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Volatility Dynamics and Interdependencies in US Grain Commodity Futures: Evidence from CCC EGARCH Modeling

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ABSTRACT

This study employs the CCC EGARCH model with a t-distribution to analyze volatility dynamics and interdependencies among US grain commodity futures, focusing on wheat, corn, soybeans, and oats. Significant volatility spillovers and conditional correlations are identified, with oats serving as a critical transmitter of volatility. The analysis reveals persistent shocks and leverage effects, particularly in wheat and oats, underscoring the necessity for robust risk management strategies. This research provides food policy-relevant insights, offering strategic recommendations for policymakers to enhance market stability and resilience. By elucidating the interconnectedness of grain futures markets, this study informs commodity market stakeholders, including investors, policymakers, and industry practitioners, enabling them to navigate complex market dynamics and make informed decisions to improve food security and economic stability

Keywords: Volatility Dynamics, CCC EGARCH, Grain Commodity Futures

JEL Classification Codes: C32, G15, Q14

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INTRODUCTION

Commodities traded in agricultural markets, much like financial instruments, are influenced by various factors such as exchange rate fluctuations, shifts in global supply and demand, climate variability, and governmental policies (Özer & Yarbaşı, 2023). Significant volatility in agricultural markets poses challenges for price forecasting and creates a high-risk environment for producers, traders, consumers, investors, and policymakers. The early 2000s saw substantial economic growth in populous nations like India and China, which increased demand for oil and agricultural commodities, leading to a boom-bust cycle across various commodities in 2007-2008 (Cheng & Xiong, 2014). This period was marked by intensified price volatility in many commodities. The grain commodity futures market is recognized for its complexity and dynamism, driven by multifaceted factors. In recent years, notably from 2006 to 2010, there have been significant deviations from price averages in grain commodities, prompting revisions in government-led price stabilization programs that have garnered attention from policymakers, especially in emerging economies.

As one of the world's largest food producers, the United States maintains extensive food trade relationships with other nations, playing a pivotal role in global grain commodity price formation (Triantafyllou et al., 2015). The maturity of the US grain futures market reinforces its influence and prominence in global agricultural markets. Moreover, the grain commodity futures market serves a crucial role in protecting investors from financial risks (Lawson et al., 2021), which is essential for maintaining market integrity, bolstering investor confidence, and ensuring overall market stability. However, recent studies highlight growing concerns over the volatility of US grain commodity futures prices (Mei & Xie, 2022). These studies suggest that the futures market may be deviating from the ideal of a perfectly competitive market that accurately reflects global supply-demand dynamics and price expectations. Therefore, understanding and managing price volatility in the US grain commodity futures market is increasingly relevant for policymakers and market participants.

This study is motivated by three interrelated considerations. First, the U.S. grain futures market plays a pivotal role in global price discovery and risk

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transfer, making volatility dynamics within this market highly relevant for international food security. Second, due to limited arable land and strong substitution effects among grains, volatility shocks affecting one grain commodity are likely to transmit to others. Third, while major grains have been extensively examined, the role of relatively smaller grain markets such as oats in volatility transmission remains underexplored. These considerations jointly motivate a comprehensive multivariate analysis of volatility interdependencies among wheat, corn, soybeans, and oats.

The limited availability of arable land for crop production suggests that shocks affecting cereal crops are likely to transmit to other crops and subsequently impact food prices. Volatility in agricultural commodity markets reflects fluctuations in supply and demand dynamics, alongside external influences such as weather patterns, geopolitical tensions, and trade policies. Monitoring volatility in futures markets is crucial for market participants to gauge sentiment, predict price movements, and make informed decisions. It plays a pivotal role in price discovery by incorporating new information and market expectations about future conditions (Mensi et al., 2021). High volatility signals increased uncertainty and risk, prompting adjustments in trading strategies and positions among market participants. The US, as a major player in global grain markets, attracts significant international attention to its grain commodity futures (Mei & Xie, 2022). Volatility in these markets can spill over to international prices, impacting food security, trade flows, and economic stability in other countries.

Amidst the evolving challenges and developments in the grain commodity futures market, concerns about its competitiveness prompt ongoing efforts to strengthen regulatory oversight, enhance transparency, and safeguard investor interests. Preserving market integrity, bolstering investor confidence, and ensuring overall market stability are paramount goals (Li et al., 2018). Continuous vigilance from regulators, market participants, and stakeholders is essential to monitor market dynamics and address emerging issues effectively. Volatility presents significant challenges for risk management, amplifying uncertainty and the potential for substantial losses (Ahumada & Cornejo, 2016). Market participants may face difficulties in hedging positions or managing exposure to price fluctuations, especially in volatile conditions, thereby heightening risk and potentially destabilizing the market. While volatility is inherent in financial markets, excessive or unforeseen volatility can disrupt market efficiency and pose substantial challenges for all involved. Proactive management of volatility and maintenance of orderly market conditions necessitate robust oversight, effective risk mitigation strategies, and prompt interventions to mitigate systemic risks and sustain market stability.

