International Journal of
Financial Studies

MDPI

Article

Food Financialization: Impact of Derivatives and Index Funds on Agri-Food Market Volatility

María del Rosario Venegas [1], Jorge Feregrino [1], Nelson Lay [2] and Juan Felipe Espinosa-Cristia [3,*]

[1] FES Acatlán, Universidad Nacional Autónoma de México, Naucalpan de Juarez 53150, Mexico; marosel.venegas@gmail.com (M.d.R.V.); jorferegrino@yahoo.com (J.F.)
[2] Escuela de Psicología, Facultad Educación y Ciencias Sociales, Universidad Andres Bello, Santiago 7591538, Chile; nelson.lay@unab.cl
[3] Ecuela de Ingeniería Comercial, Departamento de Ingeniería Comercial, Universidad Técnica Federico Santa María, Valparaiso 2390123, Chile
* Correspondence: juan.espinosacr@usm.cl

Abstract: This study explores the financialization of agricultural commodities, focusing on how financial derivatives and index funds impact the volatility of agro-food markets. Using a Dynamic Conditional Correlation (DCC) GARCH model, we analyze volatility spillovers among key agricultural commodities, particularly maize, and related financial assets over a sample period from 2007 to 2020. Our analysis includes major financial assets like Exchange-Traded Funds (ETFs), the S&P 500 index, and agribusiness corporations such as ADM and Bunge and the largest corn flour producer, GRUMA. The results indicate that financial speculation, especially via passive investments such as ETFs, has intensified price volatility in commodity futures, leading to a systemic risk increase within the sector. This study provides empirical evidence of increased market integration between the agro-food sector and financial markets, underscoring risks to food security and economic stability. We conclude with recommendations for regulatory actions to mitigate systemic risks posed by the growing financial influence in agricultural markets.

Keywords: financialization; agricultural commodities; price volatility; derivatives markets; index funds; agro-food sector; systemic risk; commodity futures markets

check for updates

Citation: Venegas, María del Rosario, Jorge Feregrino, Nelson Lay, and Juan Felipe Espinosa-Cristia. 2024. Food Financialization: Impact of Derivatives and Index Funds on Agri-Food Market Volatility. *International Journal of Financial Studies* 12: 121. https://doi.org/10.3390/ijfs12040121

Academic Editor: Hachmi Ben Ameur

Received: 20 October 2024
Revised: 24 November 2024
Accepted: 28 November 2024
Published: 3 December 2024

1. Introduction

The financialization of commodity markets has increased the influence and impact of financial actors in sectors such as food, fundamentally transforming price structures of essential goods. This phenomenon, characterized by the growing involvement of hedge funds, passive investment funds, and other financial entities, has altered the traditional supply–demand dynamics by introducing purely financial motivations and speculative strategies into food markets (Isakson et al. 2023; Keenan et al. 2023; Fama and Conti 2022; Sawyer 2013; Krippner 2005). The involvement of these actors has exacerbated price volatility in food markets, linking food prices with the fluctuations of other financial assets, particularly during crises, as witnessed in the 2008 global recession (Cheng and Xiong 2014; Liu and Tang 2010). This study investigates how this financialization affects the food system, raising significant challenges for both food security and economic stability.

A critical aspect of financialization is the transmission of volatility through financial instruments such as derivatives and index funds, which amplify price fluctuations in agricultural markets (Irwin and Sanders 2011). This transmission, referred to as "volatility spillover", reflects a connection between the financial and real sectors that can heighten systemic risk within food markets, reducing diversification benefits during times of financial stress and potentially exacerbating social and economic disparities (Engle 1990; Hamao et al. 1990). Examining these mechanisms is essential in order to understand how food prices can be impacted by speculative movements in futures markets and other complex financial products.

Moreover, the literature has shown that the volatility of agricultural commodity prices has a direct impact on food security, especially in emerging economies that depend heavily on food exports and imports (Erokhin et al. 2022). Previous studies underscore that price instability influenced by financial actors can lead to food insecurity in lower-income countries, where extreme price fluctuations compromise both the availability and affordability of essential goods (Candila and Farace 2018; Clapp and Isakson 2018). In this context, investigating the repercussions of financial volatility for the stability of food markets and the economies dependent on agricultural products is both timely and critical.

To analyze the central phenomenon of this article, i.e., how financialization affects the food system, posing important challenges to both food security and economic stability, the article will begin by analyzing the literature on the broader impact of the financialization phenomenon on index funds in commodity markets (Section 2.1.), and then look to the crucial issue of the deregulation and rise of banking in the commodity markets (Section 2.2). Afterward, the article reviews the importance of financial actors and their influence on food prices (Section 2.3), followed by an evaluation of volatility transmission mechanisms via financial instruments (Section 2.4). The article then examinates the impact of such volatility on food security and emerging economies (Section 2.5). Subsequently, the article describes the methodology used to investigate how the volatility of agricultural food markets affects the food system. Then, the authors present the results in Section 4. Finally, the article discusses these results in light of the literature, and posits some conclusions.

Through this structure, the study aims to provide a critical perspective on food sector financialization, presenting evidence of how financial actors and regulatory changes have intensified volatility in food markets, with substantial implications for global economic stability.

2. Financialization of Commodities, Deregulation in Banking, Volatility, and Food Prices: A Complex Relationship

2.1. The Impact of Financialization and Index Fund Investing on Commodity Market Volatility and Systemic Risk

The literature shows that the growth of index fund investing in commodity markets since the early 2000s has led to notable changes in the price dynamics of commodity futures (Corbet and Twomey 2014). The establishment of Exchange-Traded Funds (ETFs) in the commodity space contributes to greater volatility in these markets. According to Corbet and Twomey (2014), research findings reveal that the proportional holdings of ETFs in larger markets are associated with greater volatility. Such growth is linked to a broader trend of financialization in commodity markets, which has led to the integration of commodity prices and the prices of various assets and financial vehicles (Clapp 2012, 2019, 2024). The integration of commodities and equity performance led investment banks to promote commodity futures as a new asset class, attracting highly leveraged investors and institutional investors (Liebi 2020). Above all, the introduction of index funds such as Exchange Trade Funds (ETFs) has revolutionized investment positions in commodity markets (Liebi 2020; Corbet and Twomey 2014). As Buetow and Hanke (2024) point out, ETFs provide a trading capability similar to stocks that are highly liquid by prioritizing the opportunity to quickly initiate and liquidate their positions.

The effects of volatility caused by investment in commodity indices, the price of derivatives, and even the price of the underlying will be analyzed through examining the process of taking investment positions in commodity markets. The analysis of the integration of raw materials into financial markets is vital to explain how the transformation process of a commodity traded in the goods market was carried out, and how it is adapted as an underlying in the futures market.

In these financial markets, investment strategies are quite exposed to risk, one of the factors that can increase market volatility globally, particularly regarding short open interest positions of financial operators and their level of leverage. Institutional investors have progressively integrated commodity derivatives into their investment portfolios as a strategy to achieve diversification and obtain higher returns associated with the stock market. This transition from conventional equity holdings to derivatives, which encompass commodities, has been a crucial factor in the expansion of open interest (Basu and Gavin 2010). Such factors influence the futures returns of various commodities; for example, Hsieh and Ching-Fang (2016) showed a notable positive correlation between open interest and the volatility of spot prices. Since 2003, the notional market value—the total amount of an underlying asset in the contract—of derivatives has exceeded more than 5 times the world GDP. This increase in the number of negotiations was accompanied by an increase in commodity derivative transactions and lax regulation in the scope of financial intermediation over banking conglomerates. These conglomerates have used interpretations in the regulation to include within their powers commercial and derivative activities associated with the transaction of raw materials. These financial institutions play a crucial role in these markets, using derivatives for a multitude of objectives (Soumaré 2022). In this sense, Choi et al. (2016) showed that banks' positions on various raw materials and their derivatives can have negative consequences and financial stability risks when they have market power in these markets in general. In the paragraphs that follow, we examine the essential elements of banks holding derivatives within commodity markets. Massive access to commodity financial markets through investments in sophisticated passively managed financial instruments represents a risk to the derivatives market and the commodification of commodities.

2.2. Deregulation and the Rise of Bank Dominance in US Commodity Markets: From Glass–Steagall to Systemic Risk

We present the evolution of banking regulations in the United States (see Table 1) that allowed the increasing participation of banks in two stages of commodity market negotiation. In the first stage, the bank's position on primary products accumulated in its warehouses; secondly, the creation of commodity derivatives to trade these commodities in the main financial markets with the implications for systemic risk. For this reason, we present chronologically the key legislative changes that impact the structure and activities of the banking sector, according to Omarova (2008) and Stevens and Zhang (2022).

Table 1. Chronology of banking deregulation for the operation of raw materials and derivatives.

1993	1956	1980	1990
Glass–Steagall Act: Introduces separation between commercial and investment banking to reduce systemic risk. Prohibits commercial banks from trading and underwriting capital securities.	Bank Holding Company Law: Regulates bank holding companies, prohibiting them from acquiring or controlling non-banking companies. It seeks to strengthen the separation between banking and commerce.	OCC reinterprets "banking business": The Office of the Comptroller of the Currency (OCC) expands the interpretation of "banking business" to include the intermediation of financial instruments. It allows banks to trade derivatives on interest rates, currencies and precious metals.	OCC introduces "functional equivalence": The regulatory distinction between financial assets and commodities is eliminated. Banks can trade commodity swaps and commodity indices, without needing a legitimate interest in the physical underlying.

Table 1. *Cont.*

1999	2000	2000 Onwards	Present
Ley Gramm–Leach–Bliley: Allows the merger of commercial banks, insurance companies and securities firms. Financial holding companies may engage in non-financial trading activities, including the derivatives market and the commodity spot market.	Commodity Futures Modernization Act: Deregulates futures and options trading, removing limits on operational capacity and encouraging the creation of more complex commodity derivatives.	OCC allows for "physical commodity trading": Banks can acquire physical assets such as farmland, coal mines or aluminum reserves to complement their operations in the derivatives market. This increases their control over the supply chain and raises concerns about price volatility and systemic risk.	Large financial holding companies, with the approval of regulatory authorities, dominate more than 90% of financial transactions in raw materials, concentrating power and increasing volatility in the markets, with consequences for food security and access to basic products.

Source: Own elaboration based on Omarova (2008) and Stevens and Zhang (2022).

The Glass–Steagall era and its limitations (1933–1999): The foundation of American banking regulation was laid by the Glass–Steagall Act of 1933, enacted as part of the Banking Act of 1933 (Stevens and Zhang 2022). This legislation aimed to reduce systemic risk by separating commercial banking from investment banking. Banks were prohibited from underwriting corporate securities and engaging in activities such as property, commercial property, real estate, and insurance underwriting (Omarova 2008). This protected depositors' money from losses from speculative investments. However, it left a gap by leaving banking conglomerates outside of regulation. This legal gap was closed in 1956 with the Bank Holding Company Act by preventing the circumvention of Glass–Steagall restrictions through banks organized in conglomerates (Stevens and Zhang 2022).

The deregulation, control, and expansion of commodity markets (1999–present): The landscape changed dramatically with the passage of the Gramm–Leach–Bliley Act (GLBA) of 1999, also known as the Financial Services Modernization Act. This law repealed the founding principles of Glass–Steagall, allowing financial companies to merge and engage in previously prohibited activities. This deregulation granted financial institutions access to both the physical and commodity derivatives markets. The argument used for this deregulation sought to increase competition and efficiency within the financial sector. Examples of banks and financial institutions that engage in speculative commodity trading are shown in Table 2. These examples were selected because they have the highest positions in the market. The new regulatory environment promoted a significant increase in speculative activity within raw materials markets (Omarova 2008).

Table 2. Examples of banking negotiations with raw materials.

Investment Banking	Commodity Investment Business Activities
Morgan Stanley	2009 Lease rights to more than 40 thousand hectares of agricultural land in Ukraine
Goldman Sachs Barclays Deutsche Bank JP Morgan Morgan Stanley	2010–2012 Speculative profits over USD 2.7 billion traded food-based assets
Goldman Sachs	2014 Aluminum price fixers through inventory manipulation at the London Metal Exchange (LME)

Source: Own elaboration with information from the texts of Clapp and Isakson (2018) and Stevens and Zhang (2022).

