ISSN 2669-2481 / eISSN 2669-249X

VILNIUS TECH
Vilnius Gediminas Technical University

BUSINESS, MANAGEMENT AND ECONOMICS ENGINEERING

2025
Volume 23
Issue 2
Pages 302–315

https://doi.org/10.3846/bmee.2025.21568

EVALUATING THE FACTORS AFFECTING DAIRY COMMODITY RETURNS: THE CASE OF EUROPEAN DAIRY MARKETS

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Article History:
- received 21 May 2024
- accepted 06 March 2025

Abstract. *Purpose* – motivated by the price spikes and booms in major commodities markets around the world, this study looks into the factors that affect the variance in returns from dairy futures contracts. The purpose of the study is to determine whether dairy commodity prices – especially in times of economic turmoil – are being driven away from their fundamental value. The study focuses on European dairy futures markets, which are less studied by other authors in their research and are at a nascent stage of development in comparison to other agricultural commodity markets. The study includes various determinants such as energy prices, major stock indices, as well as market related variables such as financial speculation, in order to test whether returns from dairy commodities can be explained solely by macroeconomic factors or if this impact is amplified by trade volume or financial speculation within these markets. Therefore, the paper aims to assess the determinants of dairy futures prices before and after 2020, when the COVID-19 pandemic began and was followed by the war in Ukraine.

Research methodology – the authors analyse dairy commodities traded on the European Energy Exchange (EEX) and employ the generalised autoregressive conditional heteroskedasticity (GARCH) modelling, as well as the Augmented Dickey-Fuller (ADF) and Granger non-causality tests to analyse what drives the returns from dairy commodity futures and the direction of this impact. The study consists of two-time frames: before and after the COVID-19 pandemic.

Findings – an important finding from the study is that returns from dairy commodities are mostly explained by macroeconomic variables when analysing the post-2020 timeframe. Dairy commodities also experience asymmetric return volatility, showing that in dairy markets, negative returns are followed by reduced volatility. However, the role of trade volume or financial speculation on dairy commodity returns is found to be mixed or that it has an effect only on butter commodities when analysing 2020 and onward time period. Another important finding is that only returns from skimmed milk futures are significantly affected by seasonality.

Research limitations – the study uses only two dairy commodity types in the research, there is insufficient data on non-commercial positions from EEX.

Practical implications – as dairy commodities markets grow and attract more market activity, regulators should be more careful about geopolitical risks and financial speculation in European dairy futures markets.

Originality/Value – the study examines European dairy futures markets, which are relatively new compared to other commodity markets and have not received as much attention in other research.

Keywords: dairy commodities, dairy futures, financial speculation, return volatility.

JEL Classification: C58, G13, Q02.

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1. Introduction

Agricultural and agrobusiness risks, farmer income instability, and planning alternatives are among the factors causing the need for commodity futures markets for agricultural goods.

In the last two decades, a new market for financial products to hedge against market risks has emerged. Even though the European Energy Exchange (EEX) initially specialised in energy derivatives, since the mid-2000s it has offered a set of agricultural futures contracts such as potatoes, skimmed milk, butter, etc. This newly established dairy futures market is among the first of its kind in Europe, mainly operating in countries such as Germany, the Netherlands, and France. Dairy producers play an important role in the European Union, which is one of the world's leading dairy exporters, therefore offering a wide demand potential for these financial instruments. However, the European Energy Exchange (EEX) dairy futures market is relatively small compared to the New Zealand Exchange or the Chicago Mercantile of Exchange (Leung & Furfaro, 2020) and used to receive less attention from researchers due to the low liquidity of these instruments (Aschakulporn & Zhang, 2021).

Recent empirical research on commodity futures has extensively investigated futures-induced market volatility and price spikes (Li et al., 2022). Many events contributed to global commodity price volatility, including the COVID-19 pandemic, a surge in energy costs beginning in the late 2021s, and the conflict between Ukraine and Russia. This emphasises the need to examine the relationships between various commodity markets, as well as how and to what extent these characteristics show up in EU dairy product futures markets.