Despite the growing body of literature on volatility dynamics in agricultural commodity futures, existing studies predominantly focus on major grains such as corn and wheat, often treating other grains as secondary or passive markets. In particular, oats futures are often excluded from multivariate volatility frameworks or analyzed as peripheral assets, despite their growing relevance in food supply chains and futures trading. This study addresses this gap by explicitly examining the volatility transmission role of oats within the U.S. grain futures market. By identifying oats as an active volatility transmitter rather than a passive receiver, the study provides novel evidence that challenges the conventional corn-centered perspective prevailing in the literature.

This study examines volatility interaction and dispersion among wheat, corn, soybeans, and oats in US grain commodity futures. By analyzing volatility spillovers across these markets, this study explores their interconnectedness and identifies potential arbitrage opportunities and channels for information transmission. These insights are critical for developing effective food policies and risk management strategies. The findings demonstrate that volatility in a one-grain commodity market can significantly impact others, influencing global food prices and economic stability. Policymakers can leverage these insights to enhance regulatory frameworks, improve market transparency, and safeguard investor interests, ultimately contributing to food security and market resilience. Understanding and managing price volatility in the US grain commodity futures market is increasingly pertinent for policymakers and market participants. The insights gained from this study can inform food policy decisions, enhance market stability, and improve risk management practices. By identifying volatility spillovers and conditional correlations, particularly with oats as a key transmitter, this research highlights the need for strategic interventions to mitigate the impact of market fluctuations on food prices and food security. These findings are crucial for policymakers developing robust agricultural policies that ensure market resilience and economic stability.

In the following sections of the study, after briefly touching on the previous studies, the methodology of the application method of the study is mentioned in the second section. The third section provides information about the sample period and basic statistics. In the fourth section, empirical findings are mentioned. After the Suggestions and Inferences are given in the fifth chapter, the study is concluded in the sixth section.

Related Literature

The literature on agricultural commodity futures volatility can be broadly classified into three strands. The first strand focuses on the dynamics of volatility and spillover effects among major agricultural commodities, particularly corn and wheat. The second strandexamines the interaction between agricultural commodities and external markets such as energy or financial assets. The third strand employs multivariate GARCH-type models to capture volatility interdependencies across commodity markets. While these studies provide valuable insights, they largely overlook the role of minor grain commodities and rarely assess their potential influence as volatility transmitters. This study contributes to the literature by bridging this gap through a focused examination of oats within a multivariate volatility framework.

This section reviews studies on grain products, emphasizing applications like volatility spillover and interaction. Research on agricultural products frequently focuses on corn, but other significant products have also been explored. For instance, Mei and Xie (2022) investigate wheat, corn, and soybeans, demonstrating that trade policy uncertainty affects agricultural commodity prices. Sanders et al. (2010) discuss the influence of long-term index funds in markets typically dominated by short-term hedging, while Sanders and Irwin (2011) do not find Granger causality between the commodity index and selected grain futures indices, although they present limited evidence of index-driven price bubbles. Tadesse et al. (2014) explore reasons behind increases and volatility in international food prices. Özer and Yarbaşı (2023) identify persistent regime structures in the price volatility of wheat, corn, oats, and soybeans.

In further research, Xiarchos and Burnett (2018) examine volatility spillover among crude oil, ethanol, and corn futures prices, noting significant increases in volatility spillover across these markets. Staugaitis and Vaznonis (2022) analyze return volatility in agricultural commodity prices, considering the impact of crude oil and gold prices along with wheat, corn, soybean, and oat futures. Their study, employing the TGARCH model, suggests that financial speculations do not significantly impact oats. Iorgulescu et al. (2022) find no evidence affecting grain price volatility in early futures markets.

Regarding bubble assets in agricultural commodity prices, Martins (2024) investigates the short-term effects of the Black Sea grain initiative on four grain markets, highlighting global food security implications due to the Russia-Ukraine conflict. Contrary to this, Goyal and Steinbach (2023) argue that the Black Sea grain initiative may not be crucial in reducing grain commodity prices. Hilliard et al. (2023) reveal that Black Sea wheat futures and Kansas wheat futures exhibit long-term co-movement, while Polat et al. (2023) report significant increases in wheat volatility due to geopolitical risks associated with Russia's invasion of Ukraine.

METHODOLOGY

The data for this study comprises daily closing prices of four U.S. grain commodity futures: wheat, corn, soybeans, and oats. These commodities are traded on the Chicago Board of Trade (CBOT), and the data spans from January 3, 2012, to April 30, 2024. The selection of this period allows for an extensive analysis of volatility and interdependencies across different market conditions, including pre- and post-financial crisis periods.

Daily price data was sourced from the Investing database, ensuring consistency and reliability. Prices were adjusted for any splits or dividends to maintain accuracy. The continuous series of futures contracts was constructed by rolling over the nearest contracts to avoid expiration effects.

