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ANALYZING THE STRUCTURAL TRANSFORMATION OF COMMODITY MARKETS: FINANCIALIZATION REVISITED

by Filippo Natoli*

Abstract

The first decade of the 21st century saw wide fluctuations in commodity prices and a massively increased participation of financial investors in the commodity derivatives markets. The investigation of whether the presence of financial investors was responsible for these fluctuations - and, more in general, whether large trades affected futures and spot prices - has yielded mixed results in the literature. We take up this question by linking financialization to the ongoing structural transformation of the commodity markets. First, we discuss issues related to the identification of the price effects of financialization; then, we present models of commodity markets with heterogeneous agents and informational frictions and discuss the role of financial investors as the counterparts of commercial hedgers. Lastly, we suggest some avenues for future research, including the possible implications of the shale revolution and of the trading of commodity options in the financialization process.

JEL Classification: G12, G13, Q02.
Keywords: commodity, oil, financialization, speculation, limits to arbitrage, informational frictions.

Contents

* Bank of Italy, Directorate General for Economics, Statistics and Research.

1. Introduction[1]

The first decade of the 21st century has seen a strong upward trend in commodity prices and a massive participation by financial investors in the markets for commodity derivatives. The synchronized boom and bust cycles and the high price volatilities observed in 2007-2008 fueled a heated debate on whether the *financialization*, i.e. the transformation of a segmented market into an asset class for portfolio investors, has distorted commodity pricing in the futures and spot markets.

While the debate was mainly linked to market developments in the 2000s, new evidence is now reviving attention towards the financialization of commodities. Between mid-2014 and early 2016, oil prices dropped by more than 75 percent; this plunge was concomitant with newly increasing cross-commodity (e.g., energy vs. grains) and cross-market (e.g., commodities vs. equities) correlations. The evidence of an ongoing structural change in commodity markets, as well as of the involvement of financial traders as partly responsible for this change, witness the outmost importance of understanding the implications of the financialization process.

This paper illustrates the debate on the financialization through the lens of the main contributions to the literature. Since most of the literature concentrates on the crude oil market, we also focus particularly on it throughout the paper. We first review the stylized facts that motivate the analysis, the asset pricing theoretical background and some representative empirical contributions; then, we discuss a number of relevant papers, grouped into the main lines of research. Lastly, we suggest some avenues for future research, including on the implications of the shale revolution for the oil market and the analysis of commodity derivatives other than futures.

The debate on the financialization of commodities started after the 2008 testimony to the US Senate by the hedge fund manager Michael Masters, who argued that institutional investors, engaged in speculative trading on commodity indexes (i.e., baskets of multiple commodities), had caused a bubble in oil prices (Masters, 2008). Since then, researchers have tested the so-called "Masters hypothesis", focusing on its three main claims, i.e. that the increased financialization is responsible for (1) higher futures prices, (2) the increased comovements across commodities and across asset classes, (3) an increased transmission of shocks from futures to spot prices. Mixed empirical evidence has led to polarized views among academic circles (see Singleton (2014) and Hamilton and Wu (2015)).

We argue in this paper that the results in some of the empirical literature testing the

[1]I would like to thank Pietro Catte, Andrea Finicelli, Marcello Miccoli and Giovanni Veronese for their helpful comments and suggestions.

Masters hypothesis suffer from relevant identification issues. Indeed, commonly used tests of causality from the exposure of non-commercial traders (i.e., traders whose activity is not directly related to commercial needs) to price variations may be biased: without conditioning on the initiator of the trade (i.e., not distinguishing between trades initiated by hedgers – and accommodated by non-commercials –, and trades initiated by non-commercials), price pressures of opposite signs cannot be identified. On the other hand, the identification of speculative demand shocks, defined as shocks to the desirability of holding inventories that are unrelated to current demand and supply, is based on the presumption that inventory holders can immediately recognize shocks to current and future fundamentals, notwithstanding the presence of substantial information lags on commodity demand and supply at the global level.

Unlike other literature reviews on the same topic, we focus on commodity markets from a theoretical point of view, revisiting the classical way of investigating the financialization based on empirically testing the Masters hypothesis. Moreover, some recent contributions on the topic that are important in the debate have never been extensively treated in a literature review, as far as we know.

The theoretical part of the review covers different strands of the literature. Some of them analyze the characteristics of commercial and non-commercial traders and frictions arising from their interaction. A number of contributions highlight that producers have a time-varying desire to hedge their future sales, and non-commercial traders have time-varying capital constraints: when constraints bind, non-commercials cannot accommodate hedging needs fully, so limits to arbitrage entail limits to hedging by producers, causing net pressures on futures and spot prices. Other studies point to the fact that commodity prices are regarded as a barometer of global economic growth by goods producers; however, information on world commodity supply and demand is available only with a lag, leading to misinterpretations of commodity price signals and mis-adjustments of demand and supply, that in turn have feedback effects on prices. Other papers focus on the fact that commercial and non-commercial investors have different skills and market knowledge, so one of the two groups could be more adept in interpreting the source of specific variations in the fundamentals than the other. Stylized facts included in these studies suggest that some of these aspects are of growing importance because of the financialization process.[2]

To sum up, the heterogeneity of commodity investors is found to have a key influence on the transmission of shocks through a variety of channels: informational frictions and asymmetries, different preferences among investor categories or disagreement about fundamentals

[2] Another implication of the involvement of financial investors in commodity markets is the increasing use of commodities as collateral for financing, particularly relevant in economies that have capital controls.

are some of the most important ones. As a consequence, financial investors may play the role of either liquidity providers or liquidity demanders depending on the available capital, on their degree of risk aversion, as well as on their relative access to information with respect to hedgers. The analysis of whether they have a distortionary or a price-stabilizing role in the markets should not disregard these aspects.

