

Tröster, Bernhard; Gunter, Ulrich

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Trading for speculators: The role of physical actors in the financialization of coffee, cocoa and cotton value chains

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Trading for speculators: The role of physical actors in the financialization of coffee, cocoa and cotton value chains

Vienna, May 2022

Bernhard Tröster (Austrian Foundation for Development Research – ÖFSE)

Ulrich Gunter (Modul University Vienna)

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Austrian Foundation for Development Research – ÖFSE
A Austria, 1090 Vienna, Sensengasse 3, T +43 1 3174010, F -150
E office@oefse.at, I www.oefse.at, www.centrum3.at



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List of Abbreviations

ADF	Augmented Dickey Fuller
AIC	Akaike's Information Criterion
BIC	Bayesian Information Criterion
C	Commercial
CFTC	Commodity Futures Trading Commission
COT	Commitments of Traders
CTHs	Commodity Trading Houses
DNM	Detailed Netting Measure
EXR	Trade Weighted U.S. Dollar Index
GARCH	Generalized AutoRegressive Conditional Heteroscedasticity
GVCs	Global Value Chains
IT	Index Traders
LOI	Long Open Interest
MM	Managed Money
NC	Non-Commercial
OI	Open Interest
OIL	Crude Oil futures
OR	Other Reportables
PMPU	Producer/Merchant/Processor/User
PTBF	Price-to-be-fixed
RP	Risk Premiums
SD	Swap Dealers
SOI	Short Open Interest
VIX	CBOE Volatility Index
WTI	NYMEX West Texas Intermediate

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Abstract

The prices of cash crops are crucial to the livelihood of millions of households in developing countries. While the influence of financial investors on the determination of global commodity prices on derivative exchanges is extensively discussed, the role of physical actors in the global value chains (GVCs) is largely disregarded in the ‘financialization of commodities’ debate. This excludes, however, the interlinked activities of GCV lead firms in financial and physical commodity markets, by which prices are transmitted to producer countries. We, therefore, relate the buying and pricing strategies of lead firms in the coffee, cocoa and cotton GVCs with their activities as hedgers on commodity derivatives markets. Based on Open Interest (OI) data in the Commitments of Traders (COT) database, a measure of buying and selling pressure by trader categories is applied in a GARCH model. Our findings show that liquidity provision by hedgers allows speculators’ position takings to drive returns of global benchmark prices. We identify elaborated financial hedging and physical price-setting strategies as a determinant of hedgers’ activities on derivative markets, which contributes to price transmission through GVCs and thereby expose smallholder and other actors in cash crops in producer countries to price risks.

Key words: Financialization, Cash crops, Price transmission, Global Value Chains, Hedging, GARCH Models

1. Introduction

The production and export of coffee, cocoa, and cotton is an essential source of revenue for many countries and millions of smallholders in the Global South. It is estimated that 80 % of coffee is produced by 25 million smallholders (Fairtrade International 2021), while cocoa is grown by around 5 million smallholder households, particularly in West Africa (Kroeger et al. 2017), and smallholdings represent 99 % of all cotton farmers and 70 % of total cotton production (IDH 2021). For one quarter of all developing countries, one or more of these commodities was among the ten most important export goods in 2019 (UNCTAD Stat). Thus, price dynamics of these cash crops have crucial implications for development and rural livelihood in many developing countries.

Academic and public interest in the trends and variability of commodity prices has intensified along with commodity price booms and busts since the early 2000s. In particular, the growing participation of financial actors in commodity derivatives markets – known as ‘financialization of commodities’ (Tang/Xiong 2012) – has become the subject of a controversial debate. The key question revolves around the potential influence of actors with purely financial interests on commodity price dynamics. Meta-studies of more than 100 econometric studies have proven inconclusive and shown that results depend on multiple factors, including the commodities analyzed, the selection of focus variables, or the applied methodologies (Haase et al. 2016; Wimmer et al. 2020).

Commodity derivatives markets have traditionally been the places where global commodity prices are determined. These global prices serve as price benchmarks for transactions among actors along the Global Value Chains (GVCs) of commodities, which enables large multinational actors in particular to hedge their price risks related to commodity trades. The literature on the financialization of commodities is, however, largely de-coupled from physical commodity market dynamics and the actors engaged in physical GVCs; among these, lead firms in particular use derivatives markets to hedge their price risks. Similarly, the literature on commodity GVCs generally fails to take into account the importance of price determination and setting for GVC dynamics and governance (see for exceptions (Bargawi/Newman 2017; Staritz et al. 2018; van Huellen/Abubakar 2021). The overlooked interdependencies between the financial and the physical parts of commodity GVCs raise three issues: i) price transmission from financial to physical markets and the distributional effects on physical actors are not sufficiently addressed; ii) interactions and interdependencies between commercial actors using derivatives markets to hedge physical transactions and non-commercial financial actors on derivatives exchanges are ignored; and iii) characteristics of physical transactions in commodity chains are not considered in the interpretation of econometric analyses that examine the effects of financialization of commodities.

In this paper, we aim to address the latter two gaps in the literature. We build on Open Interest (OI) data from the publicly available Commitment of Traders (COT) by the Commodity Futures Trading Commission (CFTC) for 2006 to 2020 and introduce a novel indicator of trading activities by different trader classes: the Detailed Netting Measure (DNM). The measure relies on the basic idea that changes in long and short positions underlying changes in net OI can be used to identify buying and selling pressure by specific trader classes. The estimation is applied in a GARCH(1,1) model with an autoregressive term and multiplicative heteroscedasticity (Bollerslev 1986; Judge et al. 1985) in relation to futures returns.

It can be shown that distinct positioning towards long or short positions by financial actors drives weekly returns according to buying and selling pressure, but that the same long and short positioning by commercial traders affect returns in opposite ways. These return patterns are most pronounced when hedgers trade in opposing ways to financial actors within the same week, which occurred in approximately one-third of all weeks during the 14-year sample period. Thus, hedgers enable the activities by speculators that drive futures returns through liquidity provision. The flexibility for hedgers to actively engage in derivative markets in

response to speculators is grounded in the type of contracts applied by lead firms in physical transactions for coffee, cocoa, and cotton, which allow for the separation of physical and hedging transactions. At the same time, these practices expose smallholders, processors, and exporters in the Global South to price fluctuations as futures prices are transmitted through the GVCs by the price-setting practices of lead firms. A deeper understanding of these interrelations is also crucial for policy-makers in producer countries to apply policies to avoid negative effects of price volatility in their main export sectors, but also for regulators of commodity derivative markets in the Global North.

The remainder of this paper is structured as follows. Section 2 starts with an overview of the physical commodity chains for coffee, cocoa, and cotton, as well as the actors involved, and describes the interlinkages to commodity derivatives markets. Section 3 discusses the literature on the “financialization of commodities” regarding the use of COT data and related measures of speculation. Section 4 introduces the measure of trader activities by different trader categories for aggregated and disaggregated COT data. Section 5 introduces the econometric approach. Section 6 presents the results of the GARCH model. Section 7 discusses the results, including the characteristics of the physical actors in the selected commodity chains. Finally, Section 8 concludes. Supplementary material is available in the Appendix.

2. Linking Physical and Financial Commodity Markets

2.1. Global Value Chains of Cash Crops

The selected GVCs of coffee, cocoa, and cotton show several similarities with regard to global dimensions of GVC analysis, but also unique characteristics. The combination of these features determines the physical and financial commodity market linkages. The input-output structures include the growing and harvesting of coffee, cocoa, and cotton, mostly by smallholders, and initial processing steps close to the production sites. International Commodity Trading Houses (CTHs) largely export the green coffee beans and raw cocoa beans for further processing in North America and Europe, while cotton lint ready for export is sent primarily to countries with a large textile sector in South and South-East Asia.

The geographical scope of the coffee and cocoa GVCs includes a distinct South-North pattern, as the final products of coffee and cocoa are primarily produced by multinational coffee roasters and chocolate manufacturers in the Global North for consumers in these regions. In contrast, cotton production and further processing into final products include more globally dispersed activities, with most garment production taking place in South and South-East Asia for consumption in the Global North.¹

The governance of the three GVCs concerns the actions, institutions, and norms that determine participation and the allocation of resources in the chain, and thereby the distribution of value addition, as coordinated by lead firms (Dallas et al. 2019; Gereffi et al. 2005). Such powerful actors have long been identified in specific segments of the coffee, cocoa, and cotton GVCs and have become increasingly concentrated over the last decades through mergers and acquisitions. In the case of coffee and cocoa, multinational coffee roasters and chocolate manufacturers have been identified as lead firms (Fold 2002; Ponte 2002), with the largest two roasters – Nestle and JAB Holding – capturing almost 40 % of global retail sales values in 2018 (Sachs et al. 2019). In the cocoa sector, the top six chocolate manufacturers accounted for 65 % of cocoa consumption in 2016/17 (Fold/Neilson 2016).

¹ See for detailed analyses using the Global Value Chain (GVC) or Global Production Network (GPN) approaches of coffee (Bargawi/Newman 2017; Bush 2012; Daviron/Ponte 2005), cocoa (Fold 2002; Neilson et al. 2018; Purcell 2018), and cotton (Çalışkan 2010; Quark 2013; Staritz et al. 2018)

These dynamics have been accompanied by consolidation in the international trader segment. The international trade of all three commodities is primarily carried out by a few international CTHs, many of which are engaged in two or three of these commodities. In cocoa, CTHs have integrated the grinding of cocoa beans and processing to semi-finished cocoa products that was outsourced by chocolate manufacturers in the 1980s/90s. This has led to a 'bi-polar' governance structure with chocolate manufacturers and grinder-traders dominating the value chain. The top four of these accounted for 75 % of global cocoa processing and trading in 2016/17, with only two – Cargill and Barry Callebaut – being in charge of nearly half of the market (Fountain/Huetz-Adams 2018). In coffee, five CTHs handled 50 % of total green coffee exports in 2019 (Panhuysen/Pierrot 2020). In cotton, the eight largest private traders accounted for more than 60 % of the international cotton trade (Staritz et al. 2018). Spinning mills, as buyers of cotton, are comparably less concentrated and could also be treated as part of the global textile and garment value chain (Fernandez-Stark et al. 2016). Due to the low levels of concentration both downstream and upstream from the CTHs, the cotton GVC is described as 'trader-driven' (Gibbon 2001).