However, other groups of factors influencing commodity prices arise from their trading activities. Ever since 2008, Master's hypothesis has stated that the rise of speculation within commodity markets may have impacted commodity prices and driven them away from fundamental value and was further tested by many researchers (Li et al., 2022). Researchers are particularly interested in the influence of speculation on agricultural commodity prices, including price level, volatility, future spreads, and other market indicators, as well as how speculation interacts with financial markets and how to explain price bubbles (Haase & Huss, 2018). However, most of the research was done on the timeframes between the global financial crisis and pre-COVID-19, when markets were relatively stable and defined by relatively low geopolitical risks, uncertainties, etc. Academics dispute whether increased futures price volatility is generated by futures trading and financial speculation or by fundamental supply and demand dynamics and whether more restrictions on these markets are required (Conrad, 2023) such as restrictions on investment positions, an increase in transaction charges, and an enhancement of market transparency. Therefore, the aim of this study is to determine whether commodity prices – especially in times of economic turmoil – are being driven away from their fundamental value.

2. Literature review

Dairy products prices, similar to those of other commodities, are mainly determined by their fundamental supply and demand factors. Besides macroeconomic fundamentals such as interest rates, money supply, credit spread, growing demand from emerging economies, and exchange rates (Algieri, 2021), in the case of dairy products, factors such as energy prices, grain prices resulting in feed costs and weather effects (Fernandez-Perez et al., 2023), economic sanctions (Klomp, 2020), and EU policy for the dairy market (Olipra, 2020) also play a role.

Another important factor when analysing agricultural markets is seasonality. The authors who analysed these markets highlight that agricultural futures markets experience higher price fluctuations before the beginning of the harvest (da Silveira et al., 2017). However, there is insufficient research on how dairy products react to seasonality and whether all groups of dairy products react in a similar manner.

Contemporary research is looking into whether product-asset links lead to speculative co-movement across markets during extreme events (Yuan et al., 2020; Bohl et al., 2023). Another observation is that this co-movement has increased in recent times (Wang et al., 2020). The globalisation of commodity markets, often highlighted by other authors, results in commodity price patterns that often follow price patterns in other countries. Previous research argues that dairy products are a separate commodity category with little linkage to all commodities traded internationally (Koeman & Białkowski, 2015; Rezitis & Kastner, 2021). However, the latest research indicates that co-movement also affects dairy markets, albeit limited to US markets (Fan et al., 2024) or featuring pre-2020 data (Rezitis & Tremma, 2023).

Popular theories that model the main principles of how futures markets work are the storage cost model as well as the hedging pressure and behavioural theories. From a theoretical perspective, an alternative to using futures contracts is the physical storage of goods, which inevitably has its costs. Therefore, producers engaging in trade are often ready to pay a risk premium to the other side of the futures contract as long as it does not exceed the cost of physical storage for those goods. Therefore, factors such as interest rates also affect futures prices. The risk premium created by the discrepancies between long and short positions in futures markets attracts speculators who are neither producers nor manufacturers of these goods and are often called non-commercial market participants by other researchers (Bohl & Sulewski, 2019).

Many authors use the ratio of commercial to non-commercial as measured by the Working T index (Maria et al., 2020). However, data on commercial and non-commercial market participants is only available on the Chicago Board of Trade (CBOT) market. In other markets, as an alternative to speculation, trade volume to open interest (TV/OI) shows the overall intensity of market activity. This assumes that, during periods with high levels of uncertainty, market participants take a guess on whether expected prices for the underlying product will increase or decrease, therefore creating a space for speculators who attempt to profit from price movements alone. On the one hand, speculators offer new information to commodity markets. On the other hand, they have different motivations than farmers and producers who hedge against price risk, and their behaviour patterns may lead to commodity prices varying from their fundamental value.

Most previous studies have demonstrated that price and volatility explain speculative elements better than vice versa using causality tests or that this effect is statistically insignificant (Etienne et al., 2017; Leone et al., 2019; Lehecka, 2015; Wellenreuther & Voelzke, 2019). Many academics argue that derivative market speculation has no statistically significant impact on price volatility and, in fact, helps to stabilise the market (Haase & Huss, 2018; Bohl & Sulewski, 2019). However, some studies have revealed that speculative pressure may affect how prices are formed in agricultural commodities markets (Czudaj, 2019; Bandyopadhyay et al., 2020).

A number of methodologies are used to investigate the influence of speculative behavior and other factors on agricultural commodity prices, including causal testing, such as Granger causality tests (Maria et al., 2020; Leone et al., 2019), and price volatility models, such as GARCH (Algieri, 2021; Czudaj, 2019); stochastic volatility modeling (Czudaj, 2019); HAR models (Luo et al., 2022; Lu et al., 2019); VECM (Haase et al., 2019); and others.