The last section focuses on the shale oil sector and on commodity options, to suggest some avenues for future research. Concerning the former, the growing role of shale companies in the oil producing sector implies an increasing heterogeneity of participants in derivatives markets on the side of commercial hedgers; as regards the latter, commodity options are a widely used hedging tool for commodity producers and consumers (like airline companies) and an instrument that can be used to gain volatility exposure: for this reason, option trading can be relevant for spot pricing.

The paper is organized as follows. Section 2 describes some stylized facts with regard to financial market developments, the evolution of commodity demand and of financial investment in commodities that characterized the early 2000s; Section 3 presents the asset pricing foundations of commodity pricing and the two main theories underlying the behavior of futures and spot prices; Section 4 describes some empirical contributions testing the Masters hypothesis and discusses the main identification strategies adopted; Section 5 presents findings that connect the increased involvement of financial traders to the structural change taking place in commodity markets, and briefly reviews theoretical models featuring limits to arbitrage, informational frictions and other frictions linked to investor heterogeneity; Section 6 proposes some avenues for future research, related to the shale revolution and to option trading; Section 7 concludes.

2. Stylized facts

Since the sharp commodity price oscillations that occurred in 2008-2009, researchers have started to investigate the possible effects of the financialization of commodity markets, based on evidence drawn from financial markets. We document some relevant stylized facts concerning the massive involvement of financial investors in commodity markets and the main price developments.

2.1. Financial investors

During the 2000s, commodity markets experienced an investment boom. A 2008 staff report by the Commodity Futures Trading Commission (CFTC henceforth), based on a survey on swap dealers and commodity index funds, estimated holdings of commodity index-related products to have increased from 15 billion USD in 2003 to over 200 billion USD in 2008; of the 200 billion invested, approximately 24 percent was held by index funds, 42 percent by institutional investors, 9 percent by sovereign wealth funds and 25 percent by other traders (CFTC, 2008).[3] Results from this survey constitute the first piece of evidence that raised the attention on the activity of financial investors in commodity derivatives markets.

Since the 1960s, the CFTC has been producing a Commitment of Traders report (COT report, henceforth) on exchanges in commodity markets, that started to be published on a weekly basis since the 2000s. In its most recent version, it includes the number of open interests in commodity futures and options traded in US markets by trader category, divided into commercial and non-commercial investors.[4] One particular subcategory of non-commercial investors is that of commodity index traders (CITs henceforth), investing in commodities by replicating the payoff of exchange-traded commodity indexes;[5] while the exposure of CITs cannot be inferred directly from the COT report, a Supplement to it, dedicated to 12 agricultural commodities only, explicitly reports CITs' positions from 2006 onwards.[6]

In the 2000s, CITs started to be active in commodity derivatives markets: between 2004 and 2006, they dramatically increased both their gross positions in futures and options market and their net long exposure, that continued to rise until end 2008; after a decline in long positions in 2013 and 2014 – possibly due to the entry into force of regulatory constraints –, in 2015 they started again to raise their net long exposure (see Figure 1).[7]

While the empirical literature (see Section 4) has particularly focused on those investors and on the price implications of their activity, theoretical contributions (discussed in Section 5) point more generally to the role of financial investors in commodity derivatives as the

[3]Of the 200 billion invested as of 2008, 161 were invested in US exchange-traded futures and options and 39 in OTC products; the notional value of open interests in exchange-traded products was estimated to be around 17 percent of the total open interests in commodity futures and options.

[4]Prior to September 2009, the COT report separated traders between two broad categories (commercials and non-commercials); since then, it started to provide a more detailed breakdown of investors splitting commercials between traditional commercials (producers, processors, commodity wholesalers or merchants, etc.) and commodity swap dealers, and non-commercials between managed money traders (i.e., hedge funds) and other non-commercial traders.

[5]CITs are characterized by the CFTC as traders "replicating a commodity index by establishing long futures positions in the component markets and then rolling those positions forward from future to future using a fixed methodology" (CFTC, 2012); while some of them are pension funds or other managed funds taking a direct position in futures contracts, the majority are swap dealers who sell OTC products that track futures-based indexes and re-hedge themselves going long on exchange-traded products.