Constant Conditional Correlation (CCC) GARCH Model

Although wheat, corn, soybeans, and oats are traded on the same exchange, each contract represents a distinct commodity market with heterogeneous supply and demand structures, production cycles, and risk characteristics. Therefore, volatility spillovers examined in this study reflect cross-commodity transmission mechanisms rather than intra-market volatility persistence.

In this study, we employed the CCC EGARCH model to analyze the volatility dynamics and interdependencies among U.S. grain commodity futures. This model was selected due to its ability to capture time-varying volatility and its flexibility in modeling asymmetric effects of shocks on volatility. Unlike traditional GARCH models, the EGARCH model does not require non-negativity constraints on the parameters, allowing for a more nuanced representation of volatility dynamics.

Additionally, the CCC component ensures that the conditional correlations remain constant over time, simplifying the estimation process while still providing valuable insights into the interdependencies among the commodities. The CCC EGARCH model was preferred over other multivariate models, such as Dynamic Conditional Correlation GARCH model, due to its computational efficiency and interpretability. This choice enables a focused analysis on volatility transmission mechanisms without the added complexity of time-varying correlations, which can be computationally intensive and may obscure the primary volatility spillover effects under investigation.

The estimation process involves fitting univariate EGARCH models to each series, followed by the application of the CCC framework to capture the constant conditional correlations. The conditional variance equations for each commodity are specified as:

$$log(h_{it}) = \omega_i + \sum_{l=1}^{r} \alpha_{il}\left(\frac{\varepsilon_{it-l}}{\sqrt{h_{it-1}}}\right) + \sum_{l=t}^{s} \beta_{il}\, log(h_{it-l}) + \gamma_i\left(\frac{\varepsilon_{it-l}}{\sqrt{h_{it-l}}} - \theta_i\right) \quad (1)$$

where h_{it}, represents the conditional variance, ε_{it} , is the return shock, and $\omega_i, \alpha_{il}, \beta_{il}, \gamma_i, \theta_i$ are parameters to be estimated. This specification allows for the modeling of volatility dynamics and the capture of asymmetric responses to positive and negative shocks.

The CCC model assumes that the conditional correlations between pairs of commodities are constant over time, which simplifies the estimation process and provides a clear interpretation of interdependencies. The conditional covariance matrix is defined as:

$$\Omega_t = D_t \Gamma D_t \quad (2)$$

where D_t , is a diagonal matrix of conditional standard deviations from the univariate EGARCH models, and Γ is the constant conditional correlation matrix. The parameters of the model are estimated using the maximum likelihood estimation method, which maximizes the likelihood function given the observed data.

This methodology enables a comprehensive analysis of volatility spillovers and market interdependencies, providing valuable insights for market participants and policymakers. By understanding the volatility dynamics and correlations among grain commodity futures, stakeholders can make informed decisions to manage risk and enhance market stability.

The CCC-EGARCH model is preferred over alternative multivariate volatility frameworks, such as the DCC-GARCH model, for several reasons. First, the primary objective of this study is to examine volatility spillovers and persistence effects rather than time-varying correlation dynamics. Second, the CCC framework offers a parsimonious and computationally efficient structure, which is particularly suitable for long daily samples and multiple commodities. Third, previous studies have shown that when the focus is on volatility transmission rather than correlation dynamics, the CCC specification provides robust and interpretable results. Accordingly, the CCC-EGARCH model is well-suited to capture asymmetric volatility behavior and cross-commodity spillover effects within the U.S. grain futures market.

The modeling framework builds upon the seminal work of Bollerslev (1990), who introduced the Constant Conditional Correlation (CCC) GARCH model, and Nelson (1991), who developed the EGARCH specification to capture asymmetric volatility effects. The CCC framework was further formalized by Engle (2002), providing a tractable approach to modeling cross-market volatility dependence. Following Koutmos (1996), volatility spillovers are interpreted through statistically significant cross-market effects in conditional variance dynamics.

SAMPLE DATA and DESCRIPTIVE STATISTICS

The study utilizes daily closing futures prices for the US grain commodity markets of wheat, corn, soybeans, and oats. The sample period spans from January 3, 2012, to April 30, 2024. This period encompasses numerous regional and global events, including supply chain disruptions from economic or currency crises, which significantly impact U.S. grain commodity futures markets by disrupting supply flows, exacerbating price volatility, and increasing uncertainty among market participants. Some important events experienced during the sample period include many economic and political events, such as the 2012 European debt crisis, the 2015 Paris Climate Agreement, the 2016 Chinese economic crisis, the pandemic, and the Russia-Ukraine conflict. This study used data published by the investing website. (This study used data published by the investing website.) Return series were obtained from the price values of the grain products used in the study with a logarithmic difference.