The Commodity Futures Modernization Act of 2000 set out to remove operational limits on futures and options trading; this law encouraged the development of increasingly sophisticated financial instruments based on commodity derivatives. The increased sophistication of these instruments, coupled with relaxed regulation, created opportunities for large financial institutions to leverage their resources to engage in substantial speculative transactions in commodity markets. The literature shows that financial institutions that accumulate inventory in their warehouses and operate with these inventories in the futures market are a channel for transmitting volatility between the financial market and the physical market (Cretí and Villeneuve 2014). An example is Goldman Sachs and its significant holdings and trading activities in the commodity markets, suggesting that these operations greatly influenced commodity prices and futures markets, exacerbating market inefficiencies and creating opportunities for price arbitrage.

The operation with derivatives was deepened through the Office of the Comptroller of the Currency (OCC) and the "banking powers" clause of the National Bank Law, managing to justify greater banking participation in the trade of commodity derivatives (Omarova 2008). The first was the "transparency" approach, which automatically justified the bank's participation in the derivatives market related to that commodity. The second was the concept of "functional equivalence", which eliminated the distinction between different underlying assets, treating all commodities equally as financial assets. Accordingly, the OCC authorized commodity and commodity index swaps, mirroring the treatment of interest rate or currency swaps.

A critical point highlighted is that these instruments primarily involve the exchange of cash flows based on commodity prices, without requiring the physical purchase or sale of the commodity. This means that there is no genuine need for a direct connection to the physical commodity market. The implication is that the "functional equivalence" argument, while allowing for the proliferation of commodity derivatives, ignored the fundamental differences between various commodities and their real-world market dynamics. This could lead to artificially synchronized prices and volatility effects in unrelated commodity markets, thereby increasing systemic volatility without a direct reflection in the spot prices of the underlying commodities.

Growing demand for banking participation in physical commodity trading led the OCC to once again redefine the "business of banking". This allowed banks to take positions in assets such as agricultural land, coal mines, and aluminum reserves, deepening their integration into the physical commodities market. The combination of derivatives trading and physical holdings amplified the potential for market manipulation and increased systemic risk. Large financial institutions gained capacity to store large quantities of physical products, which affected prices, production processes, and ultimately the overall economy (Mou 2010; Baines and Hager 2022). For example, we can consider Coca Cola's complaint to the London Metal Exchange (LME) against Goldman Sachs for accumulating excessive reserves of aluminum, which artificially inflated prices and subsequently affected the derivatives market (Omarova 2013).

This integration, driven by the deregulation and expansive interpretations of banking powers, creates a powerful mechanism for propagating financial instability and systemic risk. The concentration of power within a few large financial institutions (Goldman Sachs, Morgan Stanley, BlackRock), which control more than 90% of financial transactions, exacerbates this concern (Clapp 2024). The lack of clear distinctions between physical and financial commodity markets, coupled with the speculative potential of derivative instruments, presents a significant challenge to the stability of financial and real-world markets.

2.3. From Commodity Markets to the Role of Financial Actors and Their Influence on Food Prices

The commodities markets have evolved beyond their original purpose of trading agricultural products, transforming into a sophisticated arena for financial speculation. While these markets nominally deal with agricultural goods, they primarily function as vehicles for financial trading through complex mechanisms that convert physical commodities into tradeable financial assets.

Figure 1 depicts a hierarchical breakdown of the processes and elements involved in commodities and derivatives trading, specifically highlighting how physical commodities are transformed into financial assets and the role of speculation. In essence, the diagram illustrates how the transformation from a physical commodity (Underlying Asset) to a traded financial instrument (Derivatives Contract) within a liquid secondary market creates opportunities for speculation and hedging, significantly impacting price dynamics and creating a system where price is not solely driven by supply and demand for the physical commodity itself.

From Figure 1, the process shows that transformation operates through several interconnected processes. First, agricultural products are assigned market prices that establish their present value, forming the basis for derivative contracts like futures. The standardization of these contracts on organized exchanges creates crucial linkages between spot and futures markets, benefiting asset holders while potentially disadvantaging those without direct market access. The daily settlement price, determined by trading volume rather than fundamental asset value, becomes susceptible to speculative influence. This is further amplified by the secondary market, which enables traders to close positions before expiration and pursue profits through price differentials, often without any interest in the underlying commodity. Additionally, the unique ability to engage in short selling—trading assets without ownership—has intensified speculative activity, fundamentally altering how agricultural commodity prices are determined in the market.

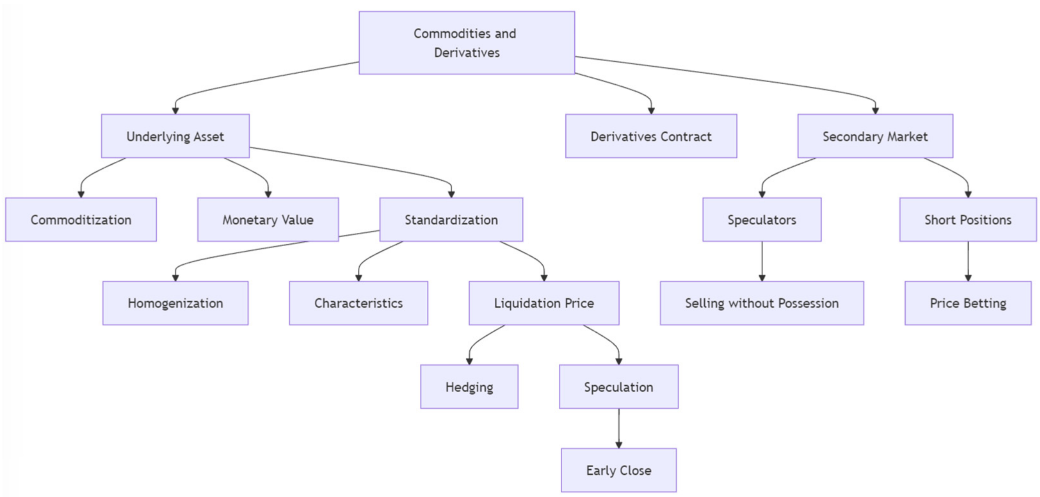

Figure 1. Latent speculation process in the raw materials market. Source: own elaboration.

The current regulations, operability, and structure of commodity markets, with their emphasis on standardization, speculative trading, and secondary market opportunities, facilitate the financialization of agricultural products, generating high returns for some participants but potentially harming producers and creating instability in the financial market and the goods market. Due to the aforementioned characteristics of raw material derivatives, they are instruments prone to receiving speculative capital; specifically, speculative positions in the raw material derivatives market are the dominant positions in the market. Li and Loewenstein (2015) point out that these speculative activities in derivatives markets impact the growth of spot prices. Likewise, Drutarovská (2014) points out that the levels of leverage inherent in these speculative activities generate vulnerabilities and financial instability at a systemic level (Isakson 2017).

The influence of financial actors, particularly hedge funds and passive investment funds, on price fluctuations in food markets is a complex interplay of financialization, speculation, and the dynamics of physical supply and demand. Financialization refers to the increasing dominance of financial motives, financial markets, actors, and institutions in the operation of domestic and international economies. This phenomenon has significantly altered the traditional relationship between prices and supply–demand dynamics, particularly in food markets, where price volatility has been exacerbated by speculative trading practices.

Hedge funds, characterized by their aggressive trading strategies, often engage in speculative activities that can lead to significant price fluctuations in food commodities. For instance, during the food price spikes observed between 2008 and 2011, hedge funds were implicated in exacerbating price volatility through speculative trading in futures markets. This financialization of food markets has had profound implications, particularly for vulnerable populations in developing regions, where food security is critically impacted by price volatility driven by financial actors (Field 2016). The interconnectedness of global financial markets means that actions taken by hedge funds can ripple through to affect local food prices, often disconnecting them from the underlying physical supply and demand conditions.

Moreover, the role of hedge funds in price discovery is nuanced. While some studies suggest that hedge fund trading can improve price discovery by aligning trades with price movements, others indicate that their speculative activities can lead to mispricing and increased volatility. For example, Brunetti et al. argue that hedge funds can reduce volatility when trading in the same direction as price changes, thereby contributing to a more efficient market (Brunetti et al. 2016). However, this is countered by evidence that hedge funds can also create price pressures that deviate from fundamental values, particularly when they engage in herding behavior or follow trends in speculative trading (Sias et al. 2016).

The impact of passive investment funds, such as index funds, on food prices is also significant. These funds typically invest in a diversified portfolio of assets, including commodities, and their trading activities can create substantial price pressure. For instance, when index funds adjust their holdings in response to changes in market indices, they can cause abrupt price movements in the underlying commodities, further decoupling prices from physical supply–demand dynamics (O'Neill and Whaley 2022). This phenomenon is particularly evident during periods of market rebalancing, where the predictable buying and selling by passive funds can lead to significant price swings, often independent of actual supply and demand conditions.

The relationship between hedge funds and food prices is further complicated by the use of financial derivatives, such as futures and options, which hedge funds employ to manage risk and speculate on price movements. The strategies employed by hedge funds can lead to increased market volatility, particularly when they utilize leverage to amplify their positions. Research indicates that hedge funds often engage in strategies that exploit price inefficiencies, which can result in short-term price distortions that do not reflect underlying supply–demand fundamentals (Hu 2023). This speculative trading can create feedback loops where price movements driven by hedge fund activity further influence their trading strategies, leading to a cycle of volatility that can destabilize food markets.

Furthermore, the concentration of capital within large hedge funds allows them to exert significant influence over market prices. As noted by Kolokolova et al., capital concentration in the largest funds enables them to move prices away from fundamental values, creating a disconnect between market prices and the physical realities of supply and demand (Kolokolova et al. 2020). This phenomenon is particularly concerning in food markets, where price volatility can have dire consequences for food security and access, especially in developing countries that are more susceptible to external shocks.

The interaction between hedge funds and passive investment funds also plays a critical role in shaping market dynamics. When hedge funds engage in speculative trading, they can trigger responses from passive funds, which may adjust their holdings based on price movements. This herding behavior can amplify price fluctuations, as both types of funds react to the same market signals, further decoupling prices from the underlying supply–demand fundamentals (Jiao and Ye 2014). The resulting volatility can create challenges for market participants, including farmers and consumers, who rely on stable prices for planning and budgeting.

2.4. Mechanisms of Volatility Transmission Through Financial Instruments

The volatility of agricultural commodity prices has been a subject of extensive research, particularly in the context of financial instruments such as derivatives and index funds. This is an important point for the present study, because it is focused on how financial derivatives and index funds impact the volatility of agro-food markets. Furthermore, financial instruments have introduced new dynamics into the agricultural markets, influencing price fluctuations through various mechanisms. This response synthesizes findings from multiple studies to elucidate how these mechanisms contribute to increased volatility in agricultural commodity prices.

One of the primary mechanisms through which financial instruments impact agricultural commodity prices is through speculation. Speculative trading, particularly by index funds, has been associated with increased price volatility. Irwin (2013) highlights that the influx of index investment into agricultural futures markets has led to significant changes in market dynamics. They argue that while some studies suggest that index funds have not caused a bubble in commodity prices, the sheer volume of speculative trading can amplify price movements, leading to increased volatility. This sentiment is echoed by Sanders et al. (2010), who note that long-only commodity index funds have been criticized for inflating prices and distorting historical price relationships, thus contributing to heightened volatility.

Moreover, the financialization of agricultural commodities has transformed them into financial assets, subjecting them to the same market forces as stocks and bonds. This transformation is discussed by Rl and Mishra (2021), who examine the financialization of Indian agricultural commodities and its implications for price volatility. They argue that as agricultural commodities become more integrated into financial markets, their prices become more sensitive to financial market dynamics, including investor sentiment and macroeconomic factors. This integration can lead to increased volatility, particularly during periods of financial stress or uncertainty.

The role of index funds in creating price bubbles is further supported by the work of (Soana et al. 2020), who investigate the activities of index traders and swap dealers. They assert that while traditional supply and demand factors can explain some price movements, they cannot fully account for the high volatility observed in agricultural commodity markets since 2007. This suggests that the speculative nature of index trading has introduced additional layers of complexity to price dynamics, exacerbating volatility.

Furthermore, the interaction between index funds and traditional commodity market participants is crucial in understanding volatility. Hamilton and Wu (2015) propose a framework for examining the effects of index-fund investing on commodity futures prices, noting that the behavior of these funds can lead to significant price fluctuations. They emphasize that the long positions maintained by index funds in near-term futures contracts can create upward pressure on prices, particularly when combined with other market participants' trading strategies.