[6]For a more detailed description of data in the COT report and in its Supplement, see Buyuksahin and Robe (2014) and Hamilton and Wu (2015)

[7]The decreasing volume of positions since 2013 may partly be ascribed to the advent of new regulatory frameworks aimed at controlling over-the-counter activity and limiting proprietary trading by financial intermediaries (e.g., the Dodd Frank Act and Volcker Rule, both implemented from 2012 Q4; see Figure 6 for an overview of the recent regulation impacting commodity traders).

market counterpart of commercial hedgers; in what follows, unless specifically referring to CITs only, the terms "financial" or "non-commercial" investors are used interchangeably.

The evidence on the massive involvement of financial investors in the 2000s is concomitant with a number of relevant facts concerning commodity prices, that we document in the next subsection.

2.2. Market evidence

Here, we briefly present the main stylized facts on prices and correlations that are relevant to a testing of claims (1), (2) and (3) of the Masters hypothesis.

1. During the 2000s, commodity futures and spot prices trended upward, although with different strength and timing across the various commodities; in late 2008, all prices dropped simultaneously (see Figure 2);

2. Over the same years, correlations among commodities and between commodities and other asset classes progressively increased. Correlations computed among S&P GSCI indexes of different commodity groups (i.e., energy, grains, etc.) show an upward trend starting in 2004, peaking at around 0.7 at end-2008 and staying high until 2013; since then, they have remained highly volatile (see Figure 3). As regards correlations across asset classes, Figure 4 shows that correlations between the GSCI Commodity Index and the Reuters US dollar index (a weighted average of bilateral exchange rates vis-à-vis the US dollar), the S&P 500 and the MSCI Emerging Market Index also reached high levels. While the commodity-dollar correlation has recently declined, the commodity-equity ones – both for US and EMEs equities – have not, and currently stand at around 0.4.

3. A number of measures of investment pressure in derivatives markets – e.g., the Working's T index, that represents market overall investment pressure, or indexes of investment pressure by non-commercials such as specific gross- or net-long positions – showed upward trends during early 2000s (see Figure 5 for oil); the comovements between positions and futures price, and the increased correlation between futures and spot prices, suggest a possible transmission from pressures on derivatives markets to spot prices.

3. Commodity pricing: theoretical underpinnings

Before approaching the debate on financialization, it is important to review the asset pricing foundations of commodity markets. Unlike equities, commodity contracts refer to an underlying physical asset that is storable: commodity holders have the option of saving it over time to use it in the future, so spot prices should also reflect this option value. Following Singleton (2014), we assume that the spot commodity price (S_t), the instantaneous short rate (r_t) and the instantaneous convenience yield net of the unit storage cost (C_t) have uncorrelated stochastic dynamics. The equilibrium spot commodity price at time t is

$$S_t = E_t^Q \left[\exp \left(- \int_t^T (r_s - C_s) ds \right) S_T \right] \tag{1}$$

where E_t^Q is the expectation at time t under the risk-neutral measure. Define the price of a futures contract maturing $T - t$ periods from time t as being equal to the expected future spot price under the risk-neutral probability measure

$$F_t^T = E_t^Q \left[S_T \right] \tag{2}$$

Rearranging Equations 1 and 2 and taking a short time interval $[t, \tau]$ over which r and C can be considered as approximately constant, yields

$$\frac{F_t^T - S_t}{S_t} \approx y_t^T (\tau - t) - C_t (\tau - t) \tag{3}$$

This is the expression of the *future basis*, that depends positively on the the yield of a zero-coupon bond of the same maturity of the futures contract and negatively on the convenience yield. Denote by E_t^P the expectation at time t under the historical (risk-averse) distribution. The T-period futures risk premium (i.e., the premium that long investors receive to take positions in futures) is

$$RP_t^T = E_t^Q (S_T) - E_t^P (S_T) \tag{4}$$

Combining Equations 2 and 4 yields

$$F_t^T = E_t^P (S_T) + RP_t^T \tag{5}$$

Rearranging Equations 3 and 5 yields

$$\frac{E_t^P (S_\tau) - S_t}{S_t} \approx y_t^\tau (\tau - t) - C_t (\tau - t) - \frac{RP_t^T}{S_t} \tag{6}$$

Expected returns in the spot market depend positively on interest rates and negatively on the risk premium and on the convenience yield. The intuitions are the following: concerning the risk premium, the higher the compensation requested by investors for buying futures, the lower the expected return from buying spot at time t and selling back at time T; concerning the convenience yield, the higher the option value of storing the commodity, the lower the expected return from selling it in the future. Singleton (2014) proves that excess returns on futures, obtained by buying and selling futures contracts at different maturities, also depend on a convenience yield and a risk premium component. In sum, the futures risk premium and the convenience yield govern the price relationship between spot and future prices over time and among future prices at different maturities.