2.2. Commodity Derivatives Markets in GVCs

A common factor among the GVCs of the two tropical foods and the one fiber commodity is price-setting practices determining the contractual details of transactions along the GVCs. The 'world prices' of the three commodities are realized on commodity derivatives markets and serve as mercantile tools in setting the prices in the multiple physical trades from producers to end-users (Çalışkan 2009). Futures prices from commodity derivatives markets in New York and London form the pricing benchmarks for most transactions in today's coffee, cocoa, and cotton GVCs, thereby relating activities on financial markets to physical commodity markets (Berg et al. 2013; ITC 2011, 2007, 2001).²

Derivatives markets have played a key role for these globally traded commodities since the emergence of world markets for staple commodities in the late 19th century. Some of the first organized derivatives markets were established for cotton (Liverpool in 1860, New York in 1870, Bremen in 1872) and coffee (New York and Le Havre in 1882, Hamburg in 1887; Dejung 2018; Hoffman 1932).³ Their key function is the hedging of price risks, but exchanges also perform price discovery and price dissemination (Goss 1986; ITC 2011), which enables their use as reference prices in physical transactions.

The significance and role of derivatives markets in price-setting and price risk management have, however, changed over time, along with the international and national institutional frameworks in which they are embedded (Nissanke 2017). In the post-war period, collective interventions in international commodity agreements intended to manage price volatility in coffee and cocoa through export quotas and buffer stocks, but often had limited effects (Gilbert 1996).⁴ In parallel with international intervention, producer countries in the Global South built up public systems to control commodity production and exports. However, by the end of the 1980s, most of the international and national institutions were largely dismantled in the course of market reforms (Akiyama et al. 2001; Gibbon/Ponte 2005).

Without public marketing boards in producer countries as counterparts in international trade, governance structures in the Global North, dominated by multinational lead firms including CTHs, expanded over the entire GVC (ebd.; Talbot 2004). A key consequence was the widespread switch from forward contracts to spot contracts in sales and export transactions between CTHs and smaller entities in producer countries. For instance, cocoa exporters in

² Only speciality qualities are priced independently from futures prices. Even though these niche markets have become more important, less than 5% of cocoa production is detached from futures prices (Fold/Neilson 2016).

³ Derivatives exchanges for cocoa followed in New York in 1925 and London 1928 (Hoffman 1932).

⁴ The coffee agreement initially stabilized international prices, so that futures trading in New York closed down in the late 1960s (Talbot 2004). Cotton prices also remained stable after the second World War without cooperation among the main producers – USA, Soviet Union and China – such that cotton futures trading became virtually obsolete in the 1950s and 60s (Dejung 2018). However, the cocoa agreement was not able to stabilize prices as intended (Gilbert 1996).

Cameroon and Nigeria had to sell spot to international traders after the liberalization of the sector (Varangis/Schreiber 2001). In contrast, Côte d'Ivoire and Ghana maintained public institutions that could sell cocoa through forward contracts and enable stabilization mechanisms in these countries (Staritz et al. 2022; van Huellen/Abubakar 2021).

The changing institutional frameworks and governance structures also resulted in an uneven distribution of price risk mitigation possibilities among GVC actors. On the one side, lead firms in the coffee, cocoa, and cotton GVCs are the main users of commodity derivatives as means of price risk hedging, which is essential for intermediaries such as CTHs. These actors transform commodities in space, time, and form, and are exposed to the risks of price changes during this transformation (Pirrong 2014). The use of futures reduces these risks to differential risks – the difference between the premiums or discounts around futures prices in buying and selling transactions – which makes financial hedging a core competence of CTHs. The risk management strategies employed by CTHs as well as other lead firms have become more sophisticated as price-to-be-fixed (PTBF) contracts have become standard in transactions between CTHs and lead firms in cocoa and coffee.⁵ These contracts allow buyers and sellers to fix prices individually through futures transactions and separate them from physical transactions, which provides actors flexibility to hedge and opportunities for additional profit generation (ITC 2011, 2007).

Most actors in producer countries, and smallholders in particular, have little to no opportunities for effective price risk management without public price stabilization mechanisms (Bargawi/Newman 2017; Kebede 2021; Purcell 2018; Staritz et al. 2018; van Huellen/Abubakar 2021). Even when public price stabilization mechanisms exist based on forward sales, for instance in Côte d'Ivoire and Ghana for cocoa or in Burkina Faso for cotton, these institutions remain highly vulnerable to the large price fluctuations that emerge in global commodity derivative markets (AUTHORS; van Huellen & Abubakar, 2021). Given that price-setting practices link producer and futures prices, it is critical to understand the role of lead firms on commodity derivatives markets, their interrelations with financial actors, and the potential impact on world commodity prices.

3. COT Data and the Financialization of Commodity Markets

3.1. The Basic Characteristics of Open Interest Data

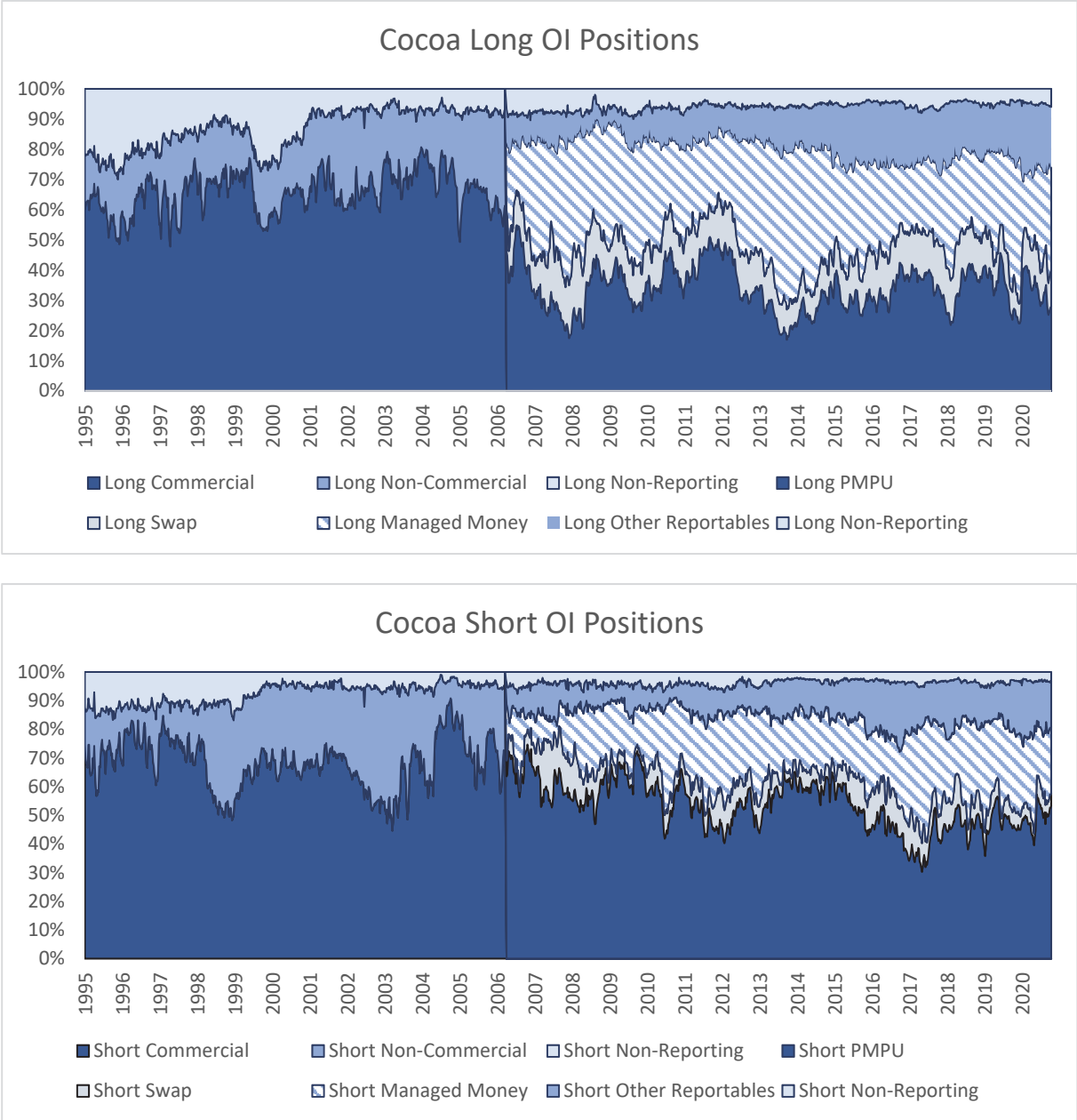
The COT database by the CFTC is the most commonly used database to construct 'direct measures of speculation' (Haase et al. 2016), or more generally to investigate activities in commodity derivatives markets. The CFTC publishes COT data for commodity futures and options traded on US commodity derivative exchanges.⁶ Historical data on commodity derivatives are available in three main reports: Legacy, Disaggregated, and Supplement. They differ by the periods covered and the breakdown of open interest (OI) and related data by trader types. The Legacy and Disaggregated reports are further available for Futures Only and Futures and Options. The Legacy reports provide the most aggregated breakdown, distinguishing only between Commercial (C) and Non-Commercial (NC) actors according to their price risk exposure to physical commodity dealings and have been available since 1986 for futures and since 1995 for futures and options.

⁵ In the cotton sector, these types of contracts (termed "on call") have long been in use by US cotton producers and buyers. Cotton is also the only commodity for which the CFTC also publishes reports on Open Interest related to on call contracts (<https://www.cftc.gov/MarketReports/CottonOnCall/index.htm>).

⁶ See <https://www.cftc.gov/MarketReports/CommitmentsofTraders/index.htm> for details. COT data are also available for non-US exchanges, such as the London Metal Exchange or the ICE Europe, but their historical breakdown by trader classes only goes back to 2012.

The Disaggregated reports have been published since 2006 and differentiate between four categories of actors: First, Producer/Merchant/Processor/User (PMPU) includes the lead firms of the physical GVCs that use derivatives primarily for hedging their physical price risk exposure; Second, Swap Dealers (SD) are partly categorized as Commercials in the Legacy report, but mostly include financial actors that invest in commodity indices — so-called Index Traders; Third, Managed Money (MM), and fourth, Other Reportables (OR), comprise financial investors (see Figure 1 for the case of cocoa).

Figure 1. Decomposition of long and short OI in cocoa futures and options by trader classes.



Source: Commodity Futures Trading Commission (CFTC). Own calculations and illustration.