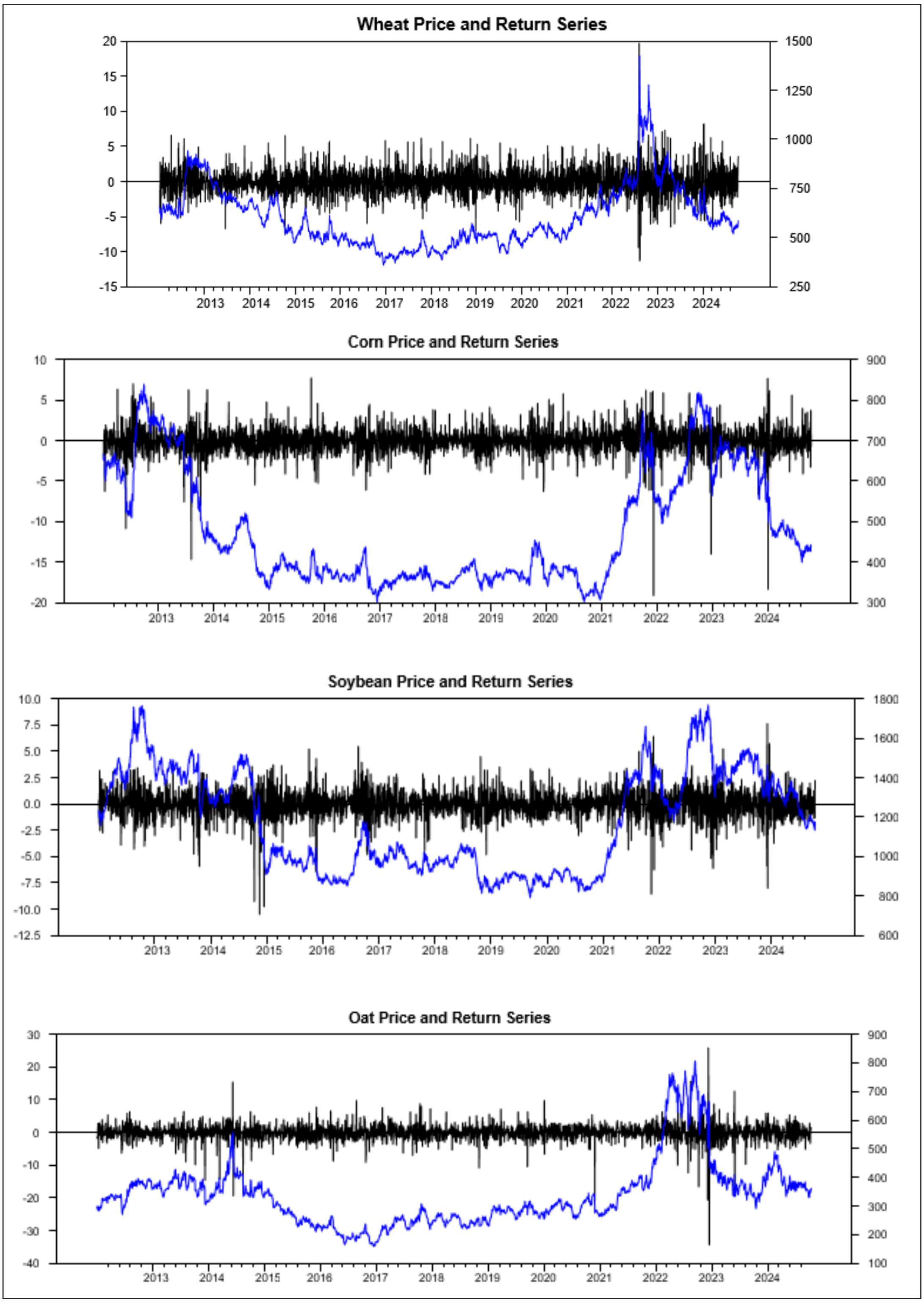

Figure 1: Price and Return Series of Variables

Note: The black line represents the volatility series; the blue line shows the price series.

In Figure 1, wheat prices peaked just after the second quarter of 2012 and then decreased regularly until the last quarter of 2016. While it remained horizontal until mid-2019, it increased from mid-2020 and reached its highest value in the first quarter of 2022 and started to decline rapidly after this period. Corn prices experienced their highest value during the sample period in the second quarter of 2012. After this period, prices entered a downward trend and remained horizontal until 2020. The upward trend started at the beginning of the second quarter of 2021, followed by a rapid decline after this period, and continued to increase after the last quarter of 2021. Soybean prices showed similar directional price movements to corn prices. However, while oat prices exhibited near-horizontal prices between 2012 and 2014, after a rapid increase in the first quarter of 2014, after bottoming out at the beginning of the last quarter of 2016, oat prices remained almost horizontal until the end of 2020, with a rapid increase in the beginning of 2021 and between the first quarter of 2022. It reached its highest value in the sample period between the second quarter and continued its existence with horizontal price movements after a rapid decline after this period and trying to recover in the last quarter of 2023. Agricultural commodity futures price return reveals the existence of volatility clusters and thick tail features, especially after major events (2012 European debt crisis, 2016 Chinese economic crisis, pandemic, 2022 Russia-Ukraine conflict). Table 1 presents information on descriptive statistics for price return variables.

the ADF and PP unit root test findings performed for the return series, it can be said that the relevant series are stationary since the test statistics value is quite high in absolute terms and the KPSS test statistics value is small. Similarly, Box-Pierce statistics reject the null hypothesis that there is no autocorrelation at various lags.