In addition to speculation, the liquidity provided by index funds can also contribute to volatility. This is an important aspect of the present study. While increased liquidity is generally seen as beneficial, it can lead to rapid price changes when large volumes of trades occur. Kleinau and Lin-Hi (2014) discuss the inconclusive nature of empirical research on the impact of speculation via index funds on commodity prices, highlighting that while some studies suggest a significant effect, others indicate that the relationship is more complex and influenced by various market conditions.

Moreover, the findings of Irwin and Sanders (2011) indicate that while there is a belief among some market participants that index fund investment was a major driver of the 2007–2008 price spikes, the empirical evidence is mixed. They suggest that the methodologies and data used in various studies may not adequately capture the nuanced relationship between index funds and price volatility. This underscores the need for a comprehensive understanding of the mechanisms at play, as simplistic interpretations may overlook critical factors influencing market behavior.

The volatility introduced by financial instruments is not limited to speculative trading; it also encompasses the broader implications of financialization. The research by Zapata et al. (2012) highlights that the representation of agricultural sectors in thematic indexes may not fully capture the diversity of the agricultural market, potentially leading to mispricing and increased volatility. This misrepresentation can exacerbate price swings, particularly in response to external shocks or changes in investor sentiment.

Additionally, the interaction between financial markets and agricultural commodity prices is further complicated by macroeconomic factors. The work of Kitano (2021) suggests that financial frictions can influence how world commodity prices affect exporting economies, indicating that the interconnectedness of financial markets can lead to increased volatility in agricultural prices. This interconnectedness is particularly pronounced during periods of economic uncertainty, where shifts in investor behavior can lead to rapid price adjustments.

The implications of these findings are significant for policymakers and market participants. Understanding the mechanisms through which financial instruments contribute to volatility can inform regulatory approaches aimed at mitigating excessive price fluctuations. For instance, the Commodity Futures Trading Commission's monitoring of index fund positions, as noted by (Sanders et al. 2010), can provide valuable insights into market dynamics and help identify potential sources of instability.

The mechanisms through which financial instruments such as derivatives and index funds contribute to increased volatility in agricultural commodity prices are multifaceted. Speculation, financialization, liquidity dynamics, and macroeconomic interactions all play critical roles in shaping price behavior. As agricultural commodities continue to be integrated into global financial markets, understanding these mechanisms will be essential for managing volatility and ensuring market stability.

The present article develops a critical perspective on food sector financialization, and presents evidence of how financial actors and regulatory changes have intensified volatility in food markets with substantial implications for global economic stability. By the study of how financial derivatives and index funds impact the volatility of agro-food markets, this article makes a contribution to the understanding of this phenomenon, and then proposes some policy measures accordingly.

Future markets operations are related with direct producers, storage companies, and food processors. These aforementioned actors have a large proportion of speculative activities; they are related to non-commercial activities whose speculative spot operations are highly leveraged. Financial depth and power are behind the leverage levels in the raw materials market, enhancing risk exposure through guarantees. The guarantees are a proportion of the notional value of the contract and, in general, are risk measures that reflect volatility in one day—that is, the maximum expected loss for the asset calculated in one day.

From a normative point of view, the traditional nature of guarantees, also called margins, implies protection insurance in organized derivatives markets, being a mechanism through which the clearing house minimizes the risk of non-compliance, since in the event of a loss scenario, it will use the guarantees to liquidate the position. However, this control mechanism can also be treated as a risk enhancer through leveraging.

Table 3 shows the leveraging of food commodity futures markets. For example, to buy or sell a future contract on corn in the CME—Chicago Market Exchange—it is necessary to have initial liquidity of USD 1200; however, the exposure we have to risk is USD 20,000. The calculated level of leverage is 16 to 1, that is, only one-sixteenth of the investment value is required. In this way, when we see this operation as speculative, it represents liquidity advantages over a cash operation, where the total capital of the investment value would be required (cited in Table 3 as notional value).

On the other hand, if we assume that the participants do not face liquidity constraints, the leverage ratio suggests that, if they had the total investment capital, they could amplify their risk between 14 and 22 times in raw materials operations (first five lines of Table 3), considering the total amount of the investment. For instance, with USD 20,000 in liquidity, they could increase the exposure of a derivatives operation based on fluctuations in corn prices to more than USD 333,000.

Table 3. Leverage in futures contracts.

Future	Price	Contract Size	Quotation Unit	Margin (USD)	Notional Value (USD)	Leverage
soybean	998.4	5000 bushels	U.S. cents	2200	49,920	22 a 1
S&P 500	5652	USD 50 per point	USD	13,800	282,600	20 a 1
corn	400.2	5000 bushels	U.S. cents	1200	20,010	16 a 1
wheat	549.6	5000 bushels	U.S. cents	1900	27,480	14 a 1
soybean oil	41.68	60,000 pounds	U.S. cents	1700	25,008	14 a 1
IPC	52,480	10 pesos per point	MXN	48,648	524,800	10 a 1
Bimbo	70.92	100 shares	MXN	927	7092	7 a 1
Grum	369.8	100 shares	MXN	4485	36,980	8 a 1

Source: Own elaboration with information from CME and MexDer.

This article's objective, therefore, is to demonstrate the level of integration between the corn market, ETFs, and the dominant grain companies worldwide. By quantifying its volatility, we aim to illustrate the increases in historical volatility, not only during the food and subprime crisis, but as a persistent feature of the corn futures market.

2.5. Impact of Volatility on Food Security and Emerging Economies

Although this study is not about import and export prices, and it is focused on how financial derivatives and index funds impact the volatility of agro-food markets, it is important to mention that general price volatility can disrupt the availability of food, affect access to nutritious diets, and undermine the stability of food systems, thereby exacerbating food insecurity. Such impacts of increased price volatility on food security and economic stability are particularly pronounced in emerging economies that rely heavily on agricultural imports or exports. This multifaceted issue is compounded by the economic dynamics of emerging economies, where agricultural sectors often play a critical role in overall economic health and social stability.

In emerging economies, food security is fundamentally linked to the availability of food, which is influenced by both domestic production and imports. Price volatility can lead to fluctuations in food availability, as sudden increases in prices can make essential food items unaffordable for large segments of the population. For instance, Erokhin et al. highlight that food imports are crucial not only for saturating domestic markets but also for ensuring stability in food availability, which is a key pillar of food security (Erokhin et al. 2022). Similarly, Kavallari and Fellmann emphasize that food security encompasses availability, access, utilization, and stability, with volatility in food prices directly impacting these dimensions (Kavallari and Fellmann 2014).

The financialization of the food system, driven by investment funds like those cited by Gilbert (2010), Kerckhoffs et al. (2010) and Clapp (2019), fuels speculative trading, particularly through ETFs and Commodity Index Funds (CIFs). This interconnexion between the food system and the financial sector increases food price volatility, particularly during economic downturns like the 2008 recession (Cheng and Xiong 2014; Liu and Tang 2010). Following this, the present study examines the consequences of this financialization on food system prices, highlighting its substantial impact on food security and economic stability.

More broadly, the economic implications of price volatility extend beyond food security to broader economic stability. In many emerging economies, agriculture is a significant contributor to GDP and employment. Price shocks can lead to decreased agricultural output and income, which in turn affect household purchasing power and food access.

More recently, the COVID-19 pandemic has been shown to disrupt food supply chains and lead to increased food prices, further straining the economic stability of countries like Indonesia, where food availability decreased significantly during the pandemic (Akbar et al. 2022; Khawar et al. 2021). This situation illustrates how other types of external shocks can exacerbate existing vulnerabilities in food systems, particularly in economies that are already grappling with high levels of poverty and unemployment.

Moreover, the relationship between economic growth and food security is complex and often cyclical. Economic downturns can lead to increased food insecurity, which can further hinder economic recovery. For instance, research indicates that economic growth in Bangladesh has a positive long-term impact on food security, but this relationship can be destabilized by external shocks such as climate change or global market fluctuations (Ceesay and Fanneh 2022). The instability of agricultural imports, as noted by Zhang et al., can undermine national food security by affecting the reliability of food supplies, particularly in countries that are heavily dependent on imports (Zhang et al. 2022). This dependency creates a precarious situation where any disruption in global markets can have immediate and severe consequences for food availability and prices.

The implications of price volatility are particularly severe for low-income households in emerging economies. These households often spend a larger proportion of their income on food, making them more susceptible to price fluctuations. As noted by Ceesay and Fanneh, the economic growth of countries can be significantly affected by food security, particularly in regions where agricultural production is a primary economic driver (Ceesay and Fanneh 2022). When food prices rise, households may be forced to reduce their consumption of nutritious foods, leading to adverse health outcomes and further entrenching cycles of poverty and food insecurity.

In addition to direct economic impacts, price volatility can also have broader social implications. Increased food prices can lead to social unrest, as seen in various global food crises where spikes in food prices have triggered protests and political instability (Katarzyna 2023). The interconnectedness of food security and political stability is critical, as food insecurity can exacerbate tensions and lead to conflict, particularly in regions already facing socio-political challenges (Kaze 2021). The need for comprehensive policies that address both food security and economic stability is thus paramount, particularly in the context of emerging economies that are vulnerable to both internal and external shocks.

Furthermore, climate change poses an additional layer of complexity to the issue of food security in emerging economies. Unpredictable weather patterns and extreme weather events can lead to crop failures and increased volatility in food prices. As highlighted by Sabola, the impacts of climate change on agricultural trade and food security are particularly concerning for emerging economies, where agriculture is a vital component of the economy (Sabola 2023). These countries often lack the infrastructure and resources to adapt to changing climatic conditions, making them more vulnerable to food insecurity as prices fluctuate.

The role of government policy in mitigating the impacts of price volatility on food security cannot be overstated. Effective agricultural policies that promote stability in food prices and enhance the resilience of food systems are essential. For instance, policies aimed at improving agricultural productivity, investing in infrastructure, and supporting smallholder farmers can help stabilize food supplies and prices (Bumbac 2019). Additionally, social safety nets and targeted interventions can protect vulnerable populations from the adverse effects of price volatility, ensuring that access to food remains stable even in times of economic distress (Fitriyani 2022).

In conclusion, the impact of increased price volatility on food security and economic stability in emerging economies is profound and multifaceted. The interplay between food availability, access, and economic stability underscores the need for integrated approaches that address the root causes of food insecurity while promoting economic resilience. As emerging economies continue to navigate the challenges posed by global market fluctuations, climate change, and socio-political instability, the development of robust food security strategies will be critical to ensuring sustainable economic growth and social stability. Focusing on how financial derivatives and index funds impact the volatility of agro-food markets, the present study develops a critical perspective on food sector financialization, and presents evidence of how financial actors and regulatory changes have intensified volatility in food markets with substantial implications for global economic stability.

3. Materials and Methods

Up to this point in the research, we have found that regulatory modifications, legal interpretations, the commodification and commercialization of agri-food materials, and the intrinsic characteristics of derivatives make them prone to use as speculative vehicles. In the next section, we test for the existence of both own and cross-volatility spillovers between commodity futures, the financial market, ETFs (Exchanged-Traded Funds), and the world-class flour company, GRUMA. The objective is to analyze the existence of volatility transfer between various financial assets in the agri-food sector, to demonstrate the deepening, spread and persistence of financial volatility. The literature has shown renewed interest in the study of the transmission of volatility between different markets. As has been shown in the literature review, the contributions have focused on the transmission of volatility between stock market indices, and recently there has been an interest in analyzing the effects that index funds have. Specifically, the literature has focused on the financialization of food, where index funds play an important role in the financial deepening of the sector.

As we have noted, the link between the financialization of food and investment funds associated with agri-food companies (Gilbert 2010; Kerckhoffs et al. 2010; Clapp 2019) allows us to argue for the recurrent existence of speculative operations through these instruments, particularly ETFs and the operation of Commodity Index Funds (CIFs). The MOO ticker ETF, managed by VanEck Vectors, is indexed to the MVIS Global Agribusiness Index (MVMOOTR). According to Clapp (2019), in 2018 this fund had USD 850 million under management, making it one of the largest in agribusiness. MOO is linked to ADM, the leading company in the "Agricultural Operation" industry, with a market capitalization of USD 33.891 billion, as well as the "Agricultural Products" industry through Wilmar and Bunge, with market capitalizations of USD 21.620 billion and USD 10.919 billion, respectively. These companies rank first and second in the raw materials sectors. PBJ (Invesco Powershares Dynamic Food and Beverage Portfolio) is managed by Invesco and mirrors the behavior of the Dynamic Food & Beverage IntellidexSM Index, which is also linked to ADM. PBJ is composed of companies in the processed food, fast food, trade, services, and food retail industries (Clapp 2019). In summary, the volatility of asset prices plays a crucial role in shaping investment decisions within the broader financial markets, including the S&P 500 ETF. Investors must navigate this complexity, balancing the inherent risks of commodity price fluctuations with their investment strategies. The involvement of these actors has exacerbated price volatility in food markets, linking food prices with the fluctuations of other financial assets, particularly during crises, as witnessed in the 2008 global recession (Cheng and Xiong 2014; Liu and Tang 2010). This study investigates how this financialization affects the food system prices, raising significant challenges for both food security and economic stability.