The Supplement reports explicitly show Index Traders by specifying the Swap Dealers category for 12 agricultural commodities since 2006, as this class of financial investors has contributed to a large inflow of funds into commodity markets in the 2000s. All COT reports follow the same reporting structure, showing the total OI and the composition of Long and Short OI by trader classes on a weekly basis, including spread positions of speculators (non-

commercials, swap dealers, money managers, other reportables) that simultaneously short and long positions. Released every Friday, the reports show the OI positions at the end of trading each Tuesday and provide a snapshot of activities in the derivative markets.⁷

The COT data on OI have three specific characteristics, which are taken up in this analysis. Firstly, OI “refers to the total number of futures [and number options as futures equivalent] contracts that have been entered into and not yet exited through a transaction or delivery” (Fagan/Gencay 2008: 6). This measure captures information only on parts of total transactions occurring during a week and contains no direct information on the prices determined in these transactions (Berg 2011), which are ultimately contained in order books of the exchanges and are not publicly available. Thus, the OI data and their weekly changes can be regarded as a proxy for buying and selling activities of the different trader classes, which potentially affect commodity prices along with other transactions not captured in the OI. Market microstructure theories also suggest that the possible relation between OI and price dynamics is contemporaneous, as changes in OI reflect transactions that have an immediate impact on prices. This questions the assumed lead-lag relation underlying the Granger causality testing popularly applied in the literature (Gilbert/Pfuderer 2014; Grosche 2014).

Secondly, futures contracts require the buying and selling between counterparts, such that data on buying and selling transactions mirror each other by definition (Irwin/Sanders 2012). The number and changes of long and short OI in the COT data are equivalent and the net positions and changes in the COT data by one trader class are necessarily offset by opposite positions of other trader classes. Consequently, neither speculators nor hedgers trade only among themselves; rather, the trading activities of the two groups are interrelated (Cheng/Xiong 2014; Hachula/Rieth 2020; Kang et al. 2020).

Thirdly, changes to the net positions of the different trader classes are the outcome of various combinations of changes to long and short OI positions. The different measures for speculation, or trader activities more generally, often aggregate long and short OI data, which can reduce the informational power of these measures. In our analysis, the underlying long and short OI position changes are the basis for our variable.

3.2. Speculative Measures Based on COT Data in the Literature

The increasing volume of publications on the financialization of commodity markets emerged with the substantial growth in trading volumes and prices on commodity derivatives markets in the 2000s. Between 2006 and 2020, the average weekly OI positions increased in coffee futures and options by 120 %, in cocoa by 80 %, and in cotton by 10 %. At the same time, the number of PMPU traders included in the COT data stagnated or declined, by 10 % in the case of cotton, while the number of speculative actors increased, by 70 % in the case of cocoa, but with strong fluctuations. In combination, the average weekly OI positions held per PMPU trader have grown significantly: by 140 % in coffee and by around 30 % in cocoa and cotton, which also reflects the increasing concentration in physical trade processes for these commodities.

This started a controversial debate on the effects of the changing compositions of actors participating in commodity derivatives trading. The debate has not yet been settled, as revealed by surveys and meta-studies on the results of more than 100 papers on this issue (Boyd et al. 2018; Haase et al. 2016; van Huellen 2020; Will et al. 2015; Wimmer et al. 2020). For instance, Haase et al. (2016) demonstrate that almost equal numbers of papers report a reinforcing, weakening, or no effect of financialization on commodity price variables, but acknowledge differences regarding the type of speculative measures and price variables used in reaching these conclusions (see Table A.1 in the Appendix for a comprehensive overview on papers using COT data as variables in econometric analyses).⁸

⁷ See Fagan/Gencay 2008; Gilbert/Pfuderer 2014; Sanders et al. 2004; Sanders/Irwin 2011b for a detailed description of the different reports and a discussion on the classification of traders.

⁸ We selected papers included in (Haase et al. 2016; and Wimmer et al. 2020) that use CFTC data on open interest. We also added more recent papers but excluded publications by the same authors that replicated approaches and results.

Only a few papers use alternatives to CFTC data to measure speculative activities, either by focusing on speculative effects on supply, demand, and inventories (Juvenal/Petrella 2015; Kilian/Murphy 2014; Sockin/Xiong 2015), or by using alternative speculative measures (Henderson et al. 2015). While one strand in the literature develops theoretical models on the influence of speculation on commodity prices, which are empirically tested with direct speculative measures based on CFTC data (Acharya et al. 2013; Etula 2013; Hamilton/Wu 2015), most papers apply time-series tests relating COT data and price variables (returns, volatility, price premiums).

Granger-causality analysis has become the standard econometric methodology (Grosche 2014; Wimmer et al. 2020). Most applications seek an underlying lead-lag relationship to explain the contemporaneous positive (negative) correlation between changes in net OI of Non-Commercials, Managed Money, and Index Traders (Commercials and PMPU) and futures price dynamics (Gilbert/Pfuderer 2014; Lehecka 2015; Sanders et al. 2004; Sanders/Irwin 2017). The majority of papers that apply Granger causality tests on the influence of Index Traders on agricultural commodities, for which data are available in the Supplement report, detect no systematic influence of speculation on commodity price dynamics (see Table A1 in the Appendix).⁹

Grosche (2014) argues that a rejection of the non-causality hypothesis on lagged OI variables on futures prices would essentially violate the notion of market efficiency, as all information in OI variables will be instantaneously impounded in the market price. Given the OI calculation method of “adding all the contracts from opened trades and subtracting the contracts when a trade is closed” (CME Group 2021), OI data refer to past transactions in which prices have been determined. Only private (unexpected) information contained in lagged changes in OI could alter the size of the prediction error, which determines the likelihood of rejection of the null hypothesis (Grosche 2014).

The results of papers applying methodologies other than Granger Causality tend to show a positive influence of speculative activities on price dynamics. This is particularly true for those studies that include contemporary changes in net positions of Managed Money and Non-Commercials with changes in prices in their analysis. However, only a few papers include the activities of commercial traders and analyze interactions between speculators and hedgers, whose net positions are typically opposing. Fagan/Gencay (2008) show that extreme positions by both groups cause liquidity shocks leading to increased volatility. Cheng/Xiong (2014) focus on the positions of hedgers in wheat, corn, soybeans, and cotton futures, which fluctuate significantly more than implied by changes in forecasts of physical output and tend to change with price trends. Similarly, Cheng et al. (2015) identify financial actors as initiating trades due to changing risk absorption capacities and, thereby, as drivers of commodity prices. Also, Kang et al. (2020) show that hedgers provide liquidity to speculators, as they earn premiums in the short-run that compensate for the cost of hedging in the long-run, and that the interrelated activities of hedgers and speculators also influence expected futures returns. It is therefore important to identify the interactions among different trader classes to explain the potential effects of individual activities on futures price dynamics.

⁹ One aspect concerning Granger causality and the associated statistical tests is that they have frequently been misused and misinterpreted in the literature (see, e.g., (Gilbert 2018; Gilbert/Pfuderer 2014; or Grosche 2014 for a critique) to prove ‘real’ causality (or rather: reject a non-causality hypothesis) based on the notion that cause cannot happen after effect (Petropoulos et al. 2021). However, what Granger causality implies is only predictive causality, i.e., that the inclusion of the information contained in past observations of one variable helps predict another variable more precisely in terms of a smaller out-of-sample forecast error compared to predictions omitting that information (Granger 1969; Lütkepohl 2005). Should such predictive causality be misinterpreted as ‘real’ causality, researchers would commit a so-called “post hoc ergo propter hoc” informal logical fallacy, which mistakes any phenomenon that happens earlier than another phenomenon as the cause of the latter, just because it happened earlier (Walton et al. 2008).

4. Data

We introduce the “Detailed Netting Measure” (DNM) to explain the development of returns of the three commodities. The changes in net positions of the different classes of traders are differentiated by the underlying changes in long open interest (LOI) and short open interest (SOI) positions as follows:

$$DNM_t^{class} = \begin{cases} 1, & \text{when } (LOI_t^{class} - LOI_{t-1}^{class}) > 0 \text{ AND } (SOI_t^{class} - SOI_{t-1}^{class}) < 0 \\ -1, & \text{when } (LOI_t^{class} - LOI_{t-1}^{class}) < 0 \text{ AND } (SOI_t^{class} - SOI_{t-1}^{class}) > 0, \\ 0, & \text{else} \end{cases}$$

Class includes Commercials (C) and Non-Commercials (NC) in aggregated COT data and Producer/Merchant/Processor/User (PMPU), Swap Dealers (SD), Managed Money (MM), and Other Reportables (OR) in disaggregated COT data and can be included. The DNM identifies changes in net OI that are driven by the adoption of distinct opposing positions by short and long traders within a trader class as they hold more long (short) trades and fewer short (long) trades on a Tuesday in week t compared to a Tuesday in week $t-1$. This excludes, for instance, cases of positive OI changes when LOI and SOI both grow, with the increase in LOI being higher than the increase in SOI.

Compared to commonly applied measures of net changes, the DNM filters out those cases in which the OI data indicate buying or selling pressure by one class. The DNM can therefore be used to analyze the effect of demand by different trader classes on commodity futures prices, as it identifies situations in which actors within a specific class initiate trades. The use of techniques that fail to differentiate such initiated trades from trades that respond to OI positions in other classes could be a reason for the mixed results on the influence of speculators’ OI changes and futures returns (Hachula/Rieth 2020).

Further predictors for the returns of the different commodities can be grouped into commodity-specific and general economic predictors. The first group directly enters the mean equation, while the second group enters the variance equation of the GARCH model. Commodity-specific predictors include a variable constructed from Google Trends web search indices with the search terms “coffee [cocoa] [cotton] + supply” (GOOGLE) that indicates potential changes to supply below or above forecast output, as well as the aforementioned DNM class variables of Commercials (C) and Non-Commercials (NC) at the aggregated COT level¹⁰ and for Producer/Merchant/Processor/User (PMPU) and Managed Money (MM) at the disaggregated COT level. Moreover, we add the total positions of the trader classes at the two different aggregation levels (TOTAL_CLASS).¹¹ This measure is not a commonly applied variable for trading activities (except in Bohl/Sulewski 2019) as it is a highly aggregated measure of trader activities and typically does not show effects on price dynamics. It is, however, potentially relevant here, given that a DNM value of 1 in one class can be offset by other long/short constellations with more or less LOI and SOI in the other class. Time series graphs for these variables can be found in Figures 2 (for coffee), 3 (for cocoa), and 4 (for cotton). All statistical analyses are carried out using Stata Version 16.