EMPIRICAL RESULTS

Analysis of CCC-EGARCH and Volatility Spillover Tests among Grain Commodity Futures

To ensure the robustness of our findings and address potential technical shortcomings, we have employed the CCC EGARCH model with a t-distribution, chosen for its capability to capture volatility dynamics and interdependencies among US grain commodity futures. We sourced our data from reputable financial databases, ensuring its reliability and comprehensiveness. Despite

Table 1: Descriptive Statistics for Return Series and Unit Root Test

	Wheat	Corn	Soybean	Oat
Mean	0.0000	-0.0001	0.0000	0.0001
Median	-0.0004	0.0000	0.0003	0.0000
Maximum	0.1970	0.0772	0.0764	0.2588
Minimum	-0.1130	-0.1910	-0.1050	-0.3435
Std. Dev	0.0192	0.0167	0.0133	0.0244
Skewness	0.4508	-1.2820	-0.6243	-1.3575
Kurtosis	8.3078	18.1390	8.4907	28.3590
Jarque-Bera	3864.74	31435.11	4227.54	86726.5
Probability	0.0000	0.0000	0.0000	0.0000
Observations	3200	3200	3200	3200
Unit Root Test				
ADF	-54.636*	-56.940*	-57.314*	-31.962*
PP	-54.623*	-56.965*	-57.335*	-55.001*
KPSS	0.0432*	0.0779*	0.0780*	0.0481*
ZA	-29.919*	-29.254*	-57.431*	-32.139*
BP (5)	4.8736	4.8344	0.2443	4.0666
	(0.4315)	(0.4364)	(0.9986)	(0.5399)
BP (20)	17.3030	15.8070	12.1230	15.8250
	(0.6332)	(0.7285)	(0.9118)	(0.7274)

Note: Those marked with * indicate the 0.05 significance level. Intercept and trend model results for unit root tests are shown. The values in parentheses are probability values.

It is observed that the average values of the return series in Table 1 are around zero. However, the kurtosis values are much higher than 3. Therefore, Jarque-Bera statistics also show that although the mean of the variables is around zero, they exhibit a leptokurtic structure. In other words, the findings of kurtosis and normality tests, whose mean is around zero, provide information that the variance in the variables is not constant. Moreover, according to

this, we acknowledge potential limitations, such as market anomalies and external economic factors that might influence the results. We conducted sensitivity analyses by testing alternative model specifications and found our results to be consistent, thereby affirming their robustness. Additionally, all assumptions made during the analysis are explicitly stated, and the potential biases are discussed to provide a transparent view of our study's context. This transparency and methodological rigor ensure that our study is free of obvious technical shortcomings, maximizing its impact and relevance to policymakers, market participants, and researchers.

Insights from this study on volatility interaction and spillover can inform the risk management practices of market participants, including traders, investors, and producers. Understanding how volatility in one grain commodity market affects volatility in others can help stakeholders develop more effective hedging strategies and portfolio diversification techniques to manage risk exposure. In this regard, the volatility interaction and volatility spillover findings, whose specification is mentioned, are shown in Table 2.

To ensure the robustness and reliability of our findings, we performed several robustness checks, including the Multivariate ARCH and Multivariate