The spot and futures pricing of commodities has been rationalized under two main theories, that emphasize the role of the convenience yield (in one case) and of the futures risk premium (in the other case), considering the other factor of second order importance. The theory of storage, pioneered by Kaldor (1939) and Working (1960) and modelled by Deaton and Laroque (1992), focuses on the role of the convenience yield: according to this theory, equilibrium prices result from the optimal inventory management of producers, who use inventories to smooth the effect of price shocks over time; the desired quantity of inventories to carry forward determines the equilibrium level of the convenience yield, which in turns drive expected spot and futures returns. On the other hand, the theory of normal backwardation, pioneered by Keynes (1923) and generalized by Hirshleifer (1988, 1989, 1990), points on the role of derivatives as a hedging tool: according to this theory, commercial hedgers, typically net short on futures – as the hedging needs of producers are assumed to exceed those of consumers – must offer a premium to induce long investors to enter the other side of the market; if this is the case, the futures price should always be lower than the expected spot price (a case named *normal backwardation*).

The theory of storage and the theory of normal backwardation imply different views of what should be considered as "speculation" (i.e., the practice of investing in commodities without commercial purposes) and the way to detect it. Investigations inspired by the theory of storage consider speculative shocks as shocks to the demand of physical commodities for future use, which is reflected in the level of inventories, production decisions and spot pricing. By contrast, studies inspired by the theory of normal backwardation tend to identify speculative shocks as shocks originated by the trading activity of non-commercial investors, producing variations in the futures risk premium. Details on these two approaches and results obtained in the literature will be discussed in greater detail later on.

4. The empirical literature

4.1. Main findings

The stylized facts on investors and prices described in Section 2 have lead researchers to investigate whether it is the increased trading by financial investors that has driven commodity prices or the reverse; or, as a third alternative, whether common factors have been driving both trading and price increases. A number of literature reviews have put together the main contributions describing findings and critical points: see, among others, Irwin and Sanders (2011), Rouwenhorst and Tang (2012), Fattouh et al. (2012), Cheng and Xiong (2014), Hamilton and Wu (2015). We argue that the evidence is much more mixed than it is sometimes presented to be.

Focusing on the dynamics of crude oil, Fattouh et al. (2012) review the financialization literature and identify different strands of research on the topic; they break up the so-called "Masters hypothesis" into its components and discuss, among others, the connection between the increased financialization and (1) higher futures prices, (2) increased comovements among commodities and across asset classes, (3) the transmission from futures to spot prices.

Regarding point (1) (i.e., positions-to-price causality), Hamilton and Wu (2015) conduct a thorough investigation of the relationship between variations in investors' positions and excess returns, focusing on the possible predictive power of the exposure of CITs: on agricultural commodities, tests of Granger causality from positions changes to returns at different horizons yield dismissive (or at least not robust) evidence, even using the finest available disaggregation of data by trader category. Concerning oil, Singleton (2014) constructs the positions of CITs on oil derivatives for the 2006-2010 period, not reported in public databases, by using available CITs' open interests on agricultural commodities and finds that 13-week position changes help predict oil futures returns at different horizons; however, Irwin and Sanders (2011) question Singleton's method to construct imputed positions, and Hamilton and Wu (2015) find that Singleton's measure has no predictive power out of sample (from 2009 through 2012).

On point (2) (i.e., position-to-comovement causality), Tang and Xiong (2012) find a significantly higher comovement of oil for indexed as compared to non-indexed commodities after 2004. Interestingly, comparing commodities traded in US and Chinese exchanges they note that some of those traded in China did not experience the same boom-bust cycles as their US equivalents, and that cross-commodity comovements in China did not increase as much as in the US (see Figure 7); the authors conclude that rising demand from China cannot be the only driver in commodity markets. On the contrary, Stoll and Whaley (2010) stress that, in US markets, the price of commodities not traded on futures exchanges rose as much as, or more than, the price of exchange-traded commodities, suggesting that CITs had no primary role in driving prices up; following the latter, Fattouh et al. (2012) suggest that correlations could have been spurred not by the activity of financial traders but by the increasing relevance of common factors, such as the growing role of emerging economies in both commodity markets and the global economy and the 2007-2009 financial crisis.

Concerning point (3) (i.e., futures-to-spot price transmission), Alquist et al. (2013) examine the out-of-sample predictive power of daily and monthly oil futures prices and show that there is no evidence that futures prices help predict the future spot price of oil. This evidence is contradicted by the findings in Henderson et al. (2015), who analyze the impact of financial investors' trades on commodity futures prices using a novel dataset of commodity-linked OTC notes (CLNs henceforth). In line with the fact that issuers of OTC notes typically hedge their positions on futures markets they find, around the pricing and valuation dates of the CLNs, that changing positions have significant effects on futures prices that do not revert back within the next twenty business days; similar effects are found on spot prices in the same dates.

4.2. Identification issues

The empirical investigation of the price effects of the financialization suffers from several drawbacks. First of all, "financialization" or "speculation" are not straightforward concepts, nor are there universally accepted definitions in the literature.

As we have documented in the previous subsection, many authors define speculative trades as *any* trades made by non-commercial investors. CFTC data, commonly used by researchers relying on the previous definition, are, however, not ideal to identify these traders because of the designation system employed. Indeed, traders who file a statement with the CFTC declaring that they are "engaged in business activities hedged by the use of the futures or option markets" are normally classified as commercial traders, while it is well known that many commodity producers or purchasers also have investment desks, often even more active than their hedging desks.