The general economic variables, in turn, are the same for all three markets, according to the assumption that financial risk and the development of the world economy affect the returns of each of the three commodities equally. They, therefore, represent control variables. These include the CBOE Volatility Index (VIX) as an equity market risk indicator, NYMEX West Texas Intermediate (WTI) Crude Oil futures (OIL) as a weekly proxy for global demand, and the Trade Weighted U.S. Dollar Index (EXR), given that the three commodities are internationally traded in U.S. dollars. Two dummy variables are added: one for the COVID-19 Pandemic (COVID = 1

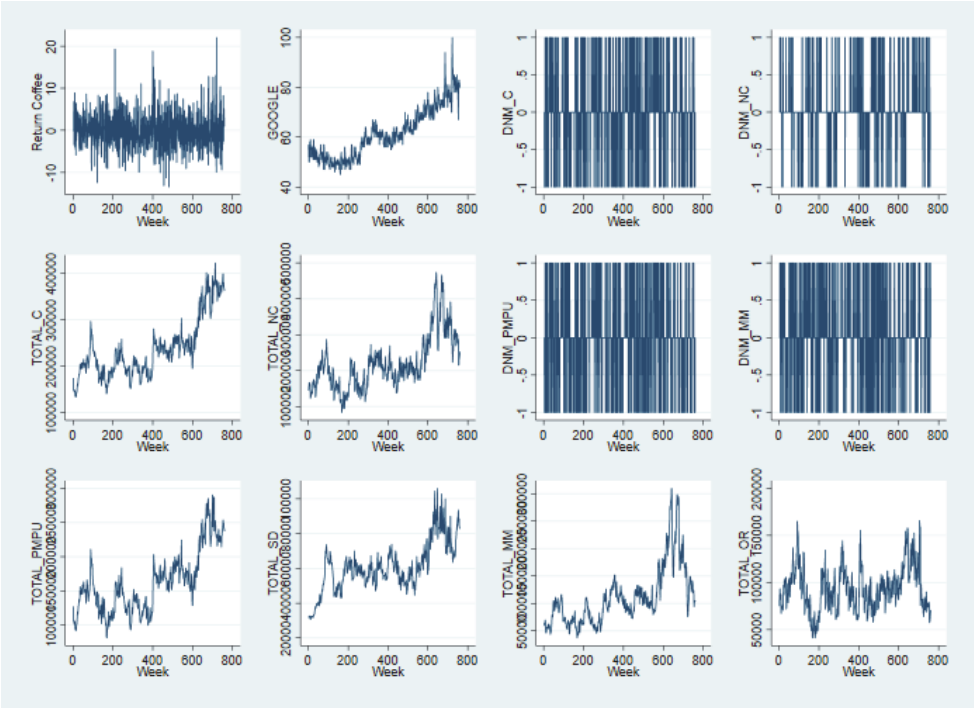
¹⁰ Following (Kim 2015), we allocate the OI positions of non-reporters in the aggregated COT reports according to the same distribution pattern as observed in the group of Commercials and Non-Commercials.

¹¹ Total positions of non-reporting traders in the case of disaggregated data are not considered to avoid multicollinearity concerns.

from 10/03/2020 [i.e., since the outbreak was officially labeled a pandemic by the World Health Organization] to 29/12/2020; =0 otherwise) and the other for the Global Financial Crisis (CRISIS =1 from 14/08/2007 to 30/06/2009; =0 otherwise). Time-series graphs for the control variables can be found in Figure 5.

In total, the samples for each commodity comprise 759 weekly observations that can be used for estimation, ranging from 20/07/2006 to 29/12/2020. Price data on futures are collected from Yahoo! Finance and represent prices of the continuous front-month contract, which are almost entirely identical to price data by the ICE. This strong correlation between two different data sources corroborates the validity of these easily accessible price data. Weekly returns are calculated as Tuesday-to-Tuesday growth rates, to match the COT data structure.¹²

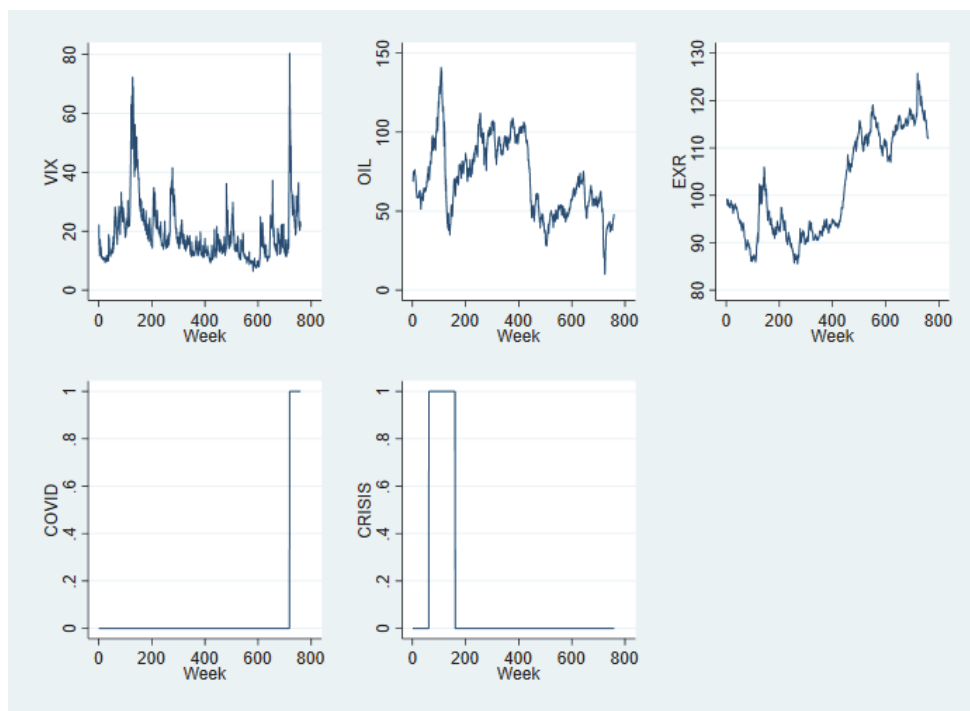
Figure 2: Time series graphs of coffee-related variables.



Source: Commodity Futures Trading Commission (CFTC). Own calculations and illustration.

¹² The data underlying this article are available in the article and in its online supplementary material (to be added).

Figure 5: Time series graphs of control variables.



Source: Commodity Futures Trading Commission (CFTC). Own calculations and illustration.

Apart from the returns, as well as the class and the dummy variables, visual inspection of Figures 2 to 5 reveals trending patterns in the data. All trending variables underwent non-seasonal unit root tests to avoid spurious regression relationships. The null hypothesis of the Augmented Dickey Fuller (ADF) test (i.e., the presence of a non-seasonal unit root; (Dickey/Fuller 1979)) including a drift term was rejected for all but one variable (EXR) at conventional significance levels (Total Managed Money for coffee and OIL each at the 5 % level; all remaining variables at the 1 % level), yielding the conclusion that virtually all variables are integrated of order $I(0)$. ADF test results can be found in Tables A2 (commodity-specific variables without DNM class variables) and A3 (control variables without dummy variables) in the Appendix, along with basic descriptive statistics.

Except for the variable GOOGLE, and more pronounced for cocoa and cotton, none of the variables seems to feature any seasonal patterns. This is also confirmed after applying STL decomposition (Cleveland et al. 1990), as GOOGLE is the only variable for which the seasonally adjusted series deviate from the non-seasonally adjusted ones. To include the potential impact of seasonal variations in web search behavior on the returns, these seasonal patterns are preserved (the STL decomposition results are not presented here due to space constraints but are available from the authors on request).

5. Econometric Model

To draw consistent conclusions from the estimation results across commodities, a consistent econometric modeling approach must be found, while conforming with the data characteristics. The model selection process resulted in a generalized ARCH (GARCH; (Bollerslev 1986)) specification with one ARCH and one GARCH term, i.e., GARCH(1,1). Higher-order GARCH specifications and more complex GARCH models were found to result in an inferior model fit and were therefore discarded for the subsequent analysis (see, e.g., (StataCorp 2019), for an overview).

Following (Du et al. 2011; Ji/Fan 2012; Nazlioglu et al. 2013; Nazlioglu/Soytas 2012), the control variables do not enter the mean but rather the variance equation, as they are more likely to influence the volatility of the returns rather than the returns themselves. This was confirmed by an inferior model fit when putting them into the mean equation in preliminary estimations. In contrast, other applications by Bohl/Stephan (2013) and Bohl/Sulewski (2019) include speculative measures in the volatility equation and control variables in the mean equation. Hence, a GARCH(1,1) model with an AR(1) term and multiplicative heteroscedasticity (Judge et al. 1985) has been employed. Formally, the econometric model reads as follows:

$$RETURN_t = \alpha + \beta(RETURN_{t-1} - \mathbf{x}_{t-1}\boldsymbol{\gamma}) + \mathbf{x}_t\boldsymbol{\gamma} + \varepsilon_t, \quad (1)$$

$$\sigma_t^2 = Var(\varepsilon_t) = \exp(\delta + \mathbf{z}_t\boldsymbol{\vartheta}) + \lambda_1\varepsilon_{t-1}^2 + \lambda_2\sigma_{t-1}^2, \quad (2)$$

where in Equation (1) – the (conditional) mean equation – *RETURN* denotes the dependent variable, α an intercept, β the impact of the lagged dependent variable (i.e., of the AR(1) term), \mathbf{x} the vector of commodity-specific variables, $\boldsymbol{\gamma}$ the corresponding coefficient vector, and ε the error term. In Equation (2) – the (conditional) variance equation – σ^2 denotes the error variance of ε , δ an intercept, \mathbf{z} the vector of control variables, $\boldsymbol{\vartheta}$ the corresponding coefficient vector, λ_1 the ARCH effect, and λ_2 the GARCH effect. For the above econometric model to be correctly specified, the following conditions must hold for the ARCH and GARCH effect: $\lambda_1 > 0$, $\lambda_2 > 0$, and $(\lambda_1 + \lambda_2) < 1$ (Bohl & Sulewski, 2019). Equations (1) and (2) are estimated using quasi-maximum likelihood methods while employing robust standard errors (Bollerslev/Wooldridge 1992).

Preliminary time series regression results employing ordinary least squares (OLS) with robust standard errors show the explanatory power of the chosen predictors as a whole in terms of model F statistics and the significant impact of past returns on current returns (i.e., of the lagged dependent variable) at least at the 5 % level for all three commodities, albeit only in one out of four cases for cotton (see Tables A4 to A6 in the Appendix). In all cases, the null hypothesis of Engle’s Lagrange multiplier test for the presence of autoregressive conditional heteroscedasticity (ARCH-LM test; i.e., absence of error variance clustering) is rejected at least at the 5 % level (Engle 1982). Consequently, some ARCH-type specification allowing for the lagged dependent variable is likely to be better suited. In addition, when comparing the values of Akaike’s information criterion (AIC; (Akaike 1974)) and of the Bayesian information criterion (BIC; (Schwarz 1978)) between Tables A4 and A6 in the Appendix and Tables 1 to 3 of the final specifications in Section 6, it can be concluded that except for two BIC values related to cocoa, all other ARCH-type specifications feature lower AIC and BIC values compared to their OLS counterparts.

