information criterion, the Schwartz (Bayesian) information criterion, and log-likelihood are used to compare models.

Data

We investigate four US dairy commodities and their futures contracts: butter, cheese, milk class III, and nonfat dry milk traded in the Chicago Mercantile Exchange (CME). Although more types of dairy products are traded on the CME, the selected four types of products have been traded continuously and can be compared when using the post-2020 timeframe. US dairy futures markets are the most extensively studied by other authors, with a relatively long trading history and continuous data available. We gather data on butter every week from February 19, 2013, to January 30, 2022; cheese every week from February 14, 2012, to January 30, 2022; milk every week from October 14, 1997, to January 30, 2022; and non-fat dry milk every week from November 19, 2013, to January 30, 2022.

Data on continuous futures contract prices is available from Bloomberg and Barchart. Data on dairy futures open positions and their structure is available from the Commodity Futures Trading Commission's Commitments of Traders (COT) weekly reports (CFTC). The COT report distinguishes between commercial and non-commercial traders (speculators). The study uses weekly data, as these reports only provide weekly data. Calculations are performed using Gretl software.

Results

Descriptive statistics and the ADF test results

We begin with descriptive statistics for all four dairy commodities (see Table 1). The dynamics of prices and speculations are presented graphically for butter (Figure 1), milk class III (Figure 2), cheese (Figure 3), and nonfat dry milk (Figure 4).

Each dairy commodity has a similar level of return volatility, with milk having the greatest (standard deviation is estimated to be 4.215) and nonfat dry milk having the lowest (standard deviation is estimated to be 3.923). Milk has the greatest Working T index mean value (1.141), whereas butter has the lowest (1.055) when using the full sample data.

This means that milk is the most volatile in terms of return, reflecting a higher price risk. Price and return fluctuation are strongly linked, yet price is most volatile for non-fat milk powder (31.470 per cent mean). If the price change is stable and trend-like, then the standard deviation of the price is large as well, but the standard deviation for returns is small.

When comparing full data and post-2020 data, as shown in Table 2, all markets are more volatile in terms of return standard deviation except for nonfat dry milk (estimated to be 3.709). In the post-2020 timeframe, cheese is estimated to have the highest value of return standard deviation (6.640).

Speculation is on average larger in the milk market when analyzing the post-2020 timeframe and is higher than for other dairy commodities (the mean of the Working T index is estimated to be 1.180 in the milk futures market). All the other three markets share similar levels of speculation between time periods. As mentioned before, when analyzing post-2020 data, milk also shows high levels of return volatility and speculation.

To sum up, the milk market shows the highest levels of speculation as measured by the Working T index and has higher return volatility compared to other dairy commodities.

Then, utilizing whole sample data for all four commodities, we present estimated results for the ADF test (see Table 3). When using full sample data, butter and nonfat dry milk prices are non-stationary (estimated p-value > 0.05), while milk and cheese prices are stationary (estimated p-value < 0.05), indicating that the mean and variance are largely consistent over time.

For all four dairy commodities, returns are stationary and have no unit root. In most cases, the long-term speculation index is stationary, except for cheese, which is non-stationary using both trend and constant models. This demonstrates that returns from dairy futures are suitable for further Granger causality investigation.

Granger causality test results

We then present the results of the Granger causality test (see Tables 4 and 5). Here we test two opposite hypotheses: whether speculation explains returns and vice versa. We use the entire dataset as well as the post-2020 timeframe. When analyzing the full sample data, there are no occurrences where the p-value was less than 0.05 to reject both hypotheses. The lowest case for the p-value is less than 0.0721 when using two time lags (-2) for cheese. As a result, there are no grounds to reject specific hypotheses h1 and h2, demonstrating that each variable moves independently and does not explain the other. Similar results are estimated for the post-2020 data. Therefore, the main hypothesis H1 cannot be accepted.

In most situations, the p-value for the second hypothesis that speculation does not cause a return is higher and is accepted with a higher p-value than the opposite hypothesis. Non-fat dry milk futures using the post-2020 timeframe are the lone exception. However, in any case, the p-value is above 0.05, so it cannot be confirmed that any parameter is statistically different from zero.