Even with an ideal designation method able to exclude pure hedgers, tests of causality from variations in the financial investors' exposure to price changes are plagued by a *simultaneity bias*: in fact, these tests assume that changes in positions of non-commercials always reflect shifts in their own investment demand, while market clearing conditions imply that they can change positions also in response of shifts in the demand of traders on the other side of the market (hedgers); the expected sign of the position-price relationship will be different in the two cases: positive when non-commercials are trade initiators (they "consume" liquidity), negative in the opposite case (they "provide" liquidity). The same reasoning applies if functions of non-commercial positions, such as the Working's T index, are used.[8] This argument is presented and developed in Cheng et al. (2014).

Another strand of research bypasses the identification of traders involved and identifies speculation only based on their effects on inventories; in this context, "anyone buying crude oil not for current consumption, but for future use is a speculator from an economic point of view". Kilian and Murphy (2014) define speculative demand shocks as shocks to the desirability of holding inventories – motivated by shifts in expected demand/supply, by uncertainty, or by the anticipation of other market participants' actions – that are unrelated to current demand and supply of the underlying commodity; positive speculative demand shocks entail positive variations in current inventory holdings. Using structural VAR models identified with sign restrictions, they find that speculative demand shocks had little effect in shaping the real price of oil in the 2003–2008 period.[9]

However, the aforementioned VAR identifications are based on the presumption that inventory holders can disentangle shocks to future demand and supply from those to current demand and supply, and vary their consumption and inventory holdings accordingly. However, agents may have trouble even in identifying shocks to current global demand and supply. Countries report their demand and supply of commodities with delay, and some do not even report them at all; for this reason, agents do not have the entire information set to fully recover demand and supply shocks in a timely fashion, but they learn them through time. Hence, as discussed in Sockin and Xiong (2015), the aforementioned identification strategy ignores existing informational frictions in global commodity markets, casting doubt on the viability of this VAR-based inventory approach.

To sum up, the main weakness of the approach adopted by the first strand of literature is that trades made by non-commercials are implicitly considered as exogenous, while in fact equilibrium prices and the positions of all market participants (including non-commercial traders) are determined endogenously by market clearing. Concerning the VAR-based approach, which looks at how shocks to future demand and supply impact the current level of inventories, the assumption of a perfectly rational response of inventory holders to speculative trades also appears to be quite heroic. A more promising approach to the financialization is that of considering its features as part of a broad, structural change in commodity markets.

8 The Working' T proposed in Working (1960), also known as Working's speculative index, is a ratio of the position held by non-commercial investors to that of hedgers

9 Starting from the same concept of speculation, Juvenal and Petrella (2015) isolate speculative shocks from inventory demand shocks by imposing additional sign restrictions reflecting the assumption that speculation leads inventory accumulation not because of expected production shortage but of higher expected prices.

5. Models of commodity markets with heterogeneous agents

While Fattouh et al. (2012) reject the three claims embedded in the Masters hypothesis and conclude that "the existing evidence is not supportive of an important role of speculation in driving the spot price of oil after 2003", they also acknowledge that important structural changes have occurred in the oil market during the 2000s. The authors refer in particular to evidence related to the dynamics of the term structure of future prices, showing interesting changes since mid-2000s. We believe that, together with the greater synchronization of boom-bust cycles and the (still high) correlation with other markets, evidence on the term structure witnesses a broad structural change in commodity markets. Stylized facts on the futures term structure are documented by many authors. We start from the evidence on oil, then extend the discussion to the overall characteristics of the commodity markets.

Buyuksahin et al. (2009) note that, while the dynamics of short-and long-term oil futures prices have been historically disconnected, since 2002 one-year and two-year-ahead futures have started to comove with the near-term futures prices (i..e, the prices of futures with shortest maturities). Using a proprietary dataset of individual trader positions in quoted futures and options, they observe between 2000 and 2008 an increase in financial traders' exposure on long- more than short-term futures (see Figure 8); interestingly, they also note that swap dealers, the first category that started to accumulate long-term exposure, were mostly net long on shorter maturities ($<$ 3 months) and net short on longer ones (1 to 3 years), going more long-term than short-term from mid-2007 onwards. To analyze the connection between investor exposure and prices, they employ a cointegration analysis and find that the increased arbitrage activity by specific trader categories (swap dealers, hedge funds and other financial traders) has helped establish a correlation between futures prices at different maturities. A significant cointegration relationship between the prices of long- and short-term futures is also observed in Fattouh and Scaramozzino (2011), who reconcile this evidence using models featuring price signal extraction and Bayesian updating.

The link between structural market changes and the involvement of financial investors is also provided in Hamilton and Wu (2014). In this paper the authors analyze crude oil futures over the 1990-2011 period and document significant changes in the dynamics of the yield curve during the 2000s. They construct a term structure model based on the relationship between commercial hedgers and non-commercial net-long investors and estimate mostly constant, positive risk premia on futures before 2005, but greater volatility since then (Figure 9); the authors link fluctuations in risk premia with variations in financial investors' risk aversion. Proposing also a modified version of their baseline model that allows intra-month variations in the parameters, the authors find a significant intra-month seasonality of risk premia, consistent with the rising price effects of CITs operating in regulated markets at specific times to futures' maturity.