6. Results

Models (1) and (2) in Tables 1 to 3 are estimated at the higher COT aggregation level, while models (3) and (4) are estimated at the disaggregated level. Models (1) and (3) consider the DNM class variables only, whereas models (2) and (4) additionally consider the total positions. From a statistical perspective, the overall model fit of the final specifications as reported in Tables 1 to 3 is satisfactory: not only do all models converge, but also feature χ^2 statistics significant at the 1 % level across commodities and cases. Moreover, while not always significantly different from zero, the conditions $\widehat{\lambda}_1 > 0$, $\widehat{\lambda}_2 > 0$, and $(\widehat{\lambda}_1 + \widehat{\lambda}_2) < 0$ from Section 5 hold for all estimated ARCH and GARCH effects.

The results on the impact of long-short constellations by trader classes as expressed in the DNM show a clear relation with returns in all three commodities. While the DNM of NC and MM have positive coefficients, these are negative for C and PMPUs. The inclusion of total position changes by class does not alter this result, however, changes in the number of positions of different classes have a significant influence (at the 10 % level) on returns but in the opposite direction than the DNM coefficients. This becomes important when analyzing the different combinations of DNM by class. Google Trends web search indices do not show any significant impact on returns in any of the cases, indicating that this proxy for potential changes to supply below or above forecast output and the associated seasonal patterns does not seem to be specific enough.

The effects on volatility in all three commodities, as shown in Tables 1 to 3, are most pronounced in the VIX, meaning that volatility in equity markets is transmitted to cash crops. This potential equity-to-commodity link has been shown by multiple studies (see, e.g., Cheng et al. 2015; Hachula/Rieth 2020). However, OIL and EXR are significant only for the volatility of coffee prices. Compared to coffee, cocoa and cotton volatility spikes tended to be less aligned with oil price changes since 2006. While U.S. Dollar dynamics traditionally impact export earnings by farmers measured in local currencies and thereby influences production and storage decisions, for instance of large farmers in Brazil, a substantial part of West African cocoa is also sold to Europe on a Euro and British Pound basis. Also, the large share of U.S. production in internationally traded cotton potentially reduces the influence of exchange rate fluctuations on cotton. The CRISIS parameter for the financial crisis in 2008/09 is significant only in volatility for coffee (negative) and cocoa (positive).

Table 1: GARCH(1,1) with AR(1) term and multiplicative heteroscedasticity estimation results for coffee.

	(1)	(2)	(3)	(4)
	Return coffee	Return coffee	Return coffee	Return coffee
<i>Mean eq.</i>				
GOOGLE	-0.0142 (-1.05)	-0.0265 (-1.22)	-0.0140 (-1.13)	-0.0115 (-0.51)
DNM_C	-2.313*** (-10.15)	-2.324*** (-10.21)		
DNM_NC	1.668*** (6.00)	1.703*** (6.07)		
TOTAL_C		0.00000709 [†] (1.78)		
TOTAL_NC		-0.00000368 (-1.26)		
DNM_PMPU			-1.693*** (-7.46)	-1.684*** (-7.54)
DNM_MM			2.110*** (8.10)	2.196*** (8.79)
TOTAL_PNMU				0.00000736 (1.62)
TOTAL_SD				0.0000130 (1.08)
TOTAL_MM				-0.0000104*** (-2.78)
TOTAL_OR				0.00000508 (0.67)
CONST	0.916 (1.09)	0.821 (0.89)	0.833 (1.09)	-0.588 (-0.50)
AR(1)	-0.0935** (-2.38)	-0.101** (-2.58)	-0.105** (-2.55)	-0.118*** (-2.80)
<i>Variance eq.</i>				
VIX	0.0383*** (3.68)	0.0381*** (3.68)	0.0389*** (3.35)	0.0401*** (3.40)
OIL	0.0122 [†] (1.84)	0.0116 [†] (1.71)	0.0185*** (2.86)	0.0192*** (2.92)
EXR	0.0280** (2.29)	0.0274** (2.27)	0.0409*** (3.27)	0.0430*** (3.42)
COVID	0.0427 (0.12)	0.00109 (0.00)	-0.132 (-0.37)	-0.182 (-0.50)
CRISIS	-0.695** (-2.24)	-0.676** (-2.17)	-0.704** (-2.02)	-0.710** (-1.98)
CONST	-2.725 (-1.62)	-2.618 (-1.58)	-4.488*** (-2.63)	-4.785*** (-2.80)
<i>(G)ARCH</i>				
λ_1	0.102*** (2.63)	0.106** (2.56)	0.141*** (3.06)	0.149*** (3.01)
λ_2	0.567*** (3.89)	0.560*** (4.02)	0.495*** (2.92)	0.489*** (3.10)
No. of obs.	759	759	759	759
Deg. of freed.	4	6	4	8
Log likelih.	-2110.3	-2108.6	-2067.4	-2062.2
χ^2	274.9	282.9	424.1	456.5
$p(\chi^2)$	2.80e-58	3.76e-58	1.74e-90	1.48e-93
No. of iter.	12	46	14	46
Converged	1	1	1	1
AIC	4246.573	4247.127	4160.799	4158.47
BIC	4306.789	4316.607	4221.015	4237.214

Own calculations. Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. t statistics in parentheses (robust standard errors).

Table 2: GARCH(1,1) with AR(1) term and multiplicative heteroscedasticity estimation results for cocoa

	(1) Return cocoa	(2) Return cocoa	(3) Return cocoa	(4) Return cocoa
<i>Mean eq.</i>				
GOOGLE	-0.000126 (-0.01)	0.0101 (0.45)	-0.000574 (-0.03)	0.0138 (0.59)
DNM_C	-1.679*** (-7.89)	-1.670*** (-7.82)		
DNM_NC	1.576*** (6.33)	1.594*** (6.34)		
TOTAL_C		-0.00000624 (-1.43)		
TOTAL_NC		0.00000308 (0.94)		
DNM_PMPU			-2.066*** (-10.43)	-2.085*** (-10.57)
DNM_MM			1.303*** (6.20)	1.299*** (6.11)
TOTAL_PNMU				-0.00000810 (-1.41)
TOTAL_SD				-0.0000174* (-1.71)
TOTAL_MM				0.00000555 (1.36)
TOTAL_OR				0.00000411 (0.54)
CONST	0.195 (0.12)	0.436 (0.27)	0.227 (0.15)	0.595 (0.37)
AR(1)	-0.0703* (-1.85)	-0.0726* (-1.91)	-0.0626 (-1.60)	-0.0710* (-1.82)
<i>Variance eq.</i>				
VIX	0.0285*** (2.61)	0.0284*** (2.66)	0.0272*** (2.74)	0.0271*** (2.75)
OIL	0.00817 (1.35)	0.00796 (1.33)	0.00925* (1.68)	0.00887 (1.60)
EXR	0.0140 (1.09)	0.0134 (1.07)	0.0161 (1.34)	0.0149 (1.24)
COVID	0.319 (0.57)	0.308 (0.57)	0.286 (0.62)	0.317 (0.73)
CRISIS	0.534* (1.71)	0.529* (1.73)	0.486* (1.71)	0.497* (1.76)
CONST	-1.946 (-1.12)	-1.804 (-1.03)	-2.196 (-1.31)	-1.982 (-1.15)
<i>(G)ARCH</i>				
λ_1	0.0692** (2.27)	0.0704** (2.30)	0.0452* (1.78)	0.0455* (1.71)
λ_2	0.776*** (7.08)	0.764*** (6.38)	0.777*** (7.86)	0.763*** (6.72)
No. of obs.	759	759	759	759
Deg. of freed.	4	6	4	8
Log likelih.	-2046.0	-2044.8	-2000.4	-1996.2
χ^2	155.8	158.4	271.6	278.1
$p(\chi^2)$	1.14e-32	1.30e-31	1.44e-57	1.90e-55
No. of iter.	14	31	12	33
Converged	1	1	1	1
AIC	4118.074	4119.589	4026.756	4026.314
BIC	4178.29	4189.069	4086.972	4105.058

Own calculations. Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. t statistics in parentheses (robust standard errors).

Table 3: GARCH(1,1) with AR(1) term and multiplicative heteroscedasticity estimation results for cotton.

	(1) Return cotton	(2) Return cotton	(4) Return cotton	(5) Return cotton
<i>Mean eq.</i>				
GOOGLE	-0.0187 (-1.17)	-0.0155 (-1.02)	-0.0190 (-1.03)	-0.0297* (-1.68)
DNM_C	-1.365*** (-6.08)	-1.361*** (-6.05)		
DNM_NC	1.421*** (6.38)	1.517*** (6.80)		
TOTAL_C		0.00000918*** (3.56)		
TOTAL_NC		-0.00000679** (-2.50)		
DNM_PMPU			-0.967*** (-2.90)	-0.906*** (-3.66)
DNM_MM			1.597*** (4.14)	1.679*** (6.30)
TOTAL_PNMU				0.0000124*** (2.75)
TOTAL_SD				-0.0000137 (-1.10)
TOTAL_MM				0.00000305 (0.54)
TOTAL_OR				-0.00000592** (-2.04)
CONST	1.580 (1.41)	0.207 (0.17)	1.548 (1.19)	1.479 (0.99)
AR(1)	-0.0765* (-1.85)	-0.0941** (-2.26)	-0.121 (-1.49)	-0.144*** (-2.94)
<i>Variance eq.</i>				
VIX	0.0284** (2.06)	0.0281* (1.93)	0.0269 (0.89)	0.0217 (1.40)
OIL	0.00541 (0.74)	0.00534 (0.72)	0.00516 (0.41)	0.00451 (0.63)
EXR	-0.0383 (-1.55)	-0.0359 (-1.44)	-0.0369 (-0.99)	-0.0360 (-1.59)
COVID	0.362 (0.72)	0.340 (0.65)	0.156 (0.27)	0.137 (0.36)
CRISIS	0.200 (0.41)	0.233 (0.48)	0.121 (0.23)	0.200 (0.44)
CONST	3.671 (1.10)	3.273 (1.00)	3.793 (0.46)	4.112 (1.37)
<i>(G)ARCH</i>				
λ_1	0.140 (1.33)	0.137 (1.47)	0.160 (0.46)	0.239 (1.46)
λ_2	0.702** (2.45)	0.728*** (2.90)	0.635 (0.60)	0.497 (1.57)
No. of obs.	759	759	759	759
Deg. of freed.	4	6	4	8
Log likelih.	-2029.2	-2021.4	-2002.0	-1993.1
χ^2	212.3	209.2	231.9	251.5
$p(\chi^2)$	8.65e-45	2.12e-42	5.04e-49	8.32e-50
No. of iter.	15	60	15	47
Converged	1	1	1	1
AIC	4084.379	4072.888	4030.018	4020.154
BIC	4144.595	4142.368	4090.234	4098.898

Own calculations. Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. t statistics in parentheses (robust standard errors).