When analyzing the aggregate effect, in all cases a p-value of below 0.05 is not met; however, for all four dairy products, returns better explain speculation than vice versa; the only exception is for nonfat milk using post-2020 data.

GARCH estimates

Then, using the whole sample and post-2020, we examine the findings of the GARCH model to see if speculation measured by the Working T index has an impact on the conditional volatility of returns from dairy futures.

We first look at the mean equation and parameter estimations here (see Tables 6 and 7). When using data for a full-time sample, these parameters are in most cases statistically insignificant, with a p-value above 0.05 showing that they are equal to zero. The most notable exception is when analyzing the post-2020 data. For butter and cheese milk, previous returns (-1) explain further returns (p-values are below 0.05 and coefficient values are -0.1641 for butter and 0.0456 for cheese).

Next, we look at the variance equation. When using data from the full-time sample and post-2020 data, the residual effect is statistically significant (p-value less than 0.05) for cheese only. In this case, volatility closely reflects its lagged values. For all four commodities, significant volatility effects indicate that there is clustered return volatility for all four commodities. When using post-2020 futures, the volatility effect is also statistically significant, except for cheese futures.

Speculation measured by the Working-T index has a negative effect on all commodities using whole data but is only statistically significant for butter (coefficient estimated to be -4.3729) and milk (coefficient estimated to be -0.8967). When using post-2020 data, coefficients change sign. but are only statistically significant for cheese, but the coefficients here are negative as well (-189.6360).

This is evidence that excessive speculative activity either has no effect or even reduces return volatility more than vice versa. The effect of speculation on return volatility does not differ dramatically when focusing on the post-2020 timeframe. Therefore, hypothesis H2 can only be partially accepted.

Discussion

In the study, the authors examined the markets for dairy product futures contracts, which have not yet been analyzed much by other authors (Du & Dong, 2016). Our study brings three important findings:

First of all, the hypothesis that speculation leads to returns in dairy commodity markets was rejected for all four dairy commodities. Similar results were obtained by other authors who analyzed the trading of agricultural products in derivatives markets and applied indicators related to the ratio of non-commercial and commercial positions, or the Working T index (Haase & Hus, 2018). Other authors have often observed that agricultural commodity returns better explain the volume of speculation in these markets (Etienne *et al.*, 2018; Wellenreuther & Voelzke, 2019). On the other hand, our study did not find such an effect. It is worth noting that the authors who determined the impact of speculation on returns mainly analyzed low-liquidity markets, such as orange juice and live cattle (Algieri & Leccadito, 2019).

Second, speculation has been found to either reduce or have no effect on the variability of returns. Other authors using GARCH methods also observed similar effects when speculation stabilized returns (Borgards & Scudaj, 2022; Etienne *et al.*, 2018). For example, such an effect was found when analyzing 2006–2017 data, especially for corn markets (Bohl & Sulewski, 2019). Other authors, after analyzing previous periods, also observed similar effects in 1995–2015 (Etienne *et al.*, 2018); 2006–2020 (Borgards & Scudaj, 2022). Positive (destabilizing) effects were identified mainly using the short-term speculation index using trade volume and open positions (Algieri & Leccadito, 2019). Our research showed that there was also a stabilizing effect on the butter market and the dairy market.

Finally, the analysis also made it possible to identify cases when there was more and when there was less speculation in these markets by analyzing the post-2020 period, when the markets are characterized by turmoil and panic. In terms of return standard deviation, all markets except for non-fat milk are more volatile during the post-2020 timeframe. In general, there is more speculation in the milk market. Similar degrees of speculation are seen in all three of the other markets throughout different time periods. Other authors found that increased speculation does not cause unrelated commodities to become correlated (Fan *et al*., 2022).

The study can be extended with data from recent periods since dairy markets are relatively new compared to other agricultural markets. The study could also use more speculation indicators if daily data were used, as in the works of other authors (Czudaj, 2019). The study could include more types of products, including energy products or metals, similar to the work of other authors, where a large set of products were studied (Wellenreuther & Voelzke, 2019). The research can also delve into the derivatives markets of other countries, for example, Euronext or EEX, or LIFFE, as shown by research done by other authors (Haase & Huss, 2018). Nonlinear Granger causality tests, continuous Granger causality tests, and more complex GARCH variants (EGARCH, EPGARCH, M-GARCH, and so on) can also be used in the research. These methods have already been applied by other authors, but this also includes other product markets (Palazzi *et al*., 2020; Ulusoy & Onbirler, 2017).