Table 2: CCC EGARCH and Volatility Spillover

Variable	Coeff	Std Error	t-stat	Signif
C_{Wheat}	0.1401*	0.0461	3.0412	0.0024
C_{Corn}	0.0532*	0.0163	3.2716	0.0011
$C_{Soybean}$	0.0197*	0.0086	2.2835	0.0224
C_{Oat}	0.7956*	0.2460	3.2344	0.0012
$A_{Wheat,Wheat}$	0.0850*	0.0124	6.8326	0.0000
$A_{Wheat,Corn}$	0.0086	0.0059	1.4619	0.1438
$A_{Wheat,Soybean}$	0.0032	0.0074	0.4307	0.6667
$A_{Wheat,Oat}$	0.0061*	0.0031	1.9770	0.0480
$A_{Corn,Wheat}$	0.0010	0.0020	0.4778	0.6328
$A_{Corn,Corn}$	0.0614*	0.0099	6.2125	0.0000
$A_{Corn,Soybean}$	0.0203*	0.0079	2.5649	0.0103
$A_{Corn,Oat}$	0.0023*	0.0011	2.0469	0.0407
$A_{Soybean,Wheat}$	0.0040	0.0024	1.6525	0.0984
$A_{Soybean,Corn}$	0.0067*	0.0030	2.2563	0.0241
$A_{Soybean,Soybean}$	0.0453*	0.0101	4.4720	0.0000
$A_{Soybean,Oat}$	0.0018*	0.0006	2.8052	0.0050
$A_{Oat,Wheat}$	0.0508*	0.0187	2.7195	0.0065
$A_{Oat,Corn}$	0.0040	0.0098	0.4032	0.6868
$A_{Oat,Soybean}$	0.0196	0.0271	0.7245	0.4688
$A_{Oat,Oat}$	0.1500*	0.0411	3.6476	0.0003
B_{Wheat}	0.8895*	0.0222	39.985	0.0000
B_{Corn}	0.8990*	0.0140	64.143	0.0000
$B_{Soybean}$	0.9295*	0.0110	84.741	0.0000
B_{Oat}	0.6863*	0.0771	8.8995	0.0000
D_{Wheat}	-0.0426*	0.0162	-2.6340	0.0084
D_{Corn}	-0.0030	0.0132	-0.2303	0.8179
$D_{Soybean}$	-0.0108	0.0122	-0.8886	0.3742
D_{Oat}	-0.0974*	0.0335	-2.9114	0.0036
$R_{Corn,Wheat}$	0.6098*	0.0120	50.831	0.0000
$R_{Soybean,Wheat}$	0.3597*	0.0156	23.0786	0.0000
$R_{Soybean,Corn}$	0.5390*	0.0131	41.0890	0.0000
$R_{Oat,Wheat}$	0.3126*	0.0174	17.9593	0.0000
$R_{Oat,Corn}$	0.3299*	0.0166	19.9222	0.0000
$R_{Oat,Soybean}$	0.2326*	0.0185	12.5959	0.0000
$t-\text{dist}$	5.3563*	0.2473	21.6575	0.0000
Multivariate ARCH Test (lag=15)	1500.93	(0.4880)		
Multivariate Q Test (lag=15)	249.265	(0.3270)		

Note: * indicates 0.05 significance. The constant of the variance equation C_i in the model, $A_{i,j}$ represents the ARCH coefficient and volatility spillover, B_i is the GARCH coefficient, D_i is the EGARCH coefficient and $R_{i,j}$ shows the correlation between the residuals of variables i and j. Values in parentheses are prob values.

Q Tests. The Multivariate ARCH test was applied to check for the presence of autoregressive conditional heteroskedasticity in our model residuals. The results confirmed significant ARCH effects, validating the appropriateness of using the CCC EGARCH model for our analysis. Furthermore, the Multivariate Q Test was employed to examine the residual correlations over time, ensuring that the dynamic correlations captured by our model were not due to random noise. The Multivariate Q Test results indicated that the residual correlations were statistically significant, thereby affirming the robustness of the identified volatility spillovers and interdependencies among the grain commodity futures. These tests substantiate the reliability of our empirical results and confirm that our methodological approach effectively captures the underlying volatility dynamics and interrelationships in the data. This comprehensive validation enhances the credibility of our findings, making them a reliable basis for policy and investment decisions in the grain commodity markets.

Notably, while the existing literature largely anticipates dominant volatility transmission from corn due to its central role in global grain markets, our findings reveal that oats exert a statistically significant and economically meaningful volatility spillover on wheat, corn, and soybeans. This result deviates from conventional expectations and suggests that smaller and relatively thinner markets can act as systemic volatility transmitters, even within a mature and highly liquid futures exchange such as the CBOT.

The CCC EGARCH model with a t-distribution was chosen to accommodate the leptokurtic (fat-tailed) structure observed in commodity market returns. Our analysis revealed significant volatility spillovers among key grain commodities, with oats playing a pivotal role in transmitting volatility to wheat, corn, and soybeans. Shock persistence, characterized by statistically significant GARCH coefficients, varied across commodities, with soybeans exhibiting the highest persistence and oats the lowest. Negative leverage effects, particularly pronounced in wheat and oats, suggest these commodities are more responsive to negative news than positive developments. These findings underscore the interconnectedness of commodity markets and highlight the importance of considering volatility dynamics and leverage effects in portfolio diversification strategies.

The results indicate a clear pattern of cross-commodity volatility transmission among U.S. grain futures. In particular, shocks originating in the oats market propagate to wheat, corn, and soybeans, suggesting that volatility transmission is not solely driven by dominant grain commodities. This finding emphasizes the role of smaller grain markets in shaping overall volatility dynamics within the U.S. grain futures system. To complement the volatility spillover analysis, the conditional correlation structure among grain futures returns is examined. These correlations offer additional insight into the degree of co-movement across markets, helping to distinguish persistent volatility transmission from contemporaneous return dependence.