Tables 4 and 5 show the weekly returns in the different combinations of the DNM by class for the two aggregation levels and the distribution of these combinations. Similar to the GARCH model, weekly returns are positive when the DNM of speculators (NC, MM) equals 1 and negative when the DNM of hedgers (C, PMPU) equals 1. For all three commodities, weekly returns are most pronounced when the DNM of hedgers and speculators, and thereby their buying and selling activities, are simultaneously opposing (columns 2 and 3). The return patterns for the different classes in the case of non-zero DNM values are also valid when the other classes do not change LOI and SOI in the opposing way.¹³ Thus, the distinct directional trade activities by speculators determine returns even when total OI by the other class increases (DNM=0).

On the aggregated level, cases of simultaneously opposing positions by hedgers and speculators cover between 12 % (cocoa) and 16 % (cotton) of all weeks from 2006 to 2020. In total, the DNM of NC and C is non-zero in around half of the cases. As the aggregated classes included diverse actors, such as commercial traders including PMPU and SD, there can be an offsetting effect. Thus, the disaggregated data in Table 5 show that the opposing DNM situations of MM and PMPU appear more often (19 % (cocoa) to 29 % (cotton) of weekly cases) and non-zero DNM appears in 61 % (coffee) to 76 % (cotton) of all weeks.

Table 4: Average weekly returns and distribution of DNM combinations in aggregated COT.

Average Return	NC 1 / C -1	NC -1 / C 1	NC 1 / C 0	NC -1 / C 0	NC 0 / C 1	NC 0 / C -1	NC 0 / C 0	Total
Coffee	3.6%	-3.8%	1.7%	-2.5%	-2.2%	2.8%	0.2%	0.1%
Cocoa	3.1%	-2.9%	2.5%	-1.4%	-1.8%	1.9%	0.2%	0.2%
Cotton	2.9%	-1.5%	1.9%	-2.3%	-2.5%	1.6%	0.4%	0.1%
Distribution	NC 1 / C -1	NC -1 / C 1	NC 1 / C 0	NC -1 / C 0	NC 0 / C 1	NC 0 / C -1	NC 0 / C 0	
Coffee	7%	6%	7%	3%	14%	11%	52%	
Cocoa	6%	6%	7%	6%	13%	11%	51%	
Cotton	6%	10%	10%	7%	10%	7%	50%	

Own calculations based on CFTC data.

Table 5: Average weekly returns and distribution of DNM combinations in disaggregated COT

Average Return	MM 1 / PMPU -1	MM -1 / PMPU 1	MM 1 / PMPU 0	MM -1 / PMPU 0	MM 0 / PMPU 1	MM 0 / PMPU -1	MM 0 / PMPU 0	Total
Coffee	4.0%	-3.1%	3.6%	-2.1%	-2.6%	1.5%	-0.2%	0.1%
Cocoa	3.2%	-2.9%	2.1%	-1.6%	-2.4%	3.1%	0.1%	0.2%
Cotton	2.3%	-2.3%	2.3%	-2.2%	-1.6%	1.9%	0.6%	0.1%
Distribution	MM 1 / PMPU -1	MM -1 / PMPU 1	MM 1 / PMPU 0	MM -1 / PMPU 0	MM 0 / PMPU 1	MM 0 / PMPU -1	MM 0 / PMPU 0	
Coffee	13%	11%	10%	7%	11%	10%	39%	
Cocoa	9%	10%	9%	8%	13%	13%	38%	
Cotton	12%	17%	12%	9%	11%	6%	34%	

Own calculations based on CFTC data.

¹³ The average and median returns are very close, indicating that most returns show the same direction in the different constellations.

7. Discussion

The DNM applied in this paper can be seen as a proxy for trades initiated by different trader classes, as it identifies situations in which actors in a given class build up long (short) positions and reduce short (long) positions over the course of a week. The prices realized in these transactions should thereby reflect the changes in buying and selling pressures. Even though the DNM has limitations similar to all speculative measures based on OI, which captures only part of the transactions undertaken during a week, and allowing that the DNM equals zero in both classes in up to 40 % of all weeks, important outcomes can nevertheless be drawn from our analysis.

First, in those weeks when hedgers and speculators take distinct directional positions, weekly returns in the selected commodity futures show clear patterns. While buying (selling) pressure by speculators (NC and MM) leads to increasing (decreasing) returns in that week, similar position changes by hedgers (C and PMPU) affect returns contrarily. Thus, only extreme buying and selling activities by speculators move returns as expected. Second, the constellations of opposing DNMs by hedgers and speculators (Tables 4 and 5) lead to more pronounced average weekly returns compared to weeks with other constellations. These outcomes are related to results in Kang et al. (2020), who show that hedgers act in a contrarian way to speculators in the short-run as they can earn liquidity provision premiums when buying pressure from speculators for long (short) positions pushes futures prices up (down).¹⁴ Second, the return patterns related to the DNM of hedgers and speculators remain valid when the LOI and SOI changes in other classes do not follow the same distinct pattern. While speculators' (NC and MM) buying and selling pressure moves futures' returns up and down, the same directional activities by hedgers (C and PMPU) are possible without driving prices in the same way. In other words, when hedgers increasingly enter LOI and exit SOI within a week, they can buy these contracts at lower prices. In the other direction, when entering into SOI and exiting LOI, they can sell at higher prices. This is contrary to the hedging pressure theory, which implies that hedgers have to offer risk premiums to speculators by buying futures at higher prices and selling at lower prices compared to expected spot prices. Thus, hedgers can also earn liquidity provision premiums in the short-run, as argued by Kang et al. (2020), even if they do not take clearly contrary positions to speculators.

The reason why buying or selling pressure by hedgers does not affect prices similarly to financial actors is potentially related to the different incentives for each group to trade. Cheng et al. (2015) identify financial investors as drivers of commodity futures prices due to their changing capacities to absorb risks in commodity markets dependent on the risk environment in other financial markets. Due to these risk adjustments, financial actors have the highest incentives to trade. In contrast, the strong variations in OI positions of hedgers in the short-run are not related to changes in physical output requiring adjustments to financial hedging (Cheng/Xiong 2014). Thus, commercial actors are much less sensitive to price and output shocks and can potentially follow the trades initiated by financial actors.

A key reason is that the lead firms, such as CTHs as well as buyers (coffee, cocoa and cotton) and large producers (cotton), use PTBF contracts as standard for transactions among themselves. This enables these actors to conduct their financial hedging through derivatives largely independent of their physical transaction and thereby to profit from liquidity provision according to the activities of financial actors. However, these short-term activities by commercial actors beyond 'textbook hedging transactions' require elaborated know-how and financial risk management systems, which are key characteristics of the dominant CTHs in agricultural commodity markets and also enable them to offer financial services (Gibbon 2014; Salerno 2017).

¹⁴ Kang et al. (2020) base their analysis on excess returns as an ex-post calculation of commodity risk premium in futures contracts, which is related but not similar to weekly returns (Hambur/Stenner 2016).

A potential limitation of the analysis here derives from the weekly frequency of data, as the DNM data show a high level of variation (Figures 2 to 4). Kang et al. (2020) also argue that premiums for liquidity provision exist only in the short-run, while in the long-run hedgers have to offer risk premiums to speculators – as expected in the hedging pressure theory. However, the relations between returns and DNM constellations remain valid for average means (and medians) of futures returns in the different DNM constellations on a six months rolling basis, even though there are larger variations between the years from 2006 to 2020 (these results are not presented here due to space constraints but are available from the authors on request). In particular, the higher average returns in six months periods with opposing DNMs by hedgers and speculators are confirmed and appear more often. However, the return patterns in cases when the DNM of hedgers equals 1 and the DNM of other classes is zero become mixed with longer term-data. Thus, the influence of the changing levels and volatility of prices from year to year could be important, as with the changes in the participation of different trader classes between 2006 and 2020.

8. Conclusions

Analyses of the ‘financialization of commodities’ have often been narrowly focused on the impact of financial actors on commodity derivatives dynamics. Consequently, the role of commercial actors using these derivatives mainly for hedging purposes, their physical and financial hedging strategies, and their interactions with speculators have generally evaded scrutiny in the debate. However, the structure and governance of the GVCs for coffee, cocoa, and cotton have undergone drastic changes, leading to highly concentrated segments with lead firms also being the main commercial actors in the related derivatives markets. Their activities and interrelations with financial actors, therefore, have important effects on the other actors in the GVCs, in particular smallholders, through the use of derivative prices as price benchmarks in bilateral transactions.

Most of the literature on this topic apply time-series tests relating OI data by the CFTC with price variables, but key characteristic of the OI data are rarely taken up and the interactions between different trader classes remain unexamined. By introducing the DNM measure, that identifies the activities of specific trader classes behind net OI changes, we show through a GARCH(1,1) model that distinct buying and selling activities by Non-Commercials in aggregated data, and Managed Money traders in disaggregated data, have a significant impact on weekly returns of coffee, cocoa, and cotton futures. At the same time, the DNM of commercial and PMPU actors are also significant, but with opposing effects on returns. As the contrasting DNM constellations of Commercials and Non-Commercials appear in a large share of weekly data since 2006 and show on average higher weekly returns than other constellations, hedgers enable financial actors to conduct their distinct buying and selling activities. This interrelation is particularly pronounced between Managed Money and PMPU, indicating that hedgers benefit from liquidity provision by selling at higher prices and buying at lower prices.

The activities by commercials on the derivative markets for the selected commodities are related to their financial hedging strategies for their price risks on physical trades. The increasingly concentrated lead firms, such as coffee roasters, chocolate manufacturers, and CTHs, primarily use elaborated PTBF contracts that distinguish between physical and hedging transactions. This provides them the flexibility to manage hedging according to dynamics on derivatives markets, such as buying pressure by speculators, rather than linking them solely to physical activities. In this way, hedgers reduce their price risks, but at the same time enable speculators to drive commodity prices.

Importantly, the interaction between hedgers and speculators on financial commodity markets also affects other physical actors in the GVCs. Since CTHs use exchange prices as price benchmarks in bilateral contracts with exporters and producers, which allows their financial

hedging strategies to be most effective, derivative prices are transmitted along the commodity chains. This exposes particularly smallholders to elaborated price risks and leaves them with few opportunities to mitigate these risks, especially if national stabilization mechanisms are not in place. In particular, the spot transaction based on current futures prices exposes smallholders to short-term price risks. Policy options in producer countries could be the stricter regulations for the activities of CTHs in the countries, the support for cooperative structures that often have the ability to sell forward and national (or regional) price stabilization mechanisms. At the same time, regulators of commodity exchanges in the Global North need to avoid excessive speculation and price fluctuations, taking into account the role of commercial actors.