Dairy markets are exposed to many types of risk, and price risk in particular. Therefore, it is necessary to implement alternatives that enable the participants of these markets to hedge against price risks, including derivatives markets. The efficient and continuous operation of these markets must thus be ensured, and they must be liquid. Non-commercial market participants can provide more liquidity to these markets, and there is little evidence to suggest that more restrictions will have a positive effect.

Other authors examine what measures to take in derivatives markets to reduce harmful price volatility and stabilize product prices (Czudaj, 2019). A more effective solution would be to implement measures of a passive nature since the reduced volume of non-commercial positions would not reduce price volatility from this point of view. This opinion is also shared by other authors who have analyzed speculation in derivative financial markets (Bohl & Sulewksi, 2019).

Conclusions

In this work, we examine the volatility of four dairy commodities using GARCH models and the Granger causality test. The realized weekly returns on dairy futures from the CME are utilized. Time series are demonstrated to be stationary and volatile, allowing for further exogenous variable modeling utilizing GARCH techniques. Furthermore, our study analyzed post-2020 data on pandemic turmoil in these markets. For speculation measurement, this study used the Working T index for excessive speculation.

The research provided three major findings. First of all, most commodities became more volatile in terms of return volatility during the post-2020 time period. However, speculation increased only in the milk market. Overall, the milk market showed the highest return volatility and speculation mean values. Second, there is no evidence that speculation causes returns, nor is there a statistically significant reverse effect that returns from dairy futures are explained by speculation. And finally, speculation, in all cases where it has a statistically significant effect on volatility, reduces it, making prices potentially more stable.

The main limitations of the study are: (i) weekly data is used instead of daily data; (ii) different product futures have different time series lengths except for the post-2020 time frame; and (iii) only four dairy futures contracts were analyzed. In future research, the indicator of short-term speculation can be used to evaluate daily data and additional types of futures contracts, such as non-dairy agricultural, for comparison purposes.

The conclusions of our study have important policy implications. Futures commodity exchange regulators suggest limiting non-commercial ownership as well as other active measures to reduce financial speculation in order to increase price stability. Our findings, along with those of other researchers, show that financial speculation has little bearing on the level and volatility of agricultural market prices and that, occasionally, the opposite is true, with an increase in non-commercial holdings possibly being followed by less volatile pricing. We demonstrate, however, that non-commercial investments may assist in stabilizing the market or reducing volatility. Therefore, regulators must be cautious about implementing tools to make these dairy commodity markets more effective and open for dairy producers and manufacturers to hedge against price risks.

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Annex

Table 1. Descriptive statistics for the price, return, and speculation index of dairy commodities using full data

Variable	Butter	Milk	Cheese	Nonfat dry milk
Price				
Mean	210.030	15.492	1.753	114.870
Minimum	124.500	8.690	1.136	68.850
Maximum	321.070	25.160	2.588	205.000
Standard deviation	39.977	3.544	0.235	36.150
Standard deviation, percent	19.034	22.873	13.426	31.470
Skewness	0.346	0.299	0.807	0.964
Ex. kurtosis	-0.270	-0.390	0.798	-0.178
Return				
Mean	0.104	0.033	0.054	0.045
Minimum	-23.351	-41.764	-38.557	-25.561
Maximum	22.387	19.746	50.483	45.721
Standard deviation	4.065	4.215	4.154	3.923
Skewness	-0.451	-1.431	1.554	3.045
Ex. kurtosis	8.762	14.984	51.587	42.510
Speculation index – Working T				
Mean	1.055	1.141	1.115	1.075
Minimum	1.000	1.000	1.000	1.000
Maximum	1.283	1.891	1.365	1.371
Standard deviation	0.047	0.142	0.079	0.063
Skewness	1.777	1.660	1.012	1.655
Ex. kurtosis	5.683	3.486	0.234	3.732