Based on previous research on agricultural product markets, this study tests the following Hypotheses:

H1: *dairy commodity returns are affected by factors reflecting the global macroeconomic environment.*

H2: *dairy commodity return volatility is increased by financial speculation within these markets.*

H3: *Dairy commodity markets, similarly to other agricultural commodities, are exposed to seasonal variation in return volatility.*

3. Research methodology

We collected data on the two most liquid dairy futures contracts traded on the European Energy Exchange [EEX] (n.d.), skimmed milk and butter, from November 13, 2014, to March 1, 2024. The study employs two-time samples: a full sample and a time sample from January 1, 2020, to March 1, 2024 comprised of daily data from continuous futures contracts. The 2020 and onward time sample defines a period of economic turmoil: COVID-19 pandemic that was followed by war in Ukraine started in February 24, 2022.

The study uses standard time series analysis tools, such as summary statistics and the Augmented Dickey-Fueller test (ADF), to determine time series stationarity, and also the Granger non-causality test to estimate causal effects. The generalised autoregressive heteroscedasticity (GARCH) approach is then used to determine how various factors influence the mean and variance of returns from dairy futures contracts. The study also provides estimates for VAR-based return decomposition using Cholesky ordering in order to assess linkages and volatility transmission directions among selected products.

The dependent variable in this study is returns from futures contracts, which is calculated as the logarithmic difference between closing prices on two consecutive days. Similarly, to other authors' who analysed fundamental factors effects on returns from commodity futures contracts (Algieri, 2021; Fernandez-Perez et al., 2023), we select four key macroeconomic variables: the Standard and Poor's commodity index (GSC), the USD to EUR exchange rate (USD), the Bloomberg Euro government 30-year term bond index (GOV), and the Euro Stoxx 50 index (STX). The study also includes seasonality (months) and financial speculation as additional factors to explain return volatility. The financial speculation index (TV/OI) is calculated as the ratio of daily trade volume (TV) to the open interest of all outstanding futures contracts (OI).

The study analyses three cases: i) full sample data with seasonality; ii) full sample data without seasonality; iii) 2020 and onward sample without seasonality.

After providing summary statistics and ADF test results, we employ the Granger non-causality test. Here we test causality between returns (dependent variable), financial speculation, and other (independent) variables. Eqs. (1)–(2) show the model used to estimate Granger non-causality. Here we test hypothesis h_0: $\rho_j \neq 0$ and $\tau_j = 0$ in order to estimate causal relationship or that returns are better explained by time-lagged selected variable, then vice versa. We choose the number of lags according to the lowest information criteria values.

$$Y_t = \pi_0 + \sum_{j=1}^{i} \pi_j Y_{i-j} + \sum_{j=1}^{i} \rho_j X_{i-j} + u_t ; \tag{1}$$

$$X_t = \sigma_0 + \sum_{j=1}^{i} \sigma_j X_{i-j} + \sum_{j=1}^{i} \tau_j Y_{i-j} + h_t , \tag{2}$$

where Y_t is the dependent variable; X_t is the independent variable; t is the time; π, ρ, σ, τ are non-causality test parameters; i is the number of time lags; u_t and h_t are error terms.

The full threshold TGARCH model can be described in two Equations: mean Equations Eq. (3) and variance Equations Eq. (4). Multiplication between the season dummy variable (Dt) and financial speculation (St) assesses whether financial speculation amplifies return volatility during the most volatile month. In order to select the month in which returns are most volatile, a preliminary GARCH model is constructed with months as dummy variables placed in the variance Equation. We place macroeconomic variables in the mean equation to assess how they influence return levels, and we place speculation variables in the variance Equation to assess how speculation influences volatility of returns from dairy futures contracts.