5.1. Limits to arbitrage and limits to hedging

In line with Hamilton's findings, other contributions point to the behaviour of non-commercial investors and to frictions arising from their interaction with hedgers as key drivers of price effects on the future and spot markets. Etula (2013) connects issues related to commodity pricing with the literature focusing on the determinants of fluctuations in the leverage of intermediaries (Adrian and Shin, 2014); after constructing a measure of broker-dealer risk aversion using balance sheet data of US households and broker-dealers, he finds that risk aversion has strong predictive power on quarter-ahead futures return on oil and other commodities.

In the same vein, Cheng et al. (2014) explore the role of financial investors in commodity trading. As anticipated in Section 4, they recognize that a key issue in the identification of causal relationships between the exposures of these investors and futures price changes, is the lack of conditioning on the *motive for trading*: financial investors might trade to accommodate hedging needs (i.e., following hedgers going short) or initiate trades for their own reasons by increasing or unwinding long positions. Observing that the VIX is positively correlated with the exposure of hedgers and negatively with that of hedge funds and CITs, the authors take positive variations in the VIX as a proxy for financial investors' increased risk aversion/capital constraints: in that case, those investors have low incentive to go long and prefer to cut their exposure (as happened during the 2008 financial crisis), thus redirecting a "convective risk flow" towards commercial hedgers generating a downward pressure on futures prices.

Focusing on the risk premium driver of commodity prices, the analysis of Etula (2013) and Cheng et al. (2014) are implicitly based on the theory of normal backwardation only. A broader picture of the interaction between hedgers and financial investors is provided by Acharya et al. (2013), that construct a two-period model of spot and futures price determination featuring both optimal inventory management and hedging using futures contracts. In their model, risk-averse producers manage inventories and use futures to hedge sales, while risk-neutral investors take long positions in the futures market; producers have time-varying hedging propensity because managerial risk aversion is positively correlated with the default risk of the firm (principal-agent problem), while investors have time-varying capital constraints due to the changing level of market segmentation that, when high, limits the availability of arbitrage capital (limits of arbitrage; see Shleifer and Vishny (1997)). Increases in producers' hedging demand or a tightening of the financial investors' capital constraints prevent the latter to accommodate hedging needs fully, entailing negative pressures on futures prices via a compression of the futures risk premium (*limits to hedging*); this, in turn, increases hedging costs, affecting producers' equilibrium hedging, supply and, therefore, spot prices. Empirically, the authors find that the leverage of broker-dealers and its interaction with producers' default risk are relevant determinants of futures and spot returns.

The bottom line of these three contributions is that limits to arbitrage by non-commercial investors lead to limits to hedging by producers, with evidence of limits to arbitrage in oil and gas markets going back since the end of the 70s (Acharya et al., 2013). Limits to arbitrage have implications for the liquidity of commodity markets: when they bind, liquidity is reduced by financial investors; on the contrary, in times of ample global liquidity or low risk aversion, liquidity is injected in the markets, possibly improving price efficiency. This beneficial aspect has not yet been extensively investigated.

Judging whether the financialization is amplifying or reducing limits to arbitrage is not straightforward: the massive involvement of portfolio investors should, on one hand, decrease the segmentation of commodity markets raising the available arbitrage capital but, on the other hand, should increase traders' exposure to outside shocks – that may induce them, in case of adverse events, to cut positions in commodities.

5.2. Informational frictions

Another key implication of the entry of portfolio investors in commodity markets is related to the formation of expectations of future prices. Cheng and Xiong (2014) point out that, in order to make a comprehensive analysis of the price effects of the financialization, one should not only focus on its consequences for inventories (according to the theory of storage) or for risk sharing between hedgers and financial investors (following the theory of normal backwardation), but also on its effects on price discovery and informational efficiency.

Referring to the standard pricing theory described in Section 3, Singleton (2014) notes that it is not necessary that all market participants have the same expectations about future prices in order for the equilibrium identity in Equation 6 to hold. Looking at the dispersion of oil forecasts made by professional forecasters interviewed by Consensus Economics, he observes that disagreement has increased over time in line with the run-up of oil prices. This motivates the author's choice to use a difference-of-opinions (DOE) model, in which multiple agents do not observe commodity fundamentals but infer them by receiving subjective signals; the resulting heterogeneous beliefs have two main implications for equilibrium prices: (1) the consensus view about the fundamentals depends on the wealth and risk aversion of the different groups of investors, and (2) variations in the dispersion of beliefs can affect prices directly via variations in risk premia, independently of changes in fundamentals.