The contribution is to integrate large corporations such as ADM, Bunge and GRUMA into the analysis, which are predominant actors in the agricultural and food sector. As Candila and Farace (2018) point out, there is little research that addresses the impact of the contagion of the volatility of agricultural products on financial stability. Some studies, such as those by Hamadi et al. (2017) explore the transmission of volatility between agricultural products and other raw materials; in our case, we integrate into the analysis corporations with a focus on the raw materials market, especially in the agri-food sector.

As it is possible to see in Table 4, we worked with the S&P 500 index as a representative of overall financial activity, as well as the main global grain trading companies listed on the NYSE, ADM and Bunge. Additionally, we gathered information from two ETFs, MOO and PBJ. The final layer focuses specifically on corn, considering the RM grain futures contracts and the shares of the world's largest flour company, GRUMA. MOO includes fertilizer companies like Nutrien and Mosaic, and machinery manufacturers like Deere & Co. from Moline, IL, USA, or AGCO from Duluth, GA, USA, which make tractors, combine harvesters and other agricultural machinery, as well as food and meat product producers such as Tyson Foods, and animal health companies such as Zoetis. The PBJ Index is composed of 30 US food and beverage companies. These are companies that are principally engaged in the manufacture, sale or distribution of food and beverage products, agricultural products and products related to the development of new food technologies, like Constellation Brands, Coca Cola, Kraft Heinz, General Mills and Pilgrim's Pride. The final layer focuses specifically on corn; considering the RM grain futures contracts, the corn future has as its underlying the spot prices in the real type 2 yellow corn market in the United States within the CME. Finally, the share price of the Mexican corporation GRUMA, which is one of the largest corn flour mills in the world, has a link to the future price of corn.

Table 4. Assets and identifiers.

Variable	Identifier in the Model
S&P 500	RSP
ADM	RDM
Bunge	RBG
MOO	RMOO
PBJ	RPBJ
Corn Futures	RM
GRUMA	RGR

Source: Own elaboration.

The interplay between these asset classes highlights the importance of understanding how assets related to commodity price movements can impact overall systemic risk and investment choices.

The DCC-GARCH model was chosen to investigate spillover effects. Contagion effects refer to the transmission of volatility from one market or asset to another. The DCC-GARCH model is appropriate for this analysis because it captures two key elements: GARCH (Generalized Autoregressive Conditional Heteroskedasticity), which models the time-varying volatility of each individual asset, as volatility tends to cluster and shift over time; and DCC (Dynamic Conditional Correlation), which focuses on the correlations between the volatilities of different assets. This model allows those correlations to evolve over time, reflecting the dynamic nature of contagion effects (Engle 2002; Billio and Caporin 2009). A strong correlation indicates that a change in the volatility of one asset is likely to be accompanied by a similar change in the volatility of another (Celık 2012).

The DCC-GARCH model was chosen to investigate spillover effects due to its robust ability to analyze both time-varying volatilities and the dynamic interdependencies among assets. Contagion effects, defined as the transmission of volatility from one market or asset to another, are particularly relevant in highly integrated financial and commodity markets. The model captures two key elements, as follows:

1. GARCH (Generalized Autoregressive Conditional Heteroskedasticity), which allows for the modeling of time-varying volatility in individual assets. This is crucial because financial and commodity markets often exhibit volatility clustering, where periods of high volatility are followed by more high volatility, and low-volatility periods follow similar patterns. This characteristic enables the model to reflect the evolving risk structure of each market;
2. DCC (Dynamic Conditional Correlation), which focuses on the correlations between the volatilities of different assets. Unlike static correlation measures, this component enables the model to adapt correlations dynamically over time, capturing the fluid nature of relationships between markets or assets under various economic conditions. This feature is particularly important for understanding contagion, as it reveals how shocks in one market propagate through others, and whether these relationships intensify during periods of financial stress or crisis (Engle 2002; Billio and Caporin 2009).

The combination of these two components makes the DCC-GARCH model particularly well-suited for studying the interplay between financial and commodity markets. In this study, it is employed to detect and quantify volatility spillovers, providing insights into how price fluctuations in one market or asset class may influence others. A strong correlation indicates that a change in the volatility of one asset is likely to be accompanied by a similar change in the volatility of another, as noted by Celık (2012). This dynamic capability is essential for understanding the interconnectedness of markets and the systemic risks associated with financialization.

In addition, the analysis of the returns of financial series through GARCH models, with both symmetric and asymmetric variations, enhances the granularity of the study. These models allow for the following:

1. **Structural volatility (ω).** This parameter represents the long-term volatility level intrinsic to each asset, independent of external shocks;
2. **Sensitivity to past shocks (α).** This parameter captures the extent to which historical shocks influence future volatility, shedding light on how markets react to sudden changes;
3. **Volatility persistence (β).** This parameter reflects how long the impact of volatility shocks lasts over time, indicating whether markets exhibit prolonged responses to perturbations.

Additionally, an asymmetric effect (γ) can be incorporated to account for leverage effects, where negative shocks tend to have a greater impact on volatility than positive shocks of the same magnitude. This feature is critical in financial and commodity markets, where downside risks often drive market behavior and decision-making.

By integrating these components, the DCC-GARCH model not only identifies volatility transfer, but also characterizes the nature and strength of these interconnections across various markets, sectors, and financial assets. This approach enables a nuanced understanding of how financialization has reshaped commodity markets, providing both theoretical and empirical support for the study's objectives. Furthermore, it allows policymakers and market participants to identify periods of heightened risk and potential interventions to mitigate systemic volatility.

3.1. Data Analysis Process and Interpretation of the Results

Once the justification for the selection of variables was presented, the data processing was performed as follows: the historical series of closing prices wa selected for the period from 2007 to 2020, with a total of 3105 daily observations. Regarding the future of corn, the soon-to-expire contract published by Yahoo finance was used.

The cleaning of the data was carried out through a joint of the time series using the listing date as the ID. The definition of the study period refers to the historical correspondence of information, and includes 2007 in order to capture the effect of the crisis. This is subprime, considering that the literature indicates that the transfer of volatility increases during periods of crisis. The coincidences of the closing quote dates were established, and we obtained a total of 3086 observations with a coincidence rate greater than 96%. In the case of missing observations, they were eliminated for all fields. We use a listwise detection method to remove any data record with missing values. This method is consistent when the missing data are not randomly distributed. The missing data are related to working days and holidays and the fiscal year; these kinds of missing of observations have a regularity. We do not follow imputation methods given the nature of the data. Regarding standardization and missing observations, the closing quotes of the financial variables were in index points, USD per share, MXN per share and cents per bushel of corn. To work with standardized data, continuous daily performance rates were calculated. The calculation of the growth rate was carried out on the immediately following business day. Regarding atypical cases, no quotes were ruled out; on the contrary, we sought to capture the heterogeneity of returns, which is an essential factor in variance modeling with MGARCH. The DDC model uses incorporated mechanisms to handle outliers through this method, using control strategies that adjust data distribution. Consistent patterns suggest that outliers might be part of a recurring phenomenon, as datasets with similar outliers have been observed in the past. The objective of this research is to identify volatility during crisis episodes, highlighting the significant role of outliers in this context. It has been recognized that outliers are crucial, as they serve as indicators of extreme events, through which volatility is transmitted. By analyzing these anomalous observations, we aim to gain deeper insights into how crises influence market dynamics, and to understand the implications of these outliers for volatility spillovers in the assets selected.

3.2. Economic Explanation of the Model Parameters

Dynamic correlation modeling, as it is important between financial assets, implies that there is a relationship that goes beyond a static state, since economic conditions, market sentiment and financial crises can alter the correlation between assets. In this way, DCC models provide a representation of the behavior and integration of markets. As noted, there is a correlation matrix for each record, and this allows the visualization of increases in the correlation and their persistence over time. The sensitivity metric tells us how strong the volatility spillover between assets is. This parameter adds evidence to the composition of conditional volatility, since it shows that a component comes from the relationship between assets and markets, not only from the historical volatility of the asset over time, since the correlation of assets and their link with the past is modeled, as well as their persistence over time. The model is made up of two main segments, incorporating the univariate volatility transfer parameters described in the GARCH family models, so the parameters omegas, alpha, beta and gamma are interpreted as already described. Additionally, with this model, it is possible to know how the correlation has changed over time; it should be noted that there is a correlation matrix for each record. This allows us to visualize whether, in the event of a scenario such as a financial crisis, pandemic, etc., the study variables keep their volatility transfer constant, or whether it is exacerbated by economic changes

The univariate variance component represents the time-varying volatility of an individual asset. It does not directly represent the correlation between assets, but is a crucial building block for calculating the dynamic conditional correlations.

3.3. Study Limitations

It can be stated that the transfer of volatility occurs, and there are limitations to determining the causality between the variables. It is difficult to determine whether volatility spillover occurs from S&P 500 companies to the corn futures market. Theoretically, it can be assumed that the riskiest assets, such as index funds, are those that generate volatility, and this risk is transmitted to the index and the stocks in particular. The link of assets with respect to corn spot prices is complicated, since the availability of data is limited with respect to corn prices. However, the periodicities are annual or monthly, diversified by region and influenced by local government subsidies. Regarding the future of the price of corn, it is necessary to construct a historical series of corn prices considering the rollover of the contract, since the possible price differential of the contract that is about to expire and the one that is about to be issued may have contagion effects and volatility. The model does not fully capture the high intraday volatility; if the opening and closing movement had a wide range, this dispersion is not modeled. In the case of ETFs, some of the assets that compose them are within the analysis, but there are limitations to differentiating how much volatility comes from the composition of the ETF. Regarding the limitations of the DCC GARCH model, firstly, they assume that financial assets are linearly correlated, which limits the analysis of complex relationships that arise mainly in periods of high volatility. By considering the normality of the standardized residuals, the model leaves out of the analysis a high concentration of extreme data that represent the impacts of highly improbable events, such as a financial crisis. The generation of forecasts is limited, since if the series is seasonal, it can trigger biases in the estimation of volatility and correlation.

4. Results of the Study

The selected period for the analysis is 2007–2020, and the study is conducted at three levels. In the first level, the DCC dynamic conditional correlations are presented, which include the main grain trading companies RADM and RBG, the ETFs RMOO and RPBJ, the S&P 500 stock market index (RSP), the corn flour company RGR, and the RM corn futures. At the second level, the multivariate volatility spillovers between the dominant global grain trading corporations and the ETFs demonstrate the integration between RADM-RBG and RMOO-RPBJ. Finally, at the third level, the relationship between RSP, representing overall financial activity, the leading corn flour corporation GRUMA (RGR), and the future of corn on the CME (RM) is analyzed. The results of the DCC Multivariate GARCH model are examined to identify volatility transfers across the markets.

4.1. Robustness Tests

The construction of the model and the process of discrimination followed three criteria: existence of heteroskedastic variance, level of significance of the univariate models and principle of parsimony and lower AIC. The statistical test of heteroscedastic variance (March Test) is a test that statistically validates the existence of heteroskedastic variance when Ho is rejected.

H0. *Constant variance.*

H1. *Heteroscedastic variance.*

The March Test (see Table 5) was applied in R-Studio to the historical series of the returns of the financial assets included in the model, considering 1 to 30 lags.

Table 5. March Test.

Assets	Lags	*p*-Value
RSP, RMOO, RPBJ, RADM y RBG	1 to 30	0.0
FM	1 to 30	0.024
RGR	1 to 15	0.025

Source: Own elaboration.

4.2. Parameter Significance and Parsimony

Prior to multivariate modeling, different univariate models were estimated, including SGARCH, IGARCH, EGARCH and GJRGARCH. Models whose parameters were not statistically significant, with higher AIC, along with those that were more complex were discriminated. Order models (1,1) were privileged, complying with the principle of parsimony. Table 6 shows the model with the best AIC. The SGARCH, IGARCH, EGARCH and GJRGARCH models were tested. The parameter values were rounded to two decimal places. A *p*-value less than 0.1 indicates that the parameter should be included in the model.