$$R_t = \alpha_0 + \alpha_1 STX_{t-1} + \alpha_2 GSC_{t-1} + \alpha_3 USD_{t-1} + \alpha_4 GOV_{t-1} + \alpha_5 R_{t-1} + u_t ; \tag{3}$$

$$h_t^2 = \beta_0 + \beta_1 u_{t-1}^2 + \beta_2 h_{t-1}^2 + \beta_3 u_{t-1}^2 d_{t-1} + \beta_4 S_{t-1} + \beta_5 D_{t-1} + \beta_6 D_{t-1} S_{t-1} , \tag{4}$$

where R_t is returns from futures contracts; STX_t is logarithmized Stoox 50 index; GSC_t is logarithmized Standard and Poor's commodity index; USD_t is logarithmized USD/EUR foreign index; GOV_t is logarithmized Euro government bond index; α_0, α_1, α_2, α_3, α_4, α_5 are model's mean equation parameters; u_t is an error term that has a variance of h_t^2; h_t^2 is the conditional variance of an error term; u_t^2 is the residual effect (alpha); h_t^2 is the variance effect (beta); d_t is the asymmetric component (d_t = 1 if u_t < 0 and d_t = 0 otherwise) (gamma); D_t is the season effect (D_t = 1 if most volatile month and D_t = 0 otherwise); S_t is the effect of financial speculation; t is the time period; β_0, β_1, β_2, β_3, β_4, β_5, β_6 are model's variance Equation parameters.

We investigate each case using two approaches: TGARCH and GARCH. The difference between the two models is that GARCH does not include the gamma variable, which indicates if there is an asymmetry in returns and conditional volatility or that negative returns from previous periods increase conditional volatility. We analyse and select models using three information criteria: the Akaike information criterion (AIC), the Bayesian information criterion (BIC), and the Hannan-Quinn (HQC). Models with low information criteria values are preferred.

4. Results and discussion

We begin our investigation by presenting summary statistics (Table 1). When full sample data is analysed, we can find that skimmed milk (SM) and butter (B) have similar degrees of price volatility, as indicated by the standard deviation (SD) compared to the mean value (28.69%

and 28.36%). However, if we look at post-2020 data, we can observe that butter has higher levels of price volatility (26.90% to 21.59%). The average price for both dairy commodities increases in 2020 and onward. The mean of financial speculation is similar for both products. However, the mean financial speculation of skimmed milk increases after 2020.

Table 1. Summary statistics (source: author's calculations using EEX, (n.d. data)

Variable	Mean	Min.	Max.	SD	SD%	Skewness	Kurtosis
Full sample							
Price SM	2242.00	1244.00	4288.00	643.26	28.69	1.15	0.96
Spec. SM	0.04	0.00	0.86	0.05	121.90	5.71	57.54
Return SM	0.01	–16.00	11.92	1.27	9480.25	–0.49	19.25
Price B	4411.00	2365.00	7525.00	1251.00	28.36	0.62	-0.34
Spec. B	0.04	0.00	0.42	0.03	90.77	3.21	22.32
Return B	0.03	–12.81	10.25	1.36	4568.26	–0.33	15.05
Year 2020 and after							
Price SM	2751.40	1826.00	4288.00	594.01	21.59	0.95	–0.21
Spec. SM	0.05	0.00	0.26	0.03	60.33	2.43	11.86
Return SM	0.00	–16.00	11.92	1.27	54860.36	–1.60	34.69
Price B	4828.90	2725.00	7525.00	1299.10	26.90	0.52	-0.78
Spec. B	0.04	0.00	0.27	0.03	59.29	2.75	16.75
Return B	0.04	–11.86	10.17	1.29	2932.15	–0.45	20.54

Next, we test the stationarity of time series (Table 2). Here we can see that all variables except for price have p-values below 0,05, thus no indications for unit root can be observed. Therefore, we use returns from futures contracts instead of absolute prices for further Granger non-causality and GARCH analysis.

Table 2. ADF test results (source: author's calculations using EEX, (n.d. data)

Name	Spec. SM	Return SM	Price SM	Spec. B	Return B	Price B
Full sample						
with constant	0.0000	0.0000	0.5222	0.0000	0.0000	0.3210
with constant and trend	0.0000	0.0000	0.6379	0.0000	0.0000	0.4464
Year 2020 and after						
with constant	0.0002	0.0000	0.7353	0.0000	0.0000	0.7386
with constant and trend	0.0000	0.0000	0.9689	0.0000	0.0000	0.8964

Next, we show graphs illustrating the dynamics of returns and financial speculation for skimmed milk (Figure 1). It can be observed that prior to 2020, financial speculation is more volatile.

Looking at the returns and financial speculation dynamics for butter, we can also observe that prior to 2020, financial speculation is more volatile (see Figure 2).