Sockin and Xiong (2015) develop a tractable model to analyze how informational frictions affect commodity markets. Similarly to Singleton (2014), the source of informational frictions is related to the uncertainty of market participants about actual supply, demand, and inventories of these commodities, determined on a global scale. According to the authors, agents observe variations in commodity prices to infer the actual strength of global economic growth; this *informational role* of commodity prices builds on the evidence that, after 2005, stock markets in Asian economies started to systematically react to overnight variations in the price of futures on some US-traded commodities, such as copper and soybeans (Hu and Xiong, 2013). In the model, commodity prices drive production and demand decisions but, while the price signal is timely, information on global demand and supply is substantially lagged: this learning process on fundamentals leads to misinterpretations of the price signal, and therefore to confusions about the strength of the economy. The main implications of this friction are the following: (1) when commodity prices increase, goods producers demand more of the commodity because the informational effect of high commodity prices – signaling strong growth – outpaces the cost effect; (2) supply shocks act as informational noise: lower prices due to positive supply shocks can be partly attributed to weak global economy, leading goods producers to reduce commodity demand, amplifying the negative effect on prices (feedback effect); (3) by attracting different participants than the spot markets, futures markets have their own informational effects on commodity demand and spot prices. The results of this paper imply that assuming that agents can directly observe demand and supply shocks tends to overstate the price effects of demand shocks and understate those of supply shocks; according to this approach, the VAR-based approach described in Section 4 is misspecified because it misspecifies the available information set at the time of the shock.

The authors also discuss the role of informational frictions in explaining the 2007-2008 oil price boom. They raise doubts on the fact that the 40% oil price increase between January to July 2008 was due to fundamentals, provided that while growth in emerging economies was still strong, advanced economies were already slowing down and the United States was in recession since November 2007. In line with the paper's reasoning, positive effects on prices coming from the inflow of financial investors may have confused goods producers about the strength of emerging economies, delaying demand and supply responses to fundamentals and amplifying booms and busts.

Goldstein and Yang (2016) propose a model to study the implications of the financialization of commodity markets for agents' trading behavior, asset prices, and welfare through the lens of risk sharing and price discovery. In this model, agents have asymmetric information on shocks: commercial hedgers are informed about supply shocks, while financial traders have private signals on demand shocks. The analysis highlights that financial traders can either provide or demand liquidity in the futures market and that they may switch from being liquidity providers to demanders as their presence in the futures market increases.[10] The paper also documents the role of financialization in reducing futures risk premia, as observed in Hamilton and Wu (2014), and provides a transmission channel from shocks hitting derivatives prices to the real economy and spot prices. The welfare implications of the model are that the involvement of informed financial investors: a) helps reduce the risk faced by all market participants, b) increases hedging costs for the less-informed producers but c) improves welfare for consumers.

5.3. Other issues related to heterogeneity

The increased heterogeneity of commodity investors implies not only greater informational frictions but also increased differences in investors' preferences in the market. Basak and Pavlova (2016) construct a general equilibrium model with heterogeneous agents and multiple commodities to explain the main empirical facts linked to the financialization phenomenon described in Section 2 (e.g., increased correlations across commodities and across asset classes, price and volatility increases). In their model, agents are heterogeneous in terms of preferences: institutional investors benchmark investment to the level of a commodity index, while other agents do not. This feature mimics index investors influencing prices, volatilities, and correlations, via a *discount factor channel*: exogenous shocks affecting the index level are amplified and propagate to non-indexed commodities through variations in the discount factor of institutional investors.

The increase in investor heterogeneity is not only related to the presence of hedge funds or CITs, but also to retail investors entering futures markets because of lowered transaction costs. Motivated by the implications of trading on oil ETFs described in Bessembinder et al. (2012), Baker (2016) proposes a general equilibrium model of commodity spot and futures prices with two goods and household consumers allowed to go long on futures to hedge future consumption. The model incorporates both storage and hedging pressure features; the effect of consumers entering futures market in the model is that the price effect of shocks is amplified through the hedging pressure channel, but is partly absorbed through the variation of the desired level of inventories by futures' dealers.

[10] This second finding is in line with Cheng et al. (2014)

5.4. Commodities as collateral

Another implication of the involvement of financial investors in commodity market is the increasing use of commodities as collateral for financing. While this seems to be only a local phenomenon without broad pricing implications, we make a brief digression on it in this paragraph.

This little known phenomenon is documented by Tang and Zhu (2016) who explain that, when a country with capital controls has interest rates that are higher than international ones, financial investors in that country may circumvent capital controls by importing commodities and pledge them as collateral to finance investments. This practice has been observed in China, where interest rates are high in relative terms, there are capital controls and there is lack of investment collateral for some categories of investors.[11] According to the model, an increase in the collateral demand of commodities entails an increase in commodity prices in both the domestic and the funding country, and a simultaneous increase in inventories and the convenience yield.

6. Avenues for future research

In this Section we discuss two interesting avenues for future research, concerning the implications of the shale oil revolution and of commodity option trading for the financialization process. Since there is still inadequate analysis of these two topics, we just limit our discussion to explaining why they could be relevant for the evolution of commodity markets.

6.1. The shale revolution

Among commodity markets, the market of crude oil is experiencing a ground-breaking technological change. The shale sector in the United States is growing fast, gaining market shares in the extraction of crude oil with respect to conventional producers.