Table 2. Descriptive statistics for the price, return, and speculation index of dairy commodities using post-2020 data

Variable	Butter	Milk	Cheese	Nonfat dry milk
Price				
Mean	206.760	19.330	1.887	133.670
Minimum	124.500	10.390	1.136	83.750
Maximum	321.070	25.160	2.588	187.300
Standard deviation	56.286	3.030	0.300	28.936
Standard deviation, percent	27.223	15.675	15.875	21.647
Skewness	0.611	-0.187	0.128	0.288
Ex. kurtosis	-1.059	-0.112	-0.118	-1.052
Return				
Mean	0.205	0.089	0.077	0.111
Minimum	-21.109	-41.764	-38.557	-25.561
Maximum	22.387	18.924	50.483	15.247
Standard deviation	4.765	5.926	6.640	3.709
Skewness	0.526	-2.050	1.306	-1.550
Ex. kurtosis	6.180	15.772	27.168	15.794
Speculation index – Working T				
Mean	1.017	1.180	1.078	1.042
Minimum	1.000	1.071	1.014	1.000
Maximum	1.068	1.423	1.151	1.134
Standard deviation	0.018	0.078	0.038	0.034
Skewness	0.846	0.977	0.171	0.885
Ex. kurtosis	-0.692	0.888	-1.117	-0.123

Table 3. Augmented Dickey-Fuller (ADF) test for time series stationarity results

Test type	**Butter**	**Milk**	**Cheese**	**Nonfat dry milk**
Using full data				
Price of commodity				
test with constant	0.1420	0.0012	0.0021	0.6082
with constant and trend	0.2999	<0.0001	0.0089	0.8539
Return of commodity				
test with constant	<0.0001	<0.0001	<0.0001	<0.0001
with constant and trend	<0.0001	<0.0001	<0.0001	<0.0001
Working T index of commodity				
test with constant	0.0114	0.0837	0.1047	0.0203
with constant and trend	0.0032	0.0166	0.1678	0.0329
Using post-2020 data				
Price of commodity				
test with constant	0.8215	0.0545	0.0556	0.7830
with constant and trend	0.2191	0.0818	0.0537	0.7761
Return of commodity				
test with constant	<0.0001	<0.0001	0.0009	<0.0001
with constant and trend	<0.0001	<0.0001	0.0060	<0.0001
Working T index of commodity				
test with constant	0.3779	0.0578	0.4478	0.2337
with constant and trend	0.4495	0.0694	0.4268	0.1079

Table 4. Estimates and p-values of Granger's causality test using full data

Hypotheses	p-value	Coefficient	Result
Butter			
Return (-1) is equal to zero	0.4906	<0.0001	
Return (-2) is equal to zero	0.6980	<0.0001	Accept h1
Return (-1) and (-2) are equal to zero	0.7364		
Speculation index (-1) is equal to zero	0.7512	-4.5809	
Speculation index (-2) is equal to zero	0.7438	4.7207	Accept h2
Speculation (-1) and (-2) are equal to zero	0.9479		
Milk			
Return (-1) is equal to zero	0.2089	-0.0003	
Return (-2) is equal to zero	0.6636	-0.0001	Accept h1
Return (-1) and (-2) are equal to zero	0.3988		
Speculation index (-1) is equal to zero	0.6477	1.3888	
Speculation index (-2) is equal to zero	0.7501	-0.9676	Accept h2
Speculation (-1) and (-2) are equal to zero	0.8138		
Cheese			
Return (-1) is equal to zero	0.5576	-0.0001	
Return (-2) is equal to zero	0.0721	0.0002	Accept h1
Return (-1) and (-2) are equal to zero	0.1674		
Speculation index (-1) is equal to zero	0.3516	15.2221	
Speculation index (-2) is equal to zero	0.3031	-16.8064	Accept h2
Speculation (-1) and (-2) are equal to zero	0.4749		
Nonfat dry milk			
Return (-1) is equal to zero	0.4654	-0.0001	
Return (-2) is equal to zero	0.7413	<0.0001	Accept h1
Return (-1) and (-2) are equal to zero	0.7251		
Speculation index (-1) is equal to zero	0.6622	-5.3063	
Speculation index (-2) is equal to zero	0.7675	3.5938	Accept h2
Speculation (-1) and (-2) are equal to zero	0.7815		