Next, we provide results from the Granger non-causality test (Table 3). Based on the lowest information criteria values, for all models, 1 day lag is used, except for speculation using

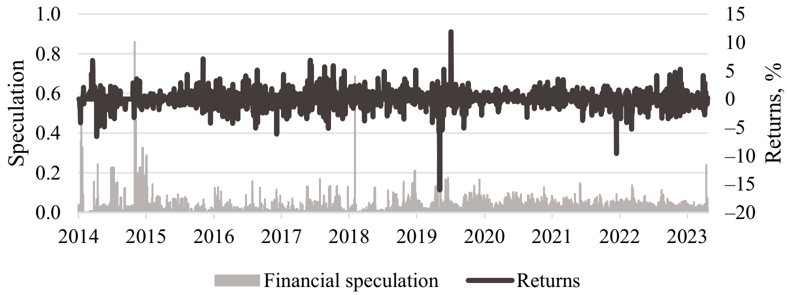

Figure 1. Dynamics of skimmed milk futures contracts financial speculation and returns (source: author's calculations using EEX, (n.d. data)

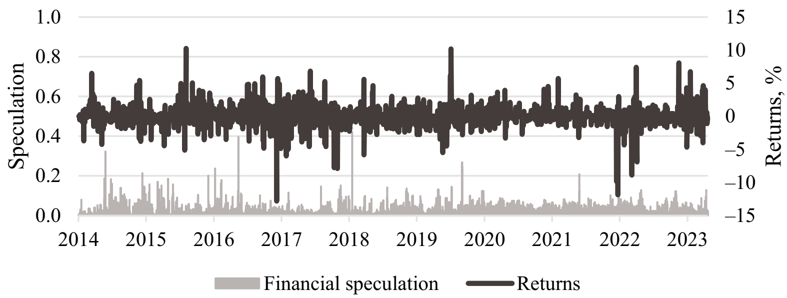

Figure 2. Dynamics of butter futures contracts financial speculation and returns (source: author's calculations using EEX, (n.d. data)

Table 3. Granger non-causality test results

Variable	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
	Butter				Skimmed milk			
	Full sample		Year 2020 and after		Full sample		Year 2020 and after	
Using GSC and returns from futures contracts:								
GSC	0.02	0.85	0.11	0.48	–0.01	0.95	0.03	0.84
Return	0.00	0.43	0.00	0.82	0.00	0.04	0.00	0.05
Using GOV and returns from futures contracts:								
GOV	0.30	0.13	0.34	0.11	0.48	0.01	0.40	0.05
Return	0.00	0.65	0.00	1.00	0.00	0.47	0.00	0.50
Using STX and returns from futures contracts:								
STX	0.07	0.76	0.45	0.16	–0.01	0.95	0.49	0.12
Return	0.00	0.27	0.00	0.16	0.00	1.00	0.00	0.73
Using USD and returns from futures contracts:								
USD	1.00	0.08	1.63	0.02	1.14	0.03	1.56	0.03
Return	0.00	0.56	0.00	1.00	0.00	0.52	0.00	0.00
Using speculation and returns from futures contracts:								
Spec.	–0.81	0.29	–1.89	0.22	0.18	0.93	–0.16	0.91
Return	0.00	0.25	0.00	0.09	0.49	0.00	0.00	0.18

a full-time sample: 3 for skimmed milk and 2 for butter. Here, after testing all 5 variables that explain returns, it can be observed that for butter futures, most p-values are above 0.05. Only USD is estimated to have a p-value less than 0.05 when analysing data from 2020 and onward. Thus, these results reject that USD does not cause returns but accept that returns do not cause USD. When analysing skimmed milk futures, there are more cases when p-values are below 0,05. It can be concluded that from analysed factors, GOV and USD most often have statistically significant causal effects on returns. For speculation in skimmed milk futures markets using full sample data, an opposite hypothesis can be accepted that speculation actually follows returns.

Next, we employ the GARCH and TGARCH models to analyse the full sample data (Table 4). Here, both commodities have lower information criteria values in the GARCH model. Thus, we selected the GARCH model to explain relationships between variables. Only the government bond index can explain returns from skimmed futures contracts (p-value below 0.05) and a positive coefficient value (0.75). Even though time series show volatility clustering (beta and alpha are statistically significant), financial speculation is statistically insignificant and shows that there is insufficient evidence for the impact of financial speculation on dairy futures contract returns.