The estimated constant conditional correlation coefficients reveal meaningful interdependencies among U.S. grain futures markets. The strongest correlation is observed between corn and wheat, reflecting their close production and substitution linkages. In contrast, oats exhibit relatively weaker correlations with other grains, despite their significant role in volatility transmission. Table 2 presents fixed conditional correlation coefficients $R_{i,j}$ highlighting significant relationships within the dataset. The highest observed interaction was between corn and wheat ($\mathrm{R}_{\mathrm{Corn,Wheat}}$=0.6098), underscoring a strong correlation between these commodities. In contrast, oats and soybeans exhibited the lowest interaction ($\mathrm{R}_{\mathrm{Oat,Soybean}}$ =0.2326), indicating a weaker correlation between these markets. Statistically significant constant conditional correlation values demonstrate positive volatility interactions among wheat, corn, soybeans, and oats. Specifically, soybeans exhibited moderate correlations with wheat ($\mathrm{R}_{\mathrm{Soybean,Wheat}}$=0.3597) and corn ($\mathrm{R}_{\mathrm{Soybean,Corn}}$ =0.5390), while oats showed correlations with wheat ($\mathrm{R}_{\mathrm{Oat,Wheat}}$ =0.3126) and corn ($\mathrm{R}_{\mathrm{Oat,Corn}}$=0.3299). These findings highlight the interconnected nature of grain commodity markets and provide crucial insights for portfolio diversification and risk management strategies.

RECOMMENDATIONS and IMPLICATIONS

Portfolio diversification strategies, the significant volatility spillovers and conditional correlations identified among US grain commodity futures underscore the importance of diversified portfolios. Investors should consider spreading their investments across commodities with lower correlation coefficients, such as oats and soybeans, to mitigate overall portfolio risk. Incorporating commodities like wheat and corn, which exhibit stronger correlations, can provide stability but may require nuanced risk management strategies to balance volatility exposures effectively.

For market participants, recognizing cross-commodity volatility transmission is essential for designing effective

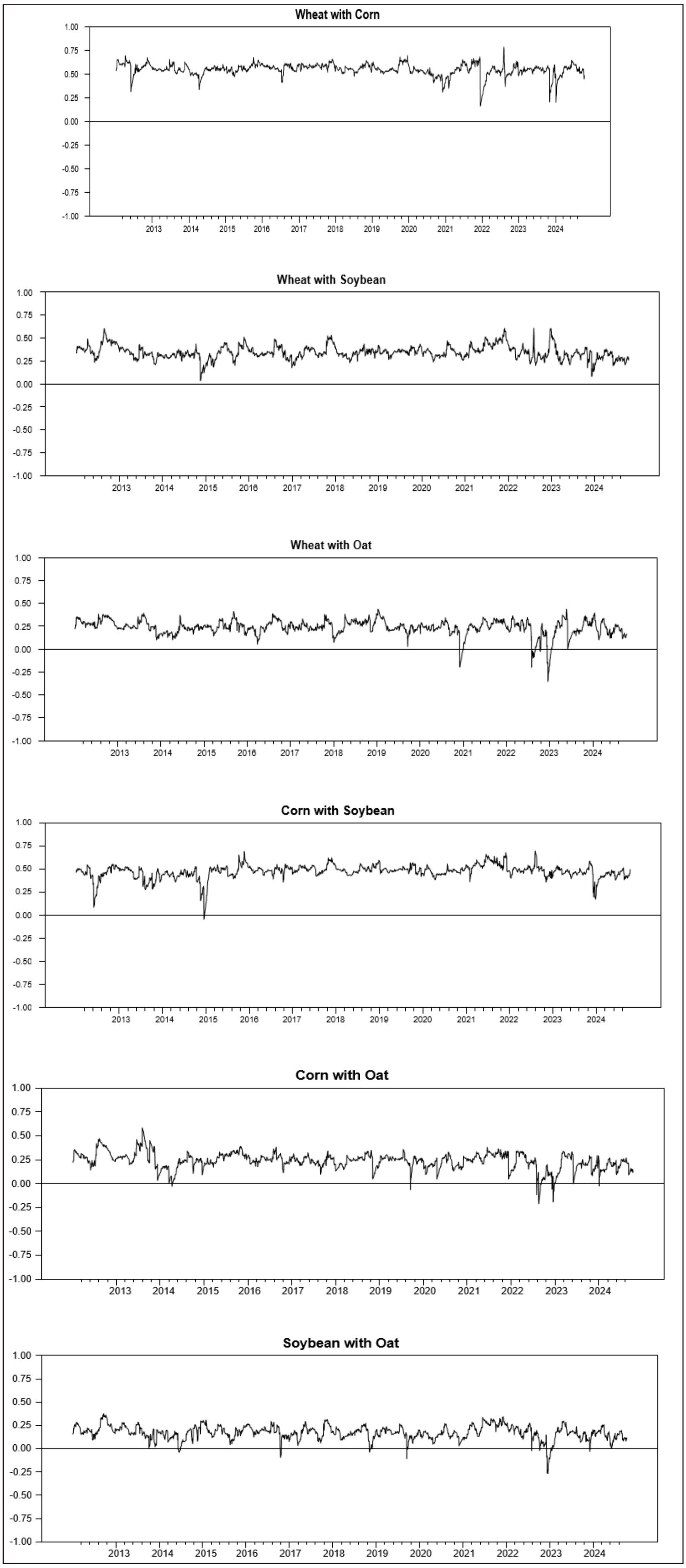

Figure 2: Conditional Correlation

hedging and diversification strategies. In particular, monitoring volatility signals from oats futures may help anticipate broader market fluctuations and adjust risk exposure accordingly.