Table 6. Univariate models of conditional variance between 2007 and 2020.

Asset	Model	Long-Term Average Variance (ω)	Component ARCH (αi)	Component GARCH (βi)	Leverage (γ)	AIC
RSP	EGARCH (1,1)	−0.32	−0.15	0.96	0.2	−6.5
	p-Value	0	0	0	0	
RADM	EGARCH (1,1)	−0.1	−0.05	0.98	0.095	−5.27
	p-Value	0	0	0	0	
RBG	EGARCH (1,1)	−0.1	−0.05	0.99	0.09	−5.38
	p-Value	0	0	0	0	
RPBJ	GARCH (1,1)	3.00×10^6	0.1	0.86	NA	−6.59
	p-Value	0.01	0	0	0	
RMOO	EGARCH (1,1)	−0.1	−0.05	0.99	0.09	−6.02
	p-Value	0	0	0	0	
RM	GJRGARCH (1,2)	5.00×10^6	0.06	β1 = 0.35 β2 = 0.55	0.06	−5.26
	p-Value	0.03	0	0.0–0.0	0	
RGR	GARCH (1,1)	6.80×10^6	0.29	0.6	NA	−5.38
	p-Value	0	0	0	0	

Source: Own elaboration, made in R-Studio.

4.3. Dynamic Conditional Correlations

The DCC model (Table 7) is significant at a 99% confidence level. For the returns of RADM and RBG, the RMOO and RPBJ ETFs, and RSP, RGR, and RM, the univariate model is symmetric, while for the remaining assets, it is exponential.

Table 7. Parameters of the DCC model between 2007 and 2020. The DCC model is presented for all the assets under study. The univariate variance responds to symmetric and asymmetric models.

Assets	Univariate Variance	Shock Size DCC(a)	Persistence DCC(b)	AIC
RM, RMOO, RBG y RGR	GARCH (1,1)	0.015437 ***	0.967665 ***	−43.490
RSP, RPBJ y RADM	EGARCH (1,1)			

*** Indicates statistical significance at 1% level. In this context, it means that the coefficients for DCC(a) (shock size) and DCC(b) (persistence) are statistically different from zero with a very high degree of confidence. Essentially, the data strongly supports the presence of these effects in the model. Source: Own elaboration. The estimate is our own and was made in R-Studio.

To examine how the markets were integrated, dispersion measures were calculated for each asset pairing (since the DCC model produces a correlation matrix for each moment t−it-it−i analyzed). In Table 8, we see that most assets exhibit a positive and strong DCC between 2007 and 2020. Only the two assets directly associated with corn (RM and RGR) show a slightly negative correlation in the first quartile. In the remaining quartiles of these assets, positive correlations are observed, but they are less intense compared to the other assets.

Table 8. Descriptive statistics on the estimates of the DCC model for the period 2007 to 2020.

	Min	P25	Median	P75	Max
RM_RSP	−7%	6%	10%	16%	33%
RM_RGR	−17%	−1%	3%	6%	22%
RM_RADM	−21%	0%	6%	12%	34%
RM_RPBJ	−16%	2%	7%	12%	29%
RM_MOO	−1%	15%	20%	25%	42%
RM_RBG	−7%	6%	10%	17%	34%
RSP_RGR	3%	19%	23%	28%	45%
RSP_RADM	22%	49%	53%	58%	74%
RSP_RPBJ	51%	70%	75%	78%	86%
RSP_MOO	52%	76%	79%	81%	88%
RSP_RBG	6%	36%	43%	49%	67%
RGR_RADM	−23%	7%	11%	16%	40%
RGR_RPBJ	−2%	14%	19%	24%	46%
RGR_RBG	−2%	16%	20%	25%	49%
RADM_RPBJ	−13%	9%	14%	20%	44%
RADM_MOO	27%	49%	53%	57%	72%
RADM_RBG	30%	51%	56%	61%	74%
RPBG_MOO	27%	46%	51%	55%	71%
RPBG_RBG	36%	55%	61%	64%	77%
RMOO_RBG	15%	36%	41%	47%	67%

Note: Each column presents percentiles of the estimated Dynamic Conditional Correlations (DCCs). *Min* and *Max* represent the minimum and maximum observed DCCs. *P25*, *Median*, and *P75* represent the 25th, 50th, and 75th percentiles, respectively, providing insights into the distribution of correlations. Source: own elaboration based on conditional correlations between the S&P 500 and agribusiness companies between 2007 and 2020.

In the next point we will analyze the dynamic conditional correlations classified by sectors, since it is from 2007 that we have the rest of the data and it is possible to make contrasts. DCC models can help identify contagion effects, where shocks in one market or asset spread to others. A sudden increase in correlation between seemingly unrelated assets might indicate a contagion effect, highlighting systemic risk.

4.4. Volatility Spillovers

The analysis conducted in this research provides evidence of financialization in the agri-food industries by demonstrating the transfer of volatility between markets; first, between the agro-industrial companies RADM and RBG and the RSP index, followed by the spillovers between them. The study will also present the integration between RADM and RBG, along with the ETFs RMOO and RPBJ, within the dominant global grain trading corporations.

The right column in Figure 2 describes the historical conditional correlations for RSP, RADM, and RBG, respectively. There is evidence of volatility transfer, where the correlation is strong, positive, and consistent, indicating that the markets are more integrated. The DCC model shows that ADM responds to financial market movements by more than 30%. Bunge's link to the index is slightly weaker, with a dip in March 2015, but most observations show correlations with the index ranging from 20% to 60%.

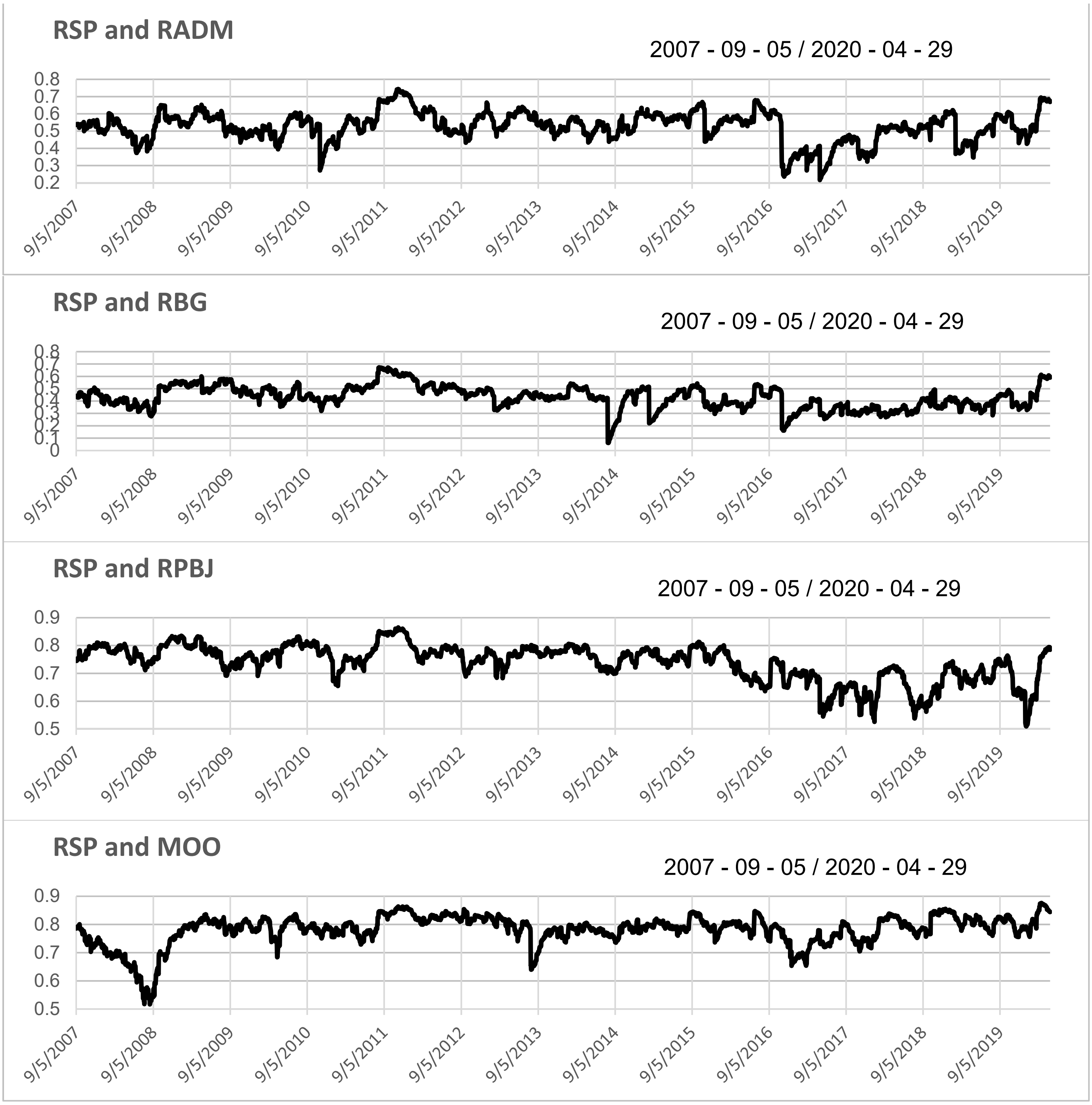

Figure 2. Integration of the financial market with agro-industrial companies and ETFs. Source: Own elaboration. Conditional correlations between the S&P 500 and agribusiness companies between 2007 and 2020.

In the period of analysis, the volatility is persistent and positive, oscillating between 30 and 70%; that is, there are major spills greater than 30% between the RSP and RDAM. Above all, we see episodes such as the 2008 crisis, featuring problems in the Eurozone and food crises, with a positive shock in 2011 showing a volatility spill of 70%. The most important negative shock was seen in 2016, which marked the beginning of problems between China and the USA. Between RSP and RBG, the volatility transfer is lower, except for in the 2011 food crisis, and there were even periods where spills only represent 1%, that is, with no relationship. This would be consistent with a dominant company like GRUMA.

In Figure 3, a similar behavior can be observed, where the spillover of 40% during the 2011 crisis is high and persists. Between RSP and the ETF RPBJ, persistent volatility is very high, and it shoots up at the beginning of the Eurozone and food crises, while volatility reduces to 50% during 2016 and 2019 and increases radically in the face of the pandemic. Regarding RSP and MOO, we see that during the mortgage crisis of 2008, there is a dissociation, but it is positive and high in 2011, and above all it remains in the range of 70% and 80% compared to the RPBJ. Furthermore, the analysis shows the effect of the COVID-19 crisis on assets in the agro-food sector, where volatility soars, and the most significant spillover effect occurs between RSP and the ETFs RMOO and RPBJ, exceeding 80%.

Concerning the volatility between ETFs and company shares, we can see from Table 8 that RADM and RMOO show persistence and high volatility spillovers of up to 72%, and Bunge shows a similar behavior with respect to RMOO, although its persistence is reduced during the period. That is, they are more associated with agribusiness ETF. With respect to RPBJ, even RADM has a negative relationship that reduces over time, and with respect to RBG, it is high and persists with RPBJ, even reaching close to 77%. Regarding RM, it has more volatility compared to RMOO. That is, RADM is less associated with a food-related index, while Bunge is more associated. We must remember the distinction of an ingredient focus vs. a raw material focus; ADM has historically shown a stronger emphasis on value-added ingredients for food and beverage applications. This translates into a likely broader range of specialized ingredients like sweeteners, starches, and specialty proteins. Bunge, while also having ingredient-based businesses, might hold a relatively larger proportion of its portfolio in raw materials and the basic processing of grains and oilseeds. This difference is a generalization; both companies have extensive offerings in both categories.

The final level analyzes the specific relationship between RSP, RGR, and RM, with the results of the DCC univariate GARCH model presented in Table 6 to identify volatility transfer across the markets. It is important to note that this provides a general analysis, with the ETFs integrated into the analysis.