Table 4. TGARCH and GARCH modelling results for full sample data (source: author's calculations using EEX, (n.d. data)

Variable	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
	TGARCH				GARCH			
	Skimmed milk		Butter		Skimmed milk		Butter	
Mean equation								
Const.	–6.72	0.00	–3.78	0.00	–3.35	0.16	–2.64	0.18
GOV (–1)	1.45	0.00	–0.17	0.00	0.75	0.00	0.18	0.38
STX (–1)	–0.29	0.10	0.46	0.00	–0.22	0.50	0.04	0.87
USD (–1)	–3.03	0.00	1.82	0.00	–0.14	0.86	0.90	0.17
GSC (–1)	0.16	0.09	0.13	0.00	0.14	0.42	0.19	0.11
AR (–1)	–0.07	0.00	–0.03	0.00	–0.07	0.01	–0.03	0.33
Variance equation								
Const.	0.02	0.00	0.15	0.08	0.03	0.07	0.17	0.10
Spec. (–1)	–0.03	0.01	–0.91	0.09	–0.15	0.15	–1.44	0.10
Alpha	0.05	0.00	0.08	0.00	0.04	0.04	0.06	0.03
Beta	0.95	0.00	0.89	0.00	0.95	0.00	0.87	0.00
Gamma	0.15	0.00	–0.09	0.67				
Information criteria								
Abbrevation	Value	Is lower	Value	Is lower	Value	Is lower	Value	Is lower
AIC	7585	no	7943	no	7566	yes	7932	yes
BIC	7648	no	8006	no	7623	yes	7990	yes
HQC	7608	no	7966	no	7587	yes	7953	yes

Table 5. TGARCH and GARCH modeling results for 2020 and onward time frame (source: author's calculations using EEX, (n.d. data)

Variable	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
	TGARCH				GARCH			
	Skimmed milk		Butter		Skimmed milk		Butter	
Mean equation								
Const.	–26.55	0.00	–19.25	0.00	–18.81	0.00	–7.91	0.16
GOV (–1)	1.65	0.00	1.31	0.00	1.33	0.01	0.21	0.85
STX (–1)	1.32	0.00	0.84	0.00	1.44	0.04	0.41	0.48
USD (–1)	0.65	0.00	1.27	0.01	–1.34	0.53	2.16	0.63
GSC (–1)	0.93	0.00	0.71	0.00	–0.12	0.73	0.49	0.13
AR (–1)	0.02	0.00	0.04	0.27	–0.04	0.30	–0.02	0.76
Variance equation								
Const.	0.27	0.04	0.09	0.00	0.04	0.09	0.23	0.80
Spec. (–1)	–1.19	0.33	0.53	0.00	–0.44	0.17	–0.06	0.99
Alpha	0.33	0.00	0.14	0.00	0.05	0.22	0.15	0.68
Beta	0.65	0.00	0.84	0.00	0.94	0.00	0.73	0.34
Gamma	–0.20	0.26	–0.55	0.00				
Information criteria								
Abbrevation	Value	Is lower	Value	Is lower	Value	Is lower	Value	Is lower
AIC	3301	yes	3367	yes	3331	no	3425	no
BIC	3356	yes	3422	yes	3381	no	3475	no
HQC	3322	yes	3388	yes	3350	no	3444	no

When evaluating 2020 and onward data, the TGARCH model displays lower p-values than the GARCH model for both commodities (Table 5). In this scenario, all four macroeconomic variables have a statistically significant and positive impact on dairy futures returns. As a result, increases in commodity prices (including energy costs), the USD-EUR rate, the Euro stock index, and reductions in interest rates all increase returns on dairy futures contracts. Only butter futures contracts show a statistically significant influence from financial speculation. The TGARCH model also features a gamma coefficient that is also negative, indicating that negative returns result in lower conditional volatility.

Next, to investigate seasonality affecting volatility of returns from dairy futures contracts, we examine the preliminary GARCH model for 11 months, excluding December, to avoid multicollinearity (Table 6). The results from this model show that butter futures contracts experience the most volatile returns in October (coefficient value is positive and highest among all other months (0.0605)). Skimmed milk volatility tends to be highest in October (coefficient value is 0.0780), and this effect, unlike for butter futures contracts, is statistically significant (p-value is less than 0.5). In summary, H3 can be partially accepted when analysing skimmed milk data.