Table 5. Estimates and p-values of Granger's causality test using post-2020 data

Hypotheses	p-value	Coefficient	Result
Butter			
Return (-1) is equal to zero	0.9324	<-0.0001	
Return (-2) is equal to zero	0.2227	-0.0001	Accept h1
Return (-1) and (-2) are equal to zero	0.4734		
Speculation index (-1) is equal to zero	0.6555	25.9739	
Speculation index (-2) is equal to zero	0.8385	-11.8655	Accept h2
Speculation (-1) and (-2) are equal to zero	0.7612		
Milk			
Return (-1) is equal to zero	0.0604	<-0.0001	
Return (-2) is equal to zero	0.8921	<-0.0001	Accept h1
Return (-1) and (-2) are equal to zero	0.1623		
Speculation index (-1) is equal to zero	0.7532	4.4137	
Speculation index (-2) is equal to zero	0.9040	-1.6922	Accept h2
Speculation (-1) and (-2) are equal to zero	0.8880		
Cheese			
Return (-1) is equal to zero	0.4505	<0.0001	
Return (-2) is equal to zero	0.2528	0.0001	Accept h1
Return (-1) and (-2) are equal to zero	0.3802		
Speculation index (-1) is equal to zero	0.6258	33.0876	
Speculation index (-2) is equal to zero	0.6028	-35.2649	Accept h2
Speculation (-1) and (-2) are equal to zero	0.8686		
Nonfat dry milk			
Return (-1) is equal to zero	0.7996	<-0.0001	
Return (-2) is equal to zero	0.7898	<0.0001	Accept h1
Return (-1) and (-2) are equal to zero	0.9329		
Speculation index (-1) is equal to zero	0.5204	-14.2110	
Speculation index (-2) is equal to zero	0.3228	21.9594	Accept h2
Speculation (-1) and (-2) are equal to zero	0.4930		

Table 6. GARCH estimations for dairy commodity returns using full data

Time Period	Butter	Milk	Cheese	Nonfat dry milk
Mean equation:				
Constant	-0.0353	0.0210	0.1525	0.0824
Return	0.0207	0.0369	-0.1127*	0.0755
Variance equation:				
Constant	4.6817**	1.5626**	1.6094	4.1618
Residual	0.0324	0.0189*	0.0908**	0.0318
Volatility	0.9688**	0.9516**	0.9033**	0.8212**
Speculation index	-4.3729**	-0.8967**	-1.1682	-2.3350
Llik:	-1412.7	-3715.1	-1512.4	-1312.6
BIC:	2862.9	7473.3	3062.8	2662.3
AIC:	2837.4	7442.2	3036.8	2637.3
HQC:	2847.4	7453.8	3046.9	2647.1

Note: (*) shows p-values between 0.05 and 0.1; (**) shows p-values below 0.05.

Table 7. GARCH estimations for dairy commodity returns using post-2020 data

Time Period	Butter	Milk	Cheese	Nonfat dry milk
Mean equation:				
Constant	-0.1117	0.0276	-0.3676**	0.0539
Return	-0.1641**	0.0734	0.0456**	0.0045
Variance equation:				
Constant	-26.2293	-18.4345	229.6220**	24.4467
Residual	0.1821	0.0926	-0.0176**	0.1526
Volatility	0.7825**	0.7359**	0.2517	0.7868**
Speculation index	34.3482	20.3864	-189.6360**	-21.2055
Llik:	-430.0	-462.8	-446.2	-378.9
BIC:	895.4	961.0	927.8	-793.2
AIC:	874.1	939.6	906.4	771.8
HQC:	882.7	948.3	915.1	780.5

Note: (*) shows p-values between 0.05 and 0.1; (**) shows p-values below 0.05.