The analysis reveals that the assets exhibit a strong positive Dynamic Conditional Correlation (DCC) between 2007 and 2020. In Figure 3, while the first quartile shows a slightly negative correlation, the remaining quartiles display positive and persistent correlations, though they are less intense than those seen in traditional financial assets. The corn market appears to be the least integrated among these commodities. This finding is particularly interesting, as it reinforces evidence of the ongoing commodification and commercialization of food products. It is worth noting that the initial inclusion of these food commodities in investment portfolios was justified by their absent or even negative correlation with other financial assets. From Table 8, it can be observed that volatility spillovers between corn futures contracts and the companies RADM, RBG, and RGR show quite a volatile relationship regarding the transfer of volatility, ranging from negative relationships of −21% to a positive relationship of 36% in the case of RADM. The negative sign indicates an inverse relationship in the spillover of volatility, where an increase in the stock price reduces the company's quotation. The price futures turned out to be more integrated with the ETFs MOO and RPBJ, exhibiting volatility spillovers of 43% and 34%, respectively, which support the hypothesis that there are spillovers of volatility between the ETFs and the futures price. This implies that in the context of decision-making for the hedging or speculation of corn contracts, the behavior of the ETF can generate volatility concerning this commodity.

Although at first glance the results may seem discouraging due to the negative correlation observed in the first quartile, this research identifies two important subtleties that strengthen the hypothesis, which we will develop further. In recent years, various analyses have provided evidence that commodity markets have increasingly integrated into financial markets, moving away from the previously observed absent and, in some cases, negative correlation rates.

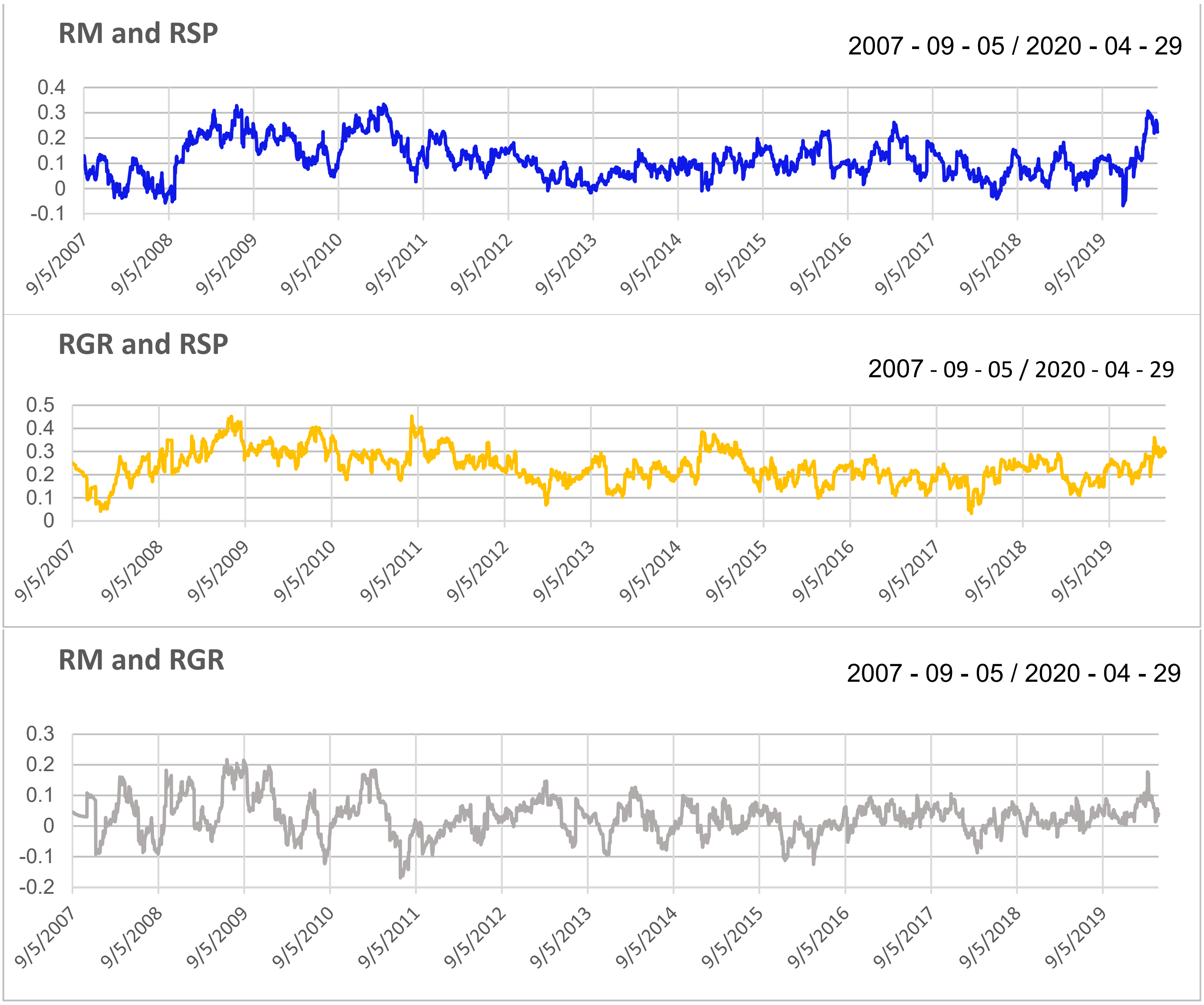

Figure 3. Dynamic conditional correlations for corn, in the period 2007 to 2020. Source: Own elaboration.

5. Discussion

5.1. Discussion on Volatility Spillovers and the Effect of Financialization on Food Security

The findings of this study align with and extend the existing body of literature on the financialization of food commodities, offering empirical evidence that supports the theoretical frameworks proposed by scholars like Clapp (2012) and Isakson (2017). These results reveal a strong correlation between financial markets and assets in agro-food commodities. The multivariate GARCH models employed in this research demonstrate how volatility spillovers between financial assets and agricultural markets have become more prominent since the early 2000s, confirming the hypothesis that financialization has intensified price volatility. This supports previous studies arguing that the commodification of food, driven by financial speculation, has fundamentally altered the pricing mechanisms of agricultural products, separating them from traditional supply-and-demand dynamics.

The implications of these results extend the theoretical premise that speculative financial actors, such as hedge funds and index investors, have had a disruptive impact on commodity markets. The study confirms the role of index funds and Exchange-Traded Funds (ETFs) in treating commodities like maize as financial assets rather than physical goods. This transformation has led to closer correlations between food prices and financial assets, eroding their role as a hedge against financial market volatility. Prior studies, such as those by Clapp (2019) and Silvennoinen and Thorp (2013), have pointed to this phenomenon, and the current study provides robust empirical support for these assertions. The findings emphasize that speculative activity in these markets contributes not only to short-term price volatility, but also to broader systemic risks affecting both financial markets and the real economy.

This study's findings also highlight the crucial role of deregulation in facilitating financial actors' growing influence in commodity markets. The Commodity Futures Modernization Act of 2000 is identified as a key factor that allowed for more speculative behavior, reducing the boundaries between physical commodities and financial assets. The look-through and functional equivalence principles, discussed in previous work by Omarova (2008), are validated by this study, as the deregulation led to increased leverage in commodity futures trading, especially in agricultural markets. This finding suggests that regulatory frameworks must be revisited to curb excessive speculation that has disconnected commodity prices from their underlying physical goods, thus increasing systemic risk.

In this sense, the findings of volatility spillovers between the S&P 500 (RSP) and the corn future (RM) align with the research of Silvennoinen and Thorp (2013) and Basak and Pavlova (2016). Although the DCC model is weak when contrasted with the other assets under analysis, the positive correlation adds to the evidence of a link between the financial sector and the food market. We must also note what Tovar-Barrera and Aranda-López (2024) point out regarding GRUMA's financial strategy, whereby its level of leverage has allowed it to sustain its significant market power. Furthermore, the company has shown a degree of large participation in the derivatives market through hedging and swaps as one of the largest corporate operators in the grain market (Staritz and Küblböck 2013). For a reference on the integration of the corn market with other financial assets, we return to the results of the analysis by Pal and Mitra (2019), who analyzed the integration of the crude oil market and the future of corn. It is important to highlight that these assets are related in terms of both supply (inputs for agricultural production) and demand (grains for the production of biofuels); they found a conditional correlation of 20% and, citing Gardebroek and Hernandez (2013), affirmed that interdependence intensifies after 2008, as it goes from weak to positive. Along the same lines, Silvennoinen and Thorp (2013), in the period of financial turbulence, found relationships that ranged between 10% and 40% between crude oil and corn. Returning to our analysis, we can affirm that there is a strong relationship between the future of corn and the S&P 500; that is, the markets are integrated.

The conditional correlation between ADM and Bunge is strong, persistent, and positive, ranging between 30 and 74%. This result aligns with expectations, given that both companies are leaders in their field and belong to the ABCD group (Murphy et al. 2012). However, their integration is barely higher in the first quartile than what these assets maintain with the financial sector. The conditional correlation between ADM and PBJ shows a weak integration of less than 20% in 75% of the cases; even the first quartile is negative at −13%. ADM is part of the tracking assets of this fund; however, the tracking is not as persistent and strong as that which PBJ has with the financial market. Bunge's integration with PBJ is positive, persistent, and strong, even though Bunge is not part of the companies indexed to the fund. The conditional correlations range between 36 and 77%. When comparing Bunge with all the assets analyzed, it maintains the greatest integration with PBJ. Moo, the fund associated with agribusiness with the highest level of managed assets, presents cross-volatility spillovers within the sector. This fund responds to the fluctuations of ADM, Bunge, and PBJ between 15 and 72% of their prices. It is notable that this figure is below its relationship with the S&P500, even though this fund is not indexed to it.

The broader implications of these findings are significant, especially in terms of food security and economic stability. As previous studies, such as those by Murphy et al. (2012) and Clapp (2019), have pointed out, the financialization of agricultural markets directly impacts the availability and affordability of basic foodstuffs, particularly in emerging economies. The study demonstrates that volatility spillovers from financial markets into commodity markets exacerbate price instability. The speculative nature of these financial investments makes food prices more volatile and less predictable, threatening the food security of vulnerable populations. This supports the hypothesis that financialization poses a significant risk to global food systems, and the study's results strengthen the case for regulatory interventions.

The spillover effects of volatility between financial assets and food commodities heighten the risk of price shocks and threaten food security, as speculative activity in the financial markets influences the availability and affordability of basic food products. The aforementioned phenomenon has important effects on the economic growth of countries. Countries can be significantly affected by food security, particularly in regions where agricultural production is a primary economic driver (Ceesay and Fanneh 2022). This study reaffirms previous research linking financialization with increased food price instability and highlights the need for urgent regulatory measures to mitigate these risks. Mitigating the impact of food price volatility on food security necessitates strong government action. Effective agricultural policies are crucial for price stability and resilient food systems. These include measures to improve agricultural productivity, upgrade infrastructure, and provide direct support to smallholder farmers (Bumbac 2019). Equally important are social safety nets and targeted assistance programs to protect vulnerable populations from price shocks, ensuring consistent food access during economic downturns (Fitriyani 2022).

Although this article is not particularly focused on providing guidance to companies, some potential managerial implications stemming from this research highlight the intensified financialization of food commodities, indirectly through future prices, particularly maize, since the early 2000s. In fact, volatility spillover analysis reveals a complex relationship between ETF and company share price volatility. While RMOO exhibits high and persistent volatility spillovers to both RADM (up to 72%) and RBGE (similar behavior, though with reduced persistence), indicating a strong association with the agribusiness ETF, the relationship between RADM and RPBJ is notably weaker and even negative over time. Conversely, RBGE shows high and persistent volatility spillover with RPBJ (near 77%). Interestingly, RM demonstrates higher volatility than RMOO. This suggests that while ADM's (RADM) emphasis on value-added ingredients may buffer its volatility relative to the RMOO ETF, Bunge's (RBGE) potentially larger raw materials portfolio aligns more closely with the ETF's fluctuations. This observation is consistent with ADM's historical focus on specialized ingredients (sweeteners, starches, proteins) versus Bunge's comparatively higher proportion of basic raw material processing. However, it is important to note that both companies operate across a broad spectrum of agricultural products. The relatively lower volatility spillover from RMOO to RADM, despite ADM's prominent presence in the index, is a key finding, potentially attributable to the inherent volatility dampening effects of large, diversified corporations, as previously discussed with the Selene committee. Further investigation into this phenomenon, particularly in comparison with companies exhibiting higher spillover, is warranted.

The strong correlation between financial and agricultural markets, confirmed by the present study's GARCH models, demonstrates increased volatility spillovers. This underscores the need for companies operating in the agro-food sector to proactively manage price risks associated with financial market fluctuations. In fact, the findings of Hamilton and Wu (2015) directly support the need for agro-food companies to develop robust strategies for managing price risks that extend beyond traditional methods.