Next, we analyse the full sample data, including seasonality variables (Table 7). The GARCH model yields lower information values for skimmed milk, while TGARCH gives lower infor-

Table 6. GARCH variance equation results for the test for seasonality (source: author's calculations using EEX, (n.d. data)

Month	Coefficient	p-value	Coefficient	p-value
	Skimmed milk		Butter	
January	0.0605	0.0000	–0.0127	0.9125
February	–0.0336	0.0000	–0.1019	0.2681
March	0.0536	0.0000	–0.0439	0.6499
April	–0.0038	0.6525	–0.1095	0.2361
May	0.0176	0.0044	–0.0535	0.5777
June	0.0319	0.0000	–0.0927	0.3167
July	–0.0170	0.0040	–0.0925	0.3341
August	0.0776	0.0000	–0.0651	0.4821
September	–0.0264	0.0084	0.0158	0.8892
October	0.0780	0.0000	0.0605	0.5879
November	–0.0354	0.0000	–0.1534	0.2866

Table 7. TGARCH and GARCH modelling results for full sample data, including seasonality (source: author's calculations using EEX, (n.d. data)

Variable	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
	TGARCH				GARCH			
	Skimmed milk		Butter		Skimmed milk		Butter	
Mean equation								
const	–6.96	0.00	–8.58	0.00	–3.38	0.14	–2.55	0.25
GOV (–1)	1.47	0.00	0.22	0.15	0.79	0.00	0.19	0.37
STX (–1)	–0.24	0.00	0.73	0.00	–0.27	0.39	0.00	0.99
USD (–1)	–2.90	0.00	0.19	0.58	–0.17	0.81	0.78	0.23
GSC (–1)	0.12	0.00	0.20	0.09	0.17	0.27	0.23	0.06
AR (–1)	–0.07	0.03	–0.02	0.31	–0.07	0.01	–0.02	0.37
Variance equation								
Const.	0.02	0.30	0.11	0.00	0.03	0.07	0.14	0.27
Oct. (–1)	0.03	0.57	0.27	0.00	0.15	0.14	0.51	0.19
Spec. (–1)	0.00	0.96	–0.46	0.00	–0.14	0.24	–1.01	0.37
Oct. X Spec.	–0.57	0.32	–4.57	0.00	–1.63	0.07	–8.35	0.12
Alpha	0.05	0.09	0.08	0.00	0.05	0.02	0.07	0.06
Beta	0.95	0.00	0.90	0.00	0.94	0.00	0.87	0.00
Gamma	0.14	0.38	–0.29	0.00				
Information criteria								
Abbrevation	Value	Is lower	Value	Is lower	Value	Is lower	Value	Is lower
AIC	7582	no	7871	yes	7540	yes	7876	no
BIC	7657	no	7946	no	7609	yes	7945	yes
HQC	7609	no	7898	yes	7565	yes	7901	no

mation values for butter. For skimmed milk, the government bond index significantly affects returns (coefficient = 0.79, p-value < 0.05). Although skimmed milk time series data demonstrate volatility clustering (beta and alpha are statistically significant), financial speculation has no statistically significant effect on returns. Seasonality parameters have lower p-values but are greater than 0.05. Therefore, there is insufficient evidence to suggest that financial speculation amplifies returns from skimmed milk commodities during October. Next, we examine the butter futures contract using the TGARCH model. Here, the Euro stock index has a statistically significant and positive effect on returns (coefficient = 0.73, p-value < 0.05). All the variables in the variance equation are statistically significant. Financial speculation reduces butter returns (coefficient = –0.46, p-value < 0.05), and this effect is even amplified during October (coefficient = –4.57, p-value < 0.05).

Next, we provide results from forecasting variance decomposition (Table 8). The parameter matrix reveals that the past variance explains more than 95% of the return variance for both dairy commodities. However, returns from skimmed milk can explain about 3.4% of the skimmed milk return variance, while butter explains only 0.83% of the skimmed milk variance. This linkage becomes even stronger during 2020 and after (9.54% and 0.12%) and is stronger than the effects from macroeconomic variables used in the study. It can be concluded that returns from butter futures contracts follow skimmed milk returns better than vice versa. The total spillover between variables is estimated to be 2.53% when analysing full sample data and 5.17 when analysing the post-2020 time frame.