Figure 1. Price and speculation index for butter futures in Chicago Mercantile Exchange (CME) in years 2013–2022

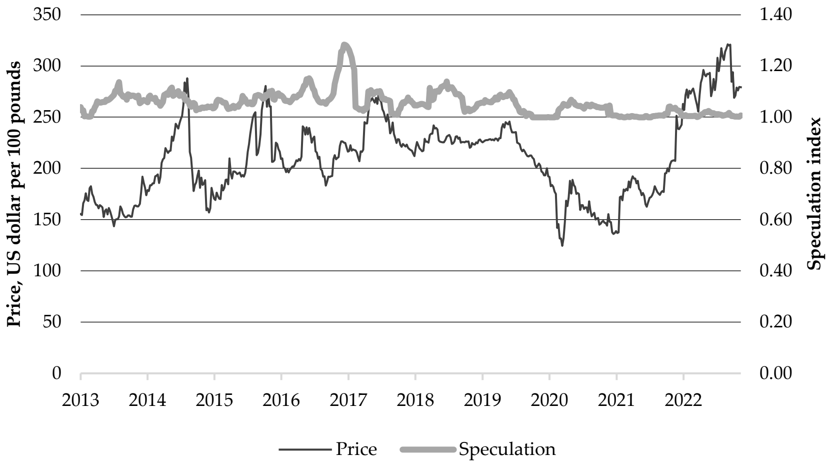

Figure 2. Price and speculation index for milk class III futures in CME in years 1997–2022

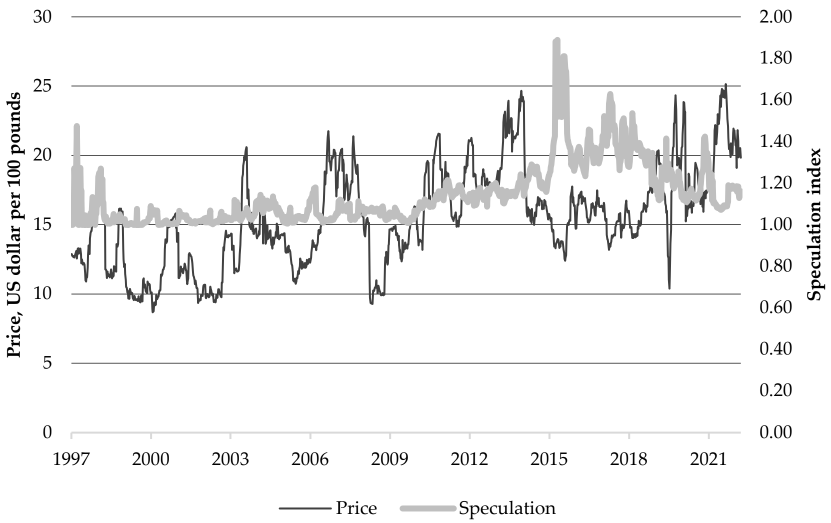

Figure 3. Price and speculation index for cheese futures in CME in years 2012–2022

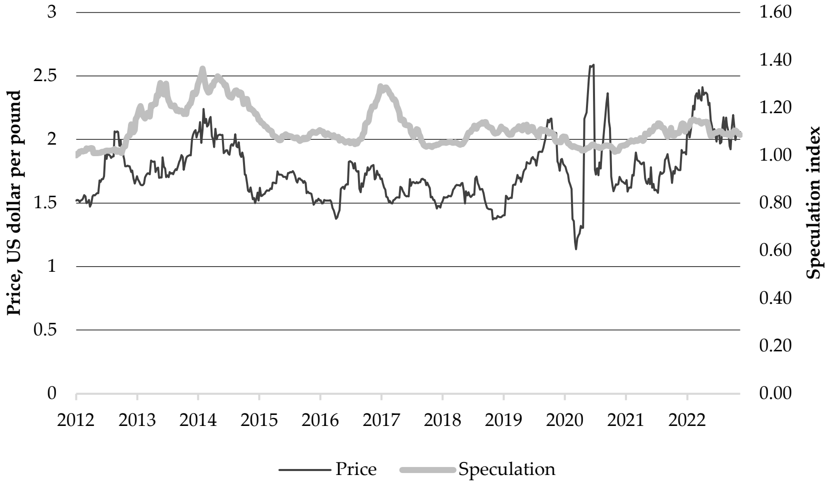

Figure 4. Price and speculation index for nonfat dry milk futures in CME in years 2013–2022