Our findings suggest other avenues for further research. Generally, research should analyze the interrelations between physical and financial commodity markets in more detail. Levels of disaggregation available in the COT data and the interactions between trader classes should be given more consideration in speculative measures used in econometric analyses around the financialization of commodities. Further research is also needed on the asymmetric exposure to price risks between lead firms and other GVC actors, given the changes in governance and institutional frameworks over the last decades.

Data Availability

All data are derived from freely available data sources. The sources are named in the text and specified as data sets in the references. The data of the detailed netting measure calculated by the authors are available upon request.

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[dataset] Daily price data of nearby ICE Futures contracts in coffee, cocoa and cotton and NYMEX WTI oil futures; openly available through Yahoo!Finance; <https://finance.yahoo.com/>

[dataset] Weekly data of Commitment of Traders (COT); openly available by the Commodity Futures Trading Commission (CFTC); <https://www.cftc.gov/MarketReports/CommitmentofTraders/HistoricalCompressed/index.htm>

[dataset] Weekly Google Trends web search indices; openly available through Google Trends; <https://trends.google.com>

[dataset] Daily data of US Dollar Index (DTWEXBGS); openly available through Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org>

[dataset] Daily data of CBOE Volatility Index (VIX); openly available through CBOE; https://www.cboe.com/tradable_products/vix/vix_historical_data/

About the authors

Bernhard Tröster (Corresponding Author) is researcher at the Austrian Foundation for Development Research (ÖFSE) with a focus on commodities & development, global value chains and production networks, and international trade.

b.troester@oefse.at

<https://orcid.org/0000-0002-2658-9218>

Ulrich Gunter is an Associate Professor (tenured) at the Department of Tourism and Service Management of MODUL University Vienna and Dean of the Graduate Degree Programs and interested in applied econometrics, with a particular focus on time-series analysis (including forecasting) and panel-data analysis.

ulrich.gunter@modul.ac.at

Appendix

Table A1: Selected articles on financialization of commodity markets using CFTC data.

Article	CFTC Stats	Speculation Measure	Econometric Approach	Commodities	Impact Speculation
Algieri (2016)	Aggregated COT(F&O)	Share long NC, Share net long NC, Working's T	Granger Causality	Agricultures	Yes (V) (+)
Algieri et al. (2017)	Disaggregated COT & CIT (F&O)	Share net Long MM and IT	Multinomial logit	Agricultures	Yes (R) (+)
Alquist & Gervais (2013)	Aggregated COT (not specified)	Working's T	Granger Causality	Oil	No (R)
Aulerich et al. (2013)	Private LTRS (FO)	Net index investment flows	Granger Causality	Agricultures	No (R) No (V)
Bohl & Stephan (2013)	Aggregated COT (Fut)	Absolute total OI NC	GARCH	Agricultures and energy	No (V)
Bohl, et al. (2013)	Disaggregated CIT & COT (F&O)	Absolute total OI IT	Stochastic Volatility model	Agricultures	No (R)
Bohl & Sulewski (2019)	Disaggregated CIT (F&O)	Absolute total and share of OI NC	GARCH	Agricultures	Yes (V) (—)
Borin & Di Nino (2012)	Disaggregated CIT (F&O)	Working's T, MM and SD long & short positions	VAR, Granger Causality , GARCH	Agricultures and energy	No (R) Yes (V) (—)
Bos & van der Molen (2012)	Aggregated COT (F&O and Fut)	Long & short positions NC	Supply-Demand Model	Coffee	Yes (P) (+)
Brunetti et al. (2016)	Private LTRS (F&O)	Number of accounts Merchants, Manufacturers, SD, MM	IV Regression	Oil, Gas, Corn	Yes (V) (—) Yes (R) (+)
Bu (2011)	Aggregate & Disaggregated COT (Fut)	Net long positions NC and MM	Granger Causality & GARCH	Oil	Y(R)(+)
Büyükhahin & Robe (2014)	Private LTRS, Disaggregated CIT (F&O)	Working's T	Regression	Commodity Index	Yes (C) (+)
Büyükhahin & Harris (2011)	Private LTRS (F&O and Fut)	Net positions all trader types	Granger Causality	Oil	No (R)
Capelle-Blancard & Coulibaly (2011)	Disaggregated CIT (F&O)	Net long IT	Granger Causality	Agricultures	No
Coleman & Dark (2012)	Aggregate COT (not specified)	OI to physical production	VECM	Agricultures, metals, energy	Yes (R) (+)
Ding et al. (2014)	Aggregate COT (not specified)	Net positions NC and C	Granger Causality	Oil	Yes (R) (+)
Ederer et al. (2016)	Disaggregated COT (Fut)	Net Positions MM	VAR	Oil, Wheat, Cotton, Coffee	Yes (R) (+)
Etienne et al. (2017)	Disaggregated CIT (F&O)	Net Positions IT	Granger Causality	Agricultures	No (R)
Fagan & Gencay (2008)	Aggregate COT (Fut)	Extreme Positions NC and N	Regression	Oil	Yes (R) (+) Yes (V) (+)
Fishe et al. (2014)	Disaggregate COT (Fut)	Relative net positions Producers, SD, MM	Regression	Agricultures	Yes (R) (+)
Gilbert (2010a)	Disaggregated CIT (F&O)	Index based on index investments	Granger Causality, Regressions	Agricultures, metals, energy	Yes (R) (+)

Gilbert (2010b)	Disaggregated CIT (F&O)	Index futures positions	Granger Causality, Regressions	Agricultures	Yes (R) (+)
Gilbert & Pfuderer (2014)	Disaggregated CIT (F&O)	Index futures positions	Granger Causality, IV Regression	Agricultures	Yes (R) (+)
Gilbert (2018)	Disaggregated CIT (F&O) & CFTC Special Call	Index based on index investments	Granger Causality	Agricultures, metals, energy	Yes (R) (+)
Haase et al. (2019)	Aggregated COT and disaggregated CIT (F&O)	Working's T	Granger Causality	Agricultures, metals, energy	No (P)
Huchet & Fam (2016)	Aggregated COT (not specified)	Absolute total and shares long positions NC	Regression, Granger Causality	Agricultures (incl. coffee, cocoa)	Yes (R) (+)
Irwin et al. (2011)	Disaggregated CIT (F&O)	Net long IT	Granger Causality	Agriculture	No (S)
Irwin & Sanders (2010)	Disaggregated CIT & COT (F&O)	Net positions IT and SD, Working's T	Granger Causality	Agriculture	No (R) No (V)
Kang et al. (2020)	Aggregate COT & Disaggregated COT (F&O)	Hedging pressure, share net long, propensity to trade	Regressions	Agricultures, metals, energy	Yes (RP) (+)
Kim (2015)	Aggregated COT (not specified)	NC positions	Regression	Agricultures, metals, energy	No (R)
Lehecka (2015)	Disaggregated CIT & Aggregated COT (F&O)	Absolute total positions NC, C & IT, Hedging pressure, Speculative pressure, Working's T	Granger Causality	Agricultures, metals, energy	No (R)
H. Mayer et al. (2017)	Aggregated COT (not specified)	Absolute total and relative positions C & NC	Granger Causality, EGARCH	Metals	No (R) No (V)
J. Mayer (2012)	Disaggregated CIT & COT (F&O)	Net long positions IT and NC	Granger Causality	Agricultures, metals, energy	Yes (R) (+) Yes (V) (+)
Naderian & Javan (2017)	Disaggregated COT (F&O)	Net positions SD and MM	Granger Causality	Oil	Yes (R) (+) Yes (V) (+) Yes (S) (+)
Obadi & Korcek (2018)	Disaggregated COT (not specified)	Long/Short ratio MM	Granger Causality	Oil	Yes (P) (+)
Ofen & Wisen (2013)	Disaggregated COT (not specified)	Share long positions all trader types	Granger Causality	Agricultures, metals, energy	No (R)
Prokopczuk et al. (2016)	Disaggregated CIT & COT (F&O)	Net long positions IT and SD	Granger Causality	Agricultures	No (R) No (R)
Sanders et al. (2004)	Aggregated COT (F&O)	Share of positions and of net long positions C and NC	Correlation, Granger Causality	Energy	No (R)
Sanders & Irwin (2010)	Disaggregated CIT (F&O)	Share net long IT	Regression	Agricultures	No (R)
Sanders & Irwin (2011a)	Disaggregated COT (F&O)	Net positions SD	Granger Causality	Agricultures and energy	No (R) Yes (V) (—)
Sanders & Irwin (2011b)	Disaggregated CIT (F&O)	Net long and share long IT	Granger Causality	Agricultures	No (R)
Sanders et al. (2009)	Aggregated COT (F&O)	Share of positions and of net long positions all trader types	Granger Causality	Agriculture	No (R)
Sassi & Werner (2013)	Aggregated COT & Disaggregated CIT (F&O)	Net positions NC and IT	Granger Causality	Wheat	Yes (R)(+)
Shanker (2017)	Aggregated COT (not specified)	Index on excessive speculation	Cross-sectional Regression	Oil	Yes (V) (+)

Shanmugam & Armah (2012)	Disaggregated (F&O)	CIT	Hedging ratios, Working's T	Granger Causality	Agricultures	No (R)
Singleton (2014)	Disaggregated (F&O)	CIT	Net positions MM and IT	Regression	Agricultures	Yes (R) (+)
Stoll & Whaley (2011)	Disaggregated (F&O)	CIT	Investment Flows IT	Granger Causality	Agricultures	No (R)
van Huellen (2018)	Disaggregated (F&O)	CIT	Hedging and Index Pressure	Error Correction Model	Coffee, Cocoa, Cotton	Yes (S) (+)

Explanatory Notes:

Includes articles 'meta-studies' by Wimmer *et al.*, (2020) and Haase *et al.*, (2016) that apply CFTC data as a speculative measures.

Bold Terms indicated the speculative measure and/or econometric approach that show an impact on commodity price characteristics.

Speculation Measure: NC=Non-commercials, C=Commercials, IT= Index Traders; SD= Swap Dealers; MM= Managed Money

Impact Speculation: (V)= Volatility, (R) = Returns, (P) = Price Level, (C) = Commodity-Equity Correlation, (S) = spreads, (RP) = Risk Premiums. If study shows an impact, the direction of the effect is indicated as (+) or (—);

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Table A2: Descriptive statistics and ADF test results of commodity-specific variables.