Table 8. Variance decomposition of forecast errors (source: author's calculations using EEX, (n.d. data)

Variable	Return SM	Return B	GSC	GOV	STX	USD	To others
Full sample							
Return SM	99.1684	0.8302	0.0002	0.0005	0.0001	0.0007	0.8316
Return B	3.4552	96.5438	0.0001	0.0001	0.0000	0.0008	3.4562
GSC	0.3311	0.0110	99.6554	0.0003	0.0022	0.0000	0.3446
GOV	0.2369	0.0246	0.7008	99.0359	0.0005	0.0013	0.9641
STX	0.2113	0.2151	8.2774	0.0345	91.2616	0.0000	8.7384
USD	0.0064	0.0031	0.5660	0.2405	0.0488	99.1353	0.8647
To others	4.2409	1.0840	9.5445	0.2759	0.0516	0.0028	15.1997
Including own	103.4093	97.6278	109.1999	99.3118	91.3132	99.1381	2.5333
2020 and after							
Return SM	99.7812	0.1201	0.0043	0.0208	0.0724	0.0012	0.2188
Return B	9.5385	90.4152	0.0128	0.0043	0.0133	0.0158	9.5848
GSC	1.6837	0.1066	98.1305	0.0080	0.0706	0.0006	1.8695
GOV	0.3713	0.0010	0.8288	98.7051	0.0782	0.0156	1.2949
STX	1.1502	0.5670	9.2068	0.0574	88.9640	0.0546	11.0360
USD	0.7202	0.1426	0.2037	0.2740	5.6537	93.0059	6.9941
To others	13.4639	0.9373	10.2564	0.3645	5.8882	0.0878	30.9981
Including own	113.2451	91.3525	108.3869	99.0696	94.8522	93.0937	5.1664

The study on the return of dairy futures contracts and its determinants made it possible to achieve several findings. First of all, speculation is observed to have an impact on return volatility in butter futures contracts only. In addition, Granger non-causality test results show that financial speculation is explained by returns better than vice versa. Thus, the speculation effect can be limited to return volatility but not the level of returns. Thus, we can only partially accept Hypothesis H2. This is similar to other authors findings who analysed agricultural futures markets (Haase & Huss, 2018). For example, Bohl and Sulewski (2019) found that in the corn market, this impact is statistically significant and negative. However, in some cases, other authors who used short-term speculation indicators found a destabilising relationship (Czudaj, 2019; Bandyopadhyay et al., 2020). Another finding is that our study also used the TGARCH model and allowed us to assess negative gamma coefficients, which indicate that negative returns on dairy futures contracts in most cases are followed by less volatile returns than vice versa. This is similar to the findings of other authors; for example, da Silveira et al. (2017) also found a negative gamma parameter when analysing data for soybeans and corn traded in the Chicago Mercantile Exchange. And finally, besides the fact that macroeconomic factors play an important role in daily volatility returns, the 2020 and after time frame shows higher return volatility and volatility spillovers within these dairy futures contracts. Thus, we accept Hypothesis H1. This is similar to other authors, such as Fan et al. (2024), who discovered that the COVID-19 pandemic amplifies dairy volatility and spillover effects, but their research is limited to US markets.

5. Conclusions

The research investigates whether commodity prices – especially in times of economic turmoil – are being driven away from their fundamental value. The study has three important findings. First, macroeconomic variables such as dairy commodity prices are influenced by selected macroeconomic factors, but mostly when analysing the post-2020 timeframe. Second, seasonality plays an important role in skimmed milk futures contracts but not in butter contracts. It was observed that returns increased in October. Finally, financial speculation has a statistically significant effect on return volatility, but only when analysing butter futures contracts. Other notable findings: skimmed milk and butter are linked together more than the selected macroeconomic factors, but returns from skimmed milk futures contracts explain butter returns better than vice versa.

Our study's results have important policy implications. As commodity markets grow and establish more, regulators should be more cautious about growing risks, including geopolitical risks and financial speculation, that may become more visible in European dairy futures markets as these markets grow in size and attract more market activity.

The main limitations of the study are: (i) there is no information on non-commercial positions available; therefore, the only metric for financial speculation is the trade volume to open interest ratio; (ii) the time period used in the study is relatively short and most relationships between returns and macroeconomic factors were discovered while analysing the post-2020-time frame; and (iii) only two dairy futures contracts are analysed. Future research could incorporate additional types of futures contracts, such as non-dairy agricultural ones, to facilitate comparisons between different commodity groups.

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