Deregulation's role in amplifying speculative activity necessitates a reassessment of risk management strategies, considering the potential for systemic shocks. The study's findings on the strong correlation between the S&P 500 and corn futures, along with the high and persistent volatility spillovers between key agribusiness players like ADM and Bunge, suggest a need for sophisticated hedging strategies and diversification beyond reliance on traditional supply-and-demand models. Given the increased volatility and interconnectedness highlighted by this study and papers like Hamilton and Wu (2015), the need for more sophisticated hedging strategies that go beyond simple supply-and-demand models is clear. Diversification strategies to reduce reliance on a single market are also supported by increased interconnectedness and volatility.

5.2. Discussion About Policy Recommendations

Government intervention is crucial to buffer the effects of volatile food prices on food security. Sound agricultural policies are essential to stabilize prices and strengthen food systems. This includes boosting agricultural productivity, modernizing infrastructure, and providing direct support to small-scale farmers (Bumbac 2019). Crucially, social safety nets and targeted aid programs are needed to shield vulnerable populations from the negative impacts of price shocks, ensuring consistent food access even during economic hardship (Fitriyani 2022).

The feasibility of the policy recommendations provided in this study—such as enhancing regulatory oversight on speculative trading, limiting leverage in commodity futures markets, and implementing stricter monitoring of index funds—requires careful consideration of the regulatory, economic, and political barriers that might impede their adoption and effectiveness.

One of the primary challenges is the disparity in regulatory frameworks across different jurisdictions. While developed economies with well-established regulatory institutions, such as the Commodity Futures Trading Commission (CFTC) in the United States, can enforce stricter oversight and reporting requirements, many emerging markets lack the institutional capacity to implement similar measures. This divergence poses a significant barrier to creating uniform policies for financialized commodity markets. Overcoming this issue may involve fostering international collaboration through platforms like the G20 or the Financial Stability Board (FSB). These entities can play a pivotal role in harmonizing regulatory standards globally, sharing expertise, and providing technical assistance to countries with less-developed regulatory systems. Such cooperation can enable the adoption of tailored policies that strengthen local markets without disrupting their integration into global trade systems.

It appears that large corporations are less affected by volatility at the financial system level, which shows what Clapp (2019, 2024) and others have already pointed out. This point aligns with the market power of a dominant player like GRUMA already mentioned in the results section, whereby the investigation demonstrated that the relationship between RSP and the RPBJ ETF shows consistently high volatility, spiking during the Eurozone crisis and moderating to around 50% in 2016 and 2019, before sharply increasing during the pandemic. The RSP–RMOO relationship showed a decoupling during the 2008 financial crisis, but a strong positive correlation (70–80%) emerged in 2011 and persisted, exceeding that observed with RPBJ.

The inherent tension between market stability and efficiency, as discussed in the text, is supported by various papers. For example, Hamilton and Wu (2015) analyze the effects of index-fund investing, which are a crucial part of financialization, on commodity prices. Their findings emphasize the complexity of this relationship and the challenge of regulating financialization without negatively impacting market efficiency—a situation that directly supports the need for a carefully designed incentive structure to encourage compliance without hindering market function.

To balance market stability and efficiency is another critical consideration. Stricter regulations, such as caps on leverage or increased transaction reporting, could enhance stability by reducing speculative risks. However, these measures might also inadvertently reduce liquidity, increase transaction costs, and deter participation from investors seeking diversification opportunities. Policymakers must navigate this tension carefully. A phased approach to regulation could mitigate these risks by initially targeting the most volatile and speculative market segments, such as short-term index funds or highly leveraged Exchange-Traded Funds (ETFs). Pilot programs could test the impacts of such measures in specific markets, allowing adjustments before broader implementation. This approach ensures that regulations are effective without undermining market efficiency.

The difficulty of implementing effective global regulations is highlighted by several studies in the literature. For example, Stevens and Zhang (2022) examined economic policy uncertainty and its effects on agricultural imports, implying that consistent global regulatory frameworks are difficult to establish and enforce. This reinforces the need for incentives to encourage compliance, especially in less-developed regulatory environments. Furthermore, incentivizing compliance is crucial. Resistance from market participants often arises from concerns about increased costs and operational burdens. To address this, governments and regulatory bodies could introduce incentives, such as tax benefits for compliance or reduced fees for operating in regulated exchanges. Public–private partnerships could also facilitate the development of regulatory frameworks that are both practical and aligned with market realities, fostering greater acceptance among key stakeholders.

Additionally, the complexity and opacity of financialized commodity markets are often mentioned in previous studies. Papers like that by Soana et al. (2020), which investigates the potential for bubbles in agricultural commodity markets, indirectly support the need for greater transparency to deter excessive speculation and increase investor confidence. Increased transparency, even without explicit incentives, can be seen as a form of indirect incentive to participate in a more regulated and transparent market environment. Transparency and education are equally important in addressing the challenges of financialized commodity markets. These markets are often characterized by their complexity and opacity, which can obscure the risks associated with speculative activities. Enhancing transparency through improved disclosure requirements and public access to market data could deter excessive speculation while maintaining investor confidence. Moreover, educating policymakers and market participants on the systemic risks posed by financialization, particularly its impact on food security, could help build broader support for regulatory reforms.

By addressing these issues, policymakers can refine the proposed recommendations to ensure their feasibility and effectiveness. A focus on overcoming regulatory barriers, balancing stability with efficiency, incentivizing compliance, and improving transparency will enable a more sustainable approach to mitigating the risks of financialization.

6. Conclusions

This study provides important insights into the financialization of agro-food markets, with a particular focus on the volatility spillovers between financial assets and agricultural commodities. The central question of the present article is how that financialization affects the food system, posing important challenges to both food security and economic stability.

Deepening this study using multivariate GARCH models enabled us to confirm the growing integration between financial markets and food commodities, exemplified by the case of maize. A primer contribution, the relevant findings strongly support the hypothesis that speculative financial actors, such as hedge funds and index funds, have significantly contributed to the volatility of food prices by treating agricultural products as financial assets. This process has disconnected commodity prices from their traditional supply-and-demand fundamentals, leading to greater price instability in the agro-food sector.

The results show the existence of persistent volatility spillovers over time between corn futures and the indexed funds MOO and PBJ, illustrating the relationship between these highly speculative instruments. In other words, the relationship between the indexed funds and the futures has implications for contracts with commodity prices, which in turn impacts the corporation GRUMA, which is present in an emerging country.

Furthermore, research highlights how deregulation, particularly following the Commodity Futures Modernization Act of 2000, has facilitated the increasing participation of financial institutions in commodity markets. This deregulation allowed for greater leverage in futures trading, transforming commodities like maize into speculative instruments. The study demonstrates that the regulatory environment has been a key factor enabling the rapid financialization of food commodities, contributing to systemic risks that affect both financial markets and the real economy.

A second contribution of this article is its methodological. This contribution is based on the integration of novel data, the application of DCC-GARCH modeling to food commodity markets, a granular volatility analysis, and finally, robust data handling. In terms of data integration, the inclusion of GRUMA, a significant corn processor, allows for a more nuanced understanding of how volatility impacts different stages of the corn value chain, moving beyond analysis that focuses solely on raw commodity futures. Additionally, the model's ability to capture time-varying volatility and dynamic correlations provides a more realistic representation of the interconnectedness and volatility clustering observed in these markets.

Furthermore, the use of GARCH models with symmetric and asymmetric variations provides a more granular analysis of volatility dynamics. The estimation of structural volatility (ω), sensitivity to past shocks (α), volatility persistence (β), and leverage effects (γ) offers insights into the long-term volatility levels, market responses to shocks, and the duration of those responses. This detailed analysis goes beyond simply identifying volatility transfers, providing a deeper understanding of market behavior and responses to systemic events. The study demonstrates a rigorous approach to data handling, addressing issues of missing data through listwise deletion (justified given the non-random nature of the missing data). While acknowledging limitations regarding intraday volatility and the complexity of ETF composition, this careful consideration of potential biases enhances the reliability and validity of the results. The direct incorporation of outlier data into the DCC-GARCH model also allows the analysis to be more robust in the presence of extreme market events.

In terms of the theoretical implications of the present study, the endogeneity of financialization and food insecurity are clear in this study's findings. This endogeneity reinforces the theoretical argument that the financialization of food commodities is not merely a consequence of market forces but also actively contributes to food insecurity, particularly in vulnerable populations. The observed volatility spillovers demonstrate a potential causal link. That is, financial market fluctuations directly translate into food price instability, affecting access and affordability. This endogeneity challenges simplistic models that treat financial markets and food systems as separate entities, highlighting the need for integrated approaches to policy and risk management. This supports the theoretical frameworks of Clapp (2012, 2019), Isakson (2017), and Clapp and Isakson (2018), who highlight the interconnectedness of financial and food systems.

A second theoretical implication concerns the limitations of self-regulation in financialized commodity markets. Undoubtedly, the present study's results question the efficacy of self-regulation in mitigating the risks associated with financialized agricultural markets. The documented increase in volatility spillovers following deregulation suggests that relying solely on market mechanisms to control speculation is insufficient. This underscores the importance of proactive government intervention to establish robust regulatory frameworks that curb excessive speculation and protect against systemic shocks. This challenges the purely free-market perspective of commodity trading and highlights the need for active government.

In the broadest context, this research underscores the need for future studies to focus on developing models that can better quantify the long-term impacts of financial speculation on food markets. While the current study focuses on volatility spillovers in maize, future research could expand this analysis to other key commodities, such as wheat, rice, and soybeans, to better understand the global implications of financialization. Future research should also explore region-specific strategies that account for the unique economic and institutional conditions of different markets, ensuring that regulatory interventions are both equitable and impactful.

This study demonstrates that the financialization of the agro-food sector poses serious challenges to the stability of global food systems. It provides clear evidence that speculative financial activities have amplified volatility in food prices, creating ripple effects that destabilize both the financial sector and real economies. To address these risks, policymakers must consider implementing stricter regulations on speculative trading and limiting the use of financial instruments such as index funds and ETFs in commodity markets. Future research should continue to explore the long-term impacts of financialization on food markets and assess the effectiveness of potential policy interventions aimed at reducing systemic risk and promoting global food security.

Author Contributions: M.d.R.V. and J.F.; methodology, M.d.R.V.; software, M.d.R.V.; validation, J.F., N.L. and J.F.E.-C.; formal analysis, M.d.R.V.; investigation, M.d.R.V., J.F., N.L. and J.F.E.-C.; resources, J.F.; data curation, M.d.R.V.; writing—original draft preparation M.d.R.V. and J.F.; writing—review and editing, M.d.R.V., J.F., N.L. and J.F.E.-C.; visualization, M.d.R.V.; supervision, J.F.; project administration, J.F. and J.F.E.-C. All authors have read and agreed to the published version of the manuscript.

Funding: This article was possible thanks to the support of DGAPA UNAM PAPIIT IN304523 "Inestabilidad y concentración financiera durante ciclo económico, bajo el marco institucional y legal de la banca central".

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data will be available upon request to the authors.

Conflicts of Interest: The authors declare no conflict of interest.

References

Akbar, Darma Rahim, Iram Mujahidin, and Andy Irawan. 2022. The Impact of the COVID-19's Economic Recession on Food Security in Indonesia. *IOP Conference Series Earth and Environmental Science* 1012: 012005. [CrossRef]

Baines, Jospeh, and Sandy Brian Hager. 2022. Commodity traders in a storm: Financialization, corporate power and ecological crisis. *Review of International Political Economy* 29: 1053–84. [CrossRef]

Basak, Suleyman, and Anna Pavlova. 2016. A model of financialization of commodities. *The Journal of Finance* 71: 1511–56. [CrossRef]

Basu, Parantap, and Walter Thomas Gavin. 2010. What explains the growth in commodity derivatives? *Federal Reserve Bank of St. Louis Review* 93: 1–18. [CrossRef]

Billio, Monica, and Massimiliano Caporin. 2009. A generalized dynamic conditional correlation model for portfolio risk evaluation. *Mathematics and Computers in Simulation* 79: 2566–78. [CrossRef]

Brunetti, Celso, Bahattin Büyükşahin, and Jeffrey H. Harris. 2016. Speculators, Prices, and Market Volatility. *Journal of Financial and Quantitative Analysis* 51: 1545–74. [CrossRef]

Buetow, Gerald, Jr., and Bernd Hanke. 2024. The Exchange Traded Fund Landscape: Past, Present, and Future. *Journal of Portfolio Management* 50: 164–181. [CrossRef]

Bumbac, Robert. 2019. Trends and Challenges in Food System Management in Emerging Economies: A Comparative Analysis Between Romania and Poland. *Review of International Comparative Management* 20: 491–502. [CrossRef]

Candila, Vincenzo, and Salvatore Farace. 2018. On the volatility spillover between agricultural commodities and Latin American stock markets. *Risks* 6: 116. [CrossRef]

Ceesay, Ebrima, and Momodou Fanneh. 2022. Economic Growth, Climate Change, and Agriculture Sector: ARDL Bounds Testing Approach for Bangladesh (1971–2020). *Economics Management and Sustainability* 7: 95–106. [CrossRef]

Celık, Sibel. 2012. The more contagion effect on emerging markets: The evidence of DCC-GARCH model. *Economic Modelling* 29: 1946–59. [CrossRef]

Cheng, Ing-Haw, and Wei Xiong. 2014. Financialization of commodity markets. *Annual Review of Financial Economics* 6: 419–41. [CrossRef]

Choi, Wonho Wilson, Jinyong Kim, and M. Kim. 2016. Derivatives holdings and market values of US bank holding companies. *Applied Economics* 48: 4747–57. [CrossRef]

Clapp, Jennifer. 2012. The financialization of food: Who is being fed. Paper prepared for presentation at the International Society for Ecological Economics Conference, Rio de Janeiro, Brazil, June 16–19; June 16.