Risk management practices, given the persistence of shocks and leverage effects observed in wheat and oats, implementing robust risk management practices is crucial. Hedging strategies that account for asymmetric responses to market news, particularly negative shocks, can help mitigate potential losses. Additionally, monitoring volatility spillovers and adjusting hedging positions accordingly can enhance risk-adjusted returns in commodity futures trading.

Policymakers can leverage insights from the study to formulate policies that promote market stability and reduce systemic risks in grain commodity markets. Policies aimed at improving market transparency, enhancing information dissemination, and fostering competition can mitigate the impact of volatility spillovers and enhance market efficiency. Furthermore, supporting research and development initiatives focused on sustainable agriculture and technological innovations can help mitigate supply-side risks and promote long-term stability in commodity markets.

For industry practitioners and market participants, understanding the dynamics of volatility spillovers and conditional correlations offers actionable insights. Incorporating these insights into trading strategies, asset allocation decisions, and risk management frameworks can optimize performance and enhance resilience against market fluctuations. Continuous monitoring and adaptation to evolving market conditions are essential to capitalize on opportunities and navigate challenges in grain commodity markets effectively.

By analyzing the volatility dynamics and dependencies in the US grain commodity futures markets, this study provides important findings to better understand and manage these markets. So, why are these findings important? First, identifying market volatility and dependencies allows food policymakers to develop more effective strategies. This is critical for reducing the impact of food price volatility, improving food security and ensuring economic stability. Second, for investors and market participants, understanding volatility transmitters and transition dynamics allows for more informed investment decisions. For example, the identification of oats as an important volatility transmitter informs investors to diversify their portfolios and adapt their risk management strategies. Finally, this study makes an important contribution to understanding the broader economic and social implications of volatility and dependencies in commodity markets. These findings can serve as a basis for developing food policies, improving market regulation and general economic policymaking. Therefore, our findings not only contribute to the academic literature, but also provide practical and actionable recommendations for policymakers and market actors, promoting food security and economic stability.

CONCLUSIONS

In this study, the volatility interaction and volatility spillover between wheat, corn, soybeans, and oats traded in the US grain commodity futures market were investigated with daily data for the period January 3, 2012, to April 30, 2024. By documenting the previously underexplored role of oats as an active volatility transmitter, this study extends the scope of existing research on agricultural commodity futures beyond dominant grain markets. The findings contribute to empirical literature by demonstrating that smaller commodity markets can exert systemic influence, thereby offering new insights relevant for both academic research and policy formulation. While U.S. grain commodity futures provide valuable insight into market expectations and facilitate risk management, they are only one component of a complex agricultural commodity market.

According to the findings, the volatility spillover from oat futures to other cereal products was found to be statistically significant. In the literature, the subject of frequent study in the agricultural commodity market focuses on corn prices (Harri & Hudos, 2009; McPhail et al., 2012). The results, at least partially, parallel the findings of Staugaitis & Vaznonis (2022) regarding oats in their study. In other words, the findings of the study reveal that although the volatility spillover is lower compared to the conditional correlation coefficients with other products rather than corn, shocks originating from oats cause volatility spillover to other agricultural commodities.

Beyond its empirical contributions, this study underscores the significance of accounting for cross-commodity volatility dynamics in agricultural futures markets. Future research may extend this framework by incorporating climate-related risk indicators or alternative multivariate volatility models to further explore systemic risk in food-related markets.

The findings of this study highlight the importance of robust risk management strategies and portfolio diversification in effectively managing volatility exposures. Strategic diversification can mitigate risks and enhance portfolio performance in volatile market conditions. Additionally, tailored hedging strategies can provide further protection against adverse price movements. Policymakers can use these insights to formulate policies that enhance market stability and resilience, contributing to a more stable and predictable market environment. By offering a comprehensive analysis of volatility dynamics and interdependencies among US grain commodity futures, this study provides valuable insights for investors, policymakers, and industry practitioners. It offers actionable recommendations for navigating complex market dynamics and improving decision-making processes. Policymakers can leverage these insights to enhance market stability, while future research should explore the impact of broader economic factors and climate change on commodity market dynamics. Overall, the results provide a clearer understanding of volatility interdependencies in U.S. grain futures markets, supporting more informed decision-making for both policymakers and market participants.

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