Variable	Commodity	No. of obs.	Mean	Std. dev.	Minimum	Maximum	ADF test result
Return	Coffee	759	.1368071	4.513354	-13.45159	22.06025	-20.004***
	Cocoa	759	.1537943	4.049826	-14.45916	14.88632	-19.968***
	Cotton	759	.141674	4.177306	-31.8322	15.47455	-19.939***
GOOGLE	Coffee	760	61.57105	9.881389	45	100	-7.121***
	Cocoa	760	72.58289	5.378773	59	100	-7.334***
	Cotton	760	68.41184	6.639413	51	100	-7.298***
DNM_C	Coffee	759	.0184453	.6182597	-1	1	N/A
	Cocoa	759	.0263505	.5940259	-1	1	N/A
	Cotton	759	.0711462	.5698656	-1	1	N/A
DNM_NC	Coffee	759	.0461133	.4782692	-1	1	N/A
	Cocoa	759	.0105402	.5005481	-1	1	N/A
	Cotton	759	-.0065876	.5822428	-1	1	N/A
TOTAL_C	Coffee	760	237634.1	63917.39	133062.9	422459.8	-4.039***
	Cocoa	760	252131.2	59014.39	147932.1	398082.5	-4.973***
	Cotton	760	310935.5	75647.3	174423	587616	-4.337***
TOTAL_NC	Coffee	760	219891.6	74051.28	83416.5	474075.9	-4.673***
	Cocoa	760	197221	79202.27	77739.8	460263.1	-6.441***
	Cotton	760	244604.3	63847.87	105396	558087	-5.776***
DNM_PMPU	Coffee	759	-.0039526	.6707104	-1	1	N/A
	Cocoa	759	.0065876	.676565	-1	1	N/A
	Cotton	759	.0935441	.6740168	-1	1	N/A
DNM_MM	Coffee	759	.055336	.639174	-1	1	N/A
	Cocoa	759	-.0065876	.6022901	-1	1	N/A
	Cotton	759	-.0013175	.7071056	-1	1	N/A
TOTAL_PMPU	Coffee	760	162470.9	45173.75	81177	290537	-3.989***
	Cocoa	760	186289.7	38647.75	109986	275967	-4.942***
	Cotton	760	189539.5	58966.16	82145	408070	-4.265***
TOTAL_SD	Coffee	760	60997.8	13950.99	30620	106010	-5.051***
	Cocoa	760	44838.53	16023.43	19854	92793	-4.014***
	Cotton	760	93633.88	17210.44	63731	160056	-4.466***
TOTAL_MM	Coffee	760	111574.9	53395.12	37088	309752	-3.717**
	Cocoa	760	123345.3	43227.5	47633	298557	-6.587***
	Cotton	760	108184.4	24421.8	49718	172902	-7.237***
TOTAL_OR	Coffee	760	93707.62	23624.33	41156	165976	-6.105***
	Cocoa	760	52333.02	26286.66	12787	145606	-4.320***
	Cotton	760	109239.1	61415.04	24662	402648	-4.821***

Own calculations.

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. See Section 4 for variable descriptions and sources.

Table A3: Descriptive statistics and ADF test results of control variables

Variable	No. of obs.	Mean	Std. dev.	Minimum	Maximum	ADF test result
VIX	760	19.26763	9.951916	6.32	80.45	-4.557***
OIL	760	71.0325	23.44338	10	141	-1.941**
EXR	760	101.5176	10.64206	85.5	125.8	-0.856
COVID	760	.0552632	N/A	0	1	N/A
CRISIS	760	.1302632	N/A	0	1	N/A

Own calculations. Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. See Section 4 and References for variable descriptions and sources.

Table A4: OLS estimation results for coffee. Own calculations.

	(1)	(2)	(3)	(4)
	Return coffee	Return coffee	Return coffee	Return coffee
RETURN (-1)	-0.170*** (-4.38)	-0.181*** (-4.68)	-0.197*** (-5.27)	-0.214*** (-5.73)
GOOGLE	-0.0506 (-1.32)	-0.0539 (-1.28)	-0.0555 (-1.52)	-0.0530 (-1.35)
DNM_C	-2.650*** (-10.09)	-2.670*** (-10.23)		
DNM_NC	1.773*** (5.87)	1.849*** (6.00)		
TOTAL_C		0.0000140** (2.51)		
TOTAL_NC		-0.00000484 (-1.29)		
DNM_PMPU			-1.972*** (-8.11)	-2.008*** (-8.22)
DNM_MM			2.450*** (9.93)	2.543*** (10.25)
TOTAL_PNMU				0.0000124 (1.62)
TOTAL_SD				0.0000250 (1.33)
TOTAL_MM				-0.0000128** (-2.55)
TOTAL_OR				0.00000683 (0.62)
VIX	-0.0444 (-1.57)	-0.0472* (-1.68)	-0.0311 (-1.12)	-0.0352 (-1.19)
OIL	0.00791 (0.50)	-0.00354 (-0.22)	0.0118 (0.76)	-0.00141 (-0.08)
EXR	0.0206 (0.41)	-0.0319 (-0.60)	0.0332 (0.68)	-0.00513 (-0.09)
COVID	1.820* (1.69)	0.786 (0.65)	1.508 (1.56)	0.580 (0.50)
CRISIS	0.0794 (0.12)	-0.0290 (-0.04)	-0.101 (-0.15)	-0.378 (-0.52)
CONST	1.340 (0.29)	5.544 (1.16)	-0.235 (-0.05)	1.844 (0.35)
No. of obs.	758	758	758	758
Deg. of freed.	9	11	9	13
R ²	0.215	0.222	0.298	0.311
Adj. R ²	0.205	0.211	0.290	0.299
F	31.17	25.89	41.54	29.20
Log likelih.	-2126.3	-2122.7	-2083.6	-2076.4
AIC	4272.54	4269.336	4187.286	4180.877
BIC	4318.847	4324.904	4233.593	4245.706
ARCH-LM	6.236	5.445	10.758	8.932
p(ARCH-LM)	0.0125	0.0196	0.0010	0.0028

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. t statistics in parentheses (robust standard errors).

Table A5: OLS estimation results for cocoa. Own calculations.

	(1)	(2)	(4)	(5)
	Return cocoa	Return cocoa	Return cocoa	Return cocoa
RETURN (-1)	-0.0936** (-2.36)	-0.0962** (-2.43)	-0.158*** (-4.15)	-0.166*** (-4.28)
GOOGLE	-0.00641 (-0.21)	0.00597 (0.19)	0.00658 (0.22)	0.0218 (0.70)
DNM_C	-1.814*** (-7.40)	-1.817*** (-7.44)		
DNM_NC	1.761*** (6.24)	1.763*** (6.18)		
TOTAL_C		-0.00000802 (-1.32)		
TOTAL_NC		0.00000658* (1.66)		
DNM_PMPU			-2.502*** (-11.64)	-2.536*** (-11.68)
DNM_MM			1.451*** (6.20)	1.438*** (5.97)
TOTAL_PNMU				-0.00000772 (-1.03)
TOTAL_SD				-0.0000216* (-1.83)
TOTAL_MM				0.0000108** (2.10)
TOTAL_OR				0.00000243 (0.25)
VIX	-0.0603** (-2.30)	-0.0624** (-2.37)	-0.0482* (-1.94)	-0.0573** (-2.30)
OIL	-0.0204* (-1.73)	-0.0243* (-1.70)	-0.0168 (-1.54)	-0.0243* (-1.67)
EXR	-0.0481* (-1.96)	-0.0572 (-1.33)	-0.0477** (-2.07)	-0.0549 (-1.50)
COVID	1.162 (1.18)	0.864 (0.86)	0.736 (0.80)	0.334 (0.36)
CRISIS	1.217* (1.89)	1.231* (1.88)	1.140* (1.88)	1.322** (2.06)
CONST	7.936** (2.00)	9.015* (1.88)	6.500* (1.75)	7.787* (1.76)
No. of obs.	758	758	758	758
Deg. of freed.	9	11	9	13
R ²	0.166	0.169	0.282	0.291
Adj. R ²	0.156	0.157	0.273	0.279
F	16.56	13.88	31.51	22.27
Log likelih.	-2066.4	-2064.9	-2009.7	-2004.9
AIC	4152.872	4153.842	4039.458	4037.771
BIC	4199.179	4209.41	4085.765	4102.601
ARCH-LM	5.585	5.377	4.183	4.628
p(ARCH-LM)	0.0181	0.0204	0.0408	0.0314

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. t statistics in parentheses (robust standard errors).

Table A6: OLS estimation results for cotton. Own calculations.

	(1)	(2)	(4)	(5)
	Return cotton	Return cotton	Return cotton	Return cotton
RETURN (-1)	-0.0447 (-0.89)	-0.0692 (-1.35)	-0.0875 (-1.65)	-0.121** (-2.25)
GOOGLE	-0.0679* (-1.94)	-0.0431 (-1.22)	-0.0701** (-2.04)	-0.0332 (-0.94)
DNM_C	-1.512*** (-6.60)	-1.512*** (-6.64)		
DNM_NC	1.303*** (5.90)	1.453*** (6.42)		
TOTAL_C		0.0000146*** (4.04)		
TOTAL_NC		-0.0000106** (-2.52)		
DNM_PMPU			-1.294*** (-5.14)	-1.304*** (-5.28)
DNM_MM			1.505*** (5.65)	1.578*** (6.17)
TOTAL_PNMU				0.0000180*** (3.49)
TOTAL_SD				0.00000435 (0.32)
TOTAL_MM				0.0000131 (1.49)
TOTAL_OR				-0.0000174*** (-3.62)
VIX	-0.0628*** (-3.00)	-0.0476** (-2.30)	-0.0645*** (-3.09)	-0.0389* (-1.74)
OIL	-0.0228* (-1.91)	-0.0303** (-2.45)	-0.0218* (-1.88)	-0.0416*** (-3.27)
EXR	-0.0291 (-0.97)	-0.0399 (-1.28)	-0.0274 (-0.91)	-0.113*** (-3.08)
COVID	1.790** (2.51)	1.198* (1.67)	1.674** (2.46)	1.162* (1.66)
CRISIS	0.623 (0.98)	0.253 (0.37)	0.597 (0.98)	0.995 (1.31)
CONST	10.51*** (3.06)	8.293** (2.48)	10.48*** (3.15)	14.14*** (3.94)
No. of obs.	758	758	758	758
Deg. of freed.	9	11	9	13
R ²	0.130	0.154	0.182	0.214
Adj. R ²	0.120	0.142	0.172	0.200
F	19.68	17.07	26.49	19.09
Log likelih.	-2106.4	-2095.7	-2083.2	-2068.0
AIC	4232.88	4215.448	4186.469	4164.051
BIC	4279.187	4271.017	4232.775	4228.88
ARCH-LM	10.575	11.651	17.950	19.578
p(ARCH-LM)	0.0011	0.0006	0.0000	0.0000

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. t statistics in parentheses (robust standard errors).