Clapp, Jennifer. 2019. The rise of financial investment and common ownership in global agrifood firms. *Review of International Political Economy* 26: 604–29. [CrossRef]

Clapp, Jennifer. 2024. Countering corporate and financial concentration in the global food system. In *Regenerative Farming and Sustainable Diets*. London: Routledge, pp. 187–193.
Clapp, Jennifer, and Ryan Isakson. 2018. Risky returns: The implications of financialization in the food system. *Development and Change* 49: 437–60. [CrossRef]
Corbet, Shaen, and Cian Twomey. 2014. Have exchange traded funds influenced commodity market volatility? *International Journal of Economics and Financial Issues* 4: 323–35.
Cretí, Anna, and Bertrand Villeneuve. 2014. Commodity storage with durable shocks: A simple Markovian model. *Mathematics and Financial Economics* 8: 169–192. [CrossRef]
Drutarovská, Jana. 2014. Speculative Activities in the Financial Markets and its Relation to the Real Economy. *Journal of Public Administration, Finance and Law* 6: 144–48.
Engle, Robert. 1990. Stock volatility and the crash of'87: Discussion. *The Review of Financial Studies* 3: 103–6. [CrossRef]
Engle, Robert. 2002. Dynamic conditional correlation: A simple class of multivariate generalized autoregressiveconditional heteroscedasticity models. *Journal of Business Economic Statistics* 20: 339–50. [CrossRef]
Erokhin, Vasili, Gao Tianming, Luminita Chivu, and Jean Vasile Andrei. 2022. Food Security in a Food Self-Sufficient Economy: A Review of China's Ongoing Transition to a Zero Hunger State. *Agricultural Economics (Zemědělská Ekonomika)* 68: 476–87. [CrossRef]
Fama, Marco, and Mauro Conti. 2022. Food security and agricultural crises in a financialized food regime. *Cambio: Rivista Sulle Trasformazioni Sociali* 23: 85–97. [CrossRef]
Field, Sean. 2016. The Financialization of Food and the 2008–2011 Food Price Spikes. *Environment and Planning a Economy and Space* 48: 2272–90. [CrossRef]
Fitriyani, Zenita Afifah. 2022. Is a Food Security Program a Solution in Family Economic Resilience? *Mega Aktiva Jurnal Ekonomi Dan Manajemen* 11: 19. [CrossRef]
Gardebroek, Cornelis, and Manuel A. Hernandez. 2013. Do energy prices stimulate food price volatility? Examining volatility transmission between US oil, ethanol and corn markets. *Energy Economics* 40: 119–29. [CrossRef]
Gilbert, Christopher L. 2010. How to understand high food prices. *Journal of Agricultural Economics* 61: 398–425. [CrossRef]
Hamadi, Hassan, Charbel Bassil, and Tamara Nehme. 2017. News surprises and volatility spillover among agricultural commodities: The case of corn, wheat, soybean and soybean oil. *Research in International Business and Finance* 41: 148–57. [CrossRef]
Hamao, Yasuhi, Ronald W. Masulis, and Victor Ng. 1990. Correlations in price changes and volatility across international stock markets. *The Review of Financial Studies* 3: 281–307. [CrossRef]
Hamilton, J. D., and J. C. Wu. 2015. Effects of Index-fund Investing on Commodity Futures Prices. *International Economic Review* 56: 187–205. [CrossRef]
Hsieh, Wen-Liang G., and Chin Ching-Fang. 2016. The Information Content of Futures Open Interest and Its Relation to Trading Activities. *Tai Da Guan Li Lun Cong* 26: 151. [CrossRef]
Hu, Yifan. 2023. Exploring Hedge Fund Strategies in Portfolio Management Using Financial Derivatives and Their Impact on Market Volatility. *Advances in Economics Management and Political Sciences* 62: 69–76. [CrossRef]
Irwin, Scott H. 2013. Commodity Index Investment and Food Prices: Does the "Masters Hypothesis" Explain Recent Price Spikes? *Agricultural Economics* 44: 29–41. [CrossRef]
Irwin, Scott H., and Dwight. R. Sanders. 2011. Index Funds, Financialization, and Commodity Futures Markets. *Applied Economic Perspectives and Policy* 33: 1–31. [CrossRef]
Isakson, Ryan. 2017. Food and finance: The financial transformation of agro-food supply chains. In *New Directions in Agrarian Political Economy*. London: Routledge, pp. 109–36.
Isakson, Ryan, Jennifer Clapp, and Phoebe Stephens. 2023. The financialization of agricultural commodities: Implications for food security. In *Handbook of Food Security and Society*. Cheltenham: Edward Elgar Publishing, pp. 202–14.
Jiao, Yawen, and Pengfei Ye. 2014. Mutual Fund Herding in Response to Hedge Fund Herding and the Impacts on Stock Prices. *Journal of Banking & Finance* 49: 131–48. [CrossRef]
Katarzyna, Marzęda-Młynarska. 2023. Food Security and International Security: Tracing the Links. *Athenaeum Polskie Studia Politologiczne* 79: 70–89. [CrossRef]
Kavallari, Aikaterini, and Thomas Fellmann. 2014. Shocks in Economic Growth=shocking Effects for Food Security? *Food Security* 6: 567–83. [CrossRef]
Kaze, Tindo Narcisse. 2021. The Repercussions of Armed Conflict on Food Security in the Republic of Cameroon. *Alternate Horizons* 4: 1–6. [CrossRef]
Keenan, Liam, Timothy Monteath, and Dariusz Wójcik. 2023. Hungry for power: Financialization and the concentration of corporate control in the global food system. *Geoforum* 147: 103909. [CrossRef]
Kerckhoffs, Thijs, Roos van Os, and Myriam Vander Stichele. 2010. *Financing Food: Financialisation and Financial Actors in Agriculture Commodity Markets*. Amsterdam: SOMO.
Khawar, Sharjeel, Raheel Suleman, Saeed Akhtar, Muhammad Riaz, Tariq Ismail, Amir Ismail, and Aneela Hameed. 2021. Impact of Viral Outbreak COVID-19 on Food Security and Related Economic Consequences. *Agricultural Sciences Journal* 3: 13–25. [CrossRef]
Kitano, Shigeto. 2021. How Do World Commodity Prices Affect Asian Commodity Exporting Economies? The Role of Financial Frictions. *Applied Economics Letters* 29: 84–90. [CrossRef]

Kleinau, Christina, and Nick Lin-Hi. 2014. Does Agricultural Commodity Speculation Contribute to Sustainable Development? *Corporate Governance* 14: 685–98. [CrossRef]

Kolokolova, Olga, Ming-Tsung Lin, and Ser-Huang Poon. 2020. Too Big to Ignore? *Hedge Fund Flows and Bond Yields. Journal of Banking & Finance* 112: 105271. [CrossRef]

Krippner, Greta R. 2005. The financialization of the American economy. *Socio-Economic Review* 3: 173–208. [CrossRef]

Li, Tao, and Mark Loewenstein. 2015. Does Speculative Activity Have Real Effects? Robert H. Smith School Research Paper No. RHS 2423360. Available online: https://doi.org/10.2139/ssrn.2423360 (accessed on 4 September 2024).

Liebi, Luca J. 2020. The effect of ETFs on financial markets: A literature review. *Financial Markets and Portfolio Management* 34: 165–78. [CrossRef]

Liu, Peng, and Ke Tang. 2010. No-arbitrage conditions for storable commodities and the modeling of futures term structures. *Journal of Banking & Finance* 34: 1675–87. [CrossRef]

Mou, Yiqun. 2010. Limits to Arbitrage and Commodity Index Investment: Front-Running the Goldman Roll. Online Resource. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1716841 (accessed on 4 September 2024).

Murphy, Sophia, David Burch, and Jennifer Clapp. 2012. *Cereal Secrets: The World's Largest Grain Traders and Global Agriculture*. Oxford: Oxfam International.

Omarova, Saule T. 2008. The Quiet Metamorphosis: How Derivatives Changed the Business of Banking. *University of Miami Law Review* 63: 1041.

Omarova, Saule T. 2013. The merchants of Wall Street: Banking, commerce, and commodities. *Minnesota Law Review* 98: 265. [CrossRef]

O'Neill, Michael, and Robert E. Whaley. 2022. Effects of Nondiscretionary Trading on Futures Prices. *Journal of Futures Markets* 43: 33–68. [CrossRef]

Pal, Debdatta, and Subrata K. Mitra. 2019. Correlation dynamics of crude oil with agricultural commodities: A comparison between energy and food crops. *Economic Modelling* 82: 453–66. [CrossRef]

Rl, Manogna, and Aswini Kumar Mishra. 2021. Financialization of Indian Agricultural Commodities: The Case of Index Investments. *International Journal of Social Economics* 49: 73–96. [CrossRef]

Sabola, Gift Andrew. 2023. Climate Change Impacts on Agricultural Trade and Food Security in Emerging Economies: Case of Southern Africa. *Discover Agriculture* 2: 12. [CrossRef]

Sanders, Dwight. R., Scott. H. Irwin, and Robert P. Merrin. 2010. The Adequacy of Speculation in Agricultural Futures Markets: Too Much of a Good Thing? *Applied Economic Perspectives and Policy* 32: 77–94. [CrossRef]

Sawyer, Malcolm. 2013. What is financialization? *International Journal of Political Economy* 42: 5–18. [CrossRef]

Sias, Richard W., Harry J. Turtle, and Blerina B. Zykaj. 2016. Hedge Fund Crowds and Mispricing. *Management Science* 62: 764–84. [CrossRef]

Silvennoinen, Annastiina, and Susan Thorp. 2013. Financialization, crisis and commodity correlation dynamics. *Journal of International Financial Markets, Institutions and Money* 24: 42–65. [CrossRef]

Soana, Maria Gaia, Giovanni Verga, and Mattia Volpi. 2020. Did Index Trader and Swap Dealer Activity Produce a Bubble in the Agricultural Commodity Market? *African Journal of Business Management* 14: 9–24. [CrossRef]

Soumaré, Issouf. 2022. *Commodity Exchanges: Concepts, Tools and Guidelines*. Cheltenham: Edward Elgar Publishing.

Staritz, Cornelia, and Karin Küblböck. 2013. *Re-Regulation of Commodity Derivative Markets: Critical Assessment of Current Reform Proposals in the EU and the US (No. 45)*. ÖFSE Working Paper. Vienna: ÖFSE.

Stevens, Reid B., and Jeffery Y. Zhang. 2022. The Costs of Banks Engaging in Non-Banking Activities: A Case Study. *Yale Journal on Regulation* 39: 375–433.

Tovar-Barrera, Elizabeth, and Juan Aranda-López. 2024. Evolución Financiera de GRUMA S.A.B. de C.V. 2017–21. *Vinculategica Efan* 10: 54–67. [CrossRef]

Zapata, Hector O., Joshua D. Detre, and Tatsuya Hanabuchi. 2012. Historical Performance of Commodity and Stock Markets. *Journal of Agricultural and Applied Economics* 44: 339–57. [CrossRef]

Zhang, Zhaohua, Roshini Brizmohun, Gang Li, and Ping Wang. 2022. Does Economic Policy Uncertainty Undermine Stability of Agricultural Imports? Evidence From China. *PLoS ONE* 17: e0265279. [CrossRef]