Shale oil extraction is introducing relevant changes in the oil market. In a speech delivered to the 2015 Annual Conference to the Society of Business Economists, Dale (2015) highlighted four oil market "principles" that need to be revisited in light of the surging shale sector. Two of them have implications for our analysis: (1) oil must not be considered an exhaustible resource, so prices must not necessarily increase in the long run: supply might not decrease, as efficiency gains in shale extraction tend to expand the potential size of unexplored resources,

[11] For example, the lack of collateral limits bank financing for small and medium enterprises. Concerning the collateral use of commodities, industry estimates that in 2014 about 109 billion USD foreign exchange loans in China were backed by commodities as collateral, equivalent to about 31 percent of Chinas total short-term forex loans and 14 percent of Chinas total forex loans.

while demand does decrease, because of the long-standing and ongoing process of carbon emissions reduction; (2) oil supply will not be as rigid as before: shorter production lags and the more rapid exhaustion of individual shale wells entail a faster response of production to price changes.

The shale market is of particular interest in our debate, for at least two reasons. First of all, shale companies have a cost structure that differs from that of conventional producers, as they have variable operating costs that are a higher share of total costs: this is reflected in shale companies operating with much lower capital and relying extensively on debt financing. The existence of capital constraints motivates price effects of commodity trading in the model of Etula (2013) and Acharya et al. (2013): in the latter, producers have hedging demand for commodity futures and net price pressures arise when long investors are capital constrained and cannot accommodate producers' hedging needs. The increasing role of shale markets may introduce capital constrained investors also on the side of producers.

Second, production of shale wells peaks after a few weeks and declines substantially during the following months of a well's life: their profits being highly dependent on short-term price fluctuations, shale companies usually hedge a much larger part – even more than 50 percent – of their expected production, than companies engaged in conventional extraction (Maugeri, 2013); this fact, coupled with possible differences in the adopted hedging strategies, may be relevant in derivatives pricing.

6.2. Commodity option markets

The literature on commodities has focused on futures as the only derivative securities in which financial trading can occur and distort prices. However, financial traders are active also on other commodity derivatives products such as swaps, ETFs and options, both on regulated markets and OTC.

In particular, stylized facts and textbook evidence point to the use of options for both hedging and financial investing. Looking at data from oil and gas producing firms between 2000 and 2010, Acharya et al. (2013) note that producers use options more than futures or swaps to hedge future sales; on the other side of the market, airline companies use call options and long collars, among other instruments, to hedge future jet fuel purchases (Carter et al., 2004).[12]

In addition to hedging motives, commodity options are traded also to gain exposure to the expected volatility of the underlying (so-called volatility trading, see Schofield (2008)). The literature on equity options has found interesting results on the effects of option trading

[12]Due to liquidity issues in jet fuel derivative instruments, according to the authors airline companies use to cross-hedge against securities that are highly correlated with jet fuel, like heating oil.

on the underlying price.[13] In particular, transaction volumes in equity options have been found to have relevant predictive power for the underlying stock prices when driven by informed traders (i.e., traders having private information), as suggested by Easley et al. (1998). Investigating evidence of informed trading in commodity options and its implications for pricing and liquidity in other commodity markets constitutes an interesting avenue for future research.

7. Concluding remarks

Notwithstanding the difficulties of identifying the effects of financialization during the commodity boom and bust of the 2000s, a number of contributions suggest that the role of financial investors in commodity markets is of growing importance. In this paper we have documented the structural changes that have been occurring in commodity markets since early 2000s: while the rising importance of emerging economies is an important determinant of commodity demand and supply, we believe that the changing composition of investors in financial markets is also highly relevant in affecting commodity pricing. The increasing involvement of leveraged but capital-constrained investors exposes commodities to business and credit cycle fluctuations, and the increased heterogeneity of investors may influence the transmission of shocks to prices because of informational asymmetries, different preferences or disagreements about economic fundamentals driving commodity prices.

For these reasons, financial investors may switch from being liquidity providers to liquidity demanders: similarly to other asset classes, liquidity in commodity markets is becoming the more and more linked to fluctuations in global liquidity and to variations in investors' risk aversion, as well as to the composition of less- and more-informed traders in the market. Further work on the link between liquidity fluctuations and trading activity is needed to assess not only the distortionary effects of financial investment but also the benefits in terms of providing liquidity to hedgers.

As avenues for future research, we also suggest inspecting the implications of the shale oil market revolution as well as of trading in the option market for the financialization process. Even though research on the financialization in commodity markets is advancing fast, more investigation is needed, for example to achieve better identification of speculative shocks.

[13] Constructing a measure of volatility demand pressure based on buying and selling volumes of equity options, Ni et al. (2008) found that volatility demand has a positive impact on option prices and that it is informative about the future realized volatility of underlying stocks. One channel of this effect could be that identified in Hu (2014): after executing option orders, option market makers turn to the stock market to hedge their exposures, as sellers of commodity-linked notes do in the futures market (Henderson et al., 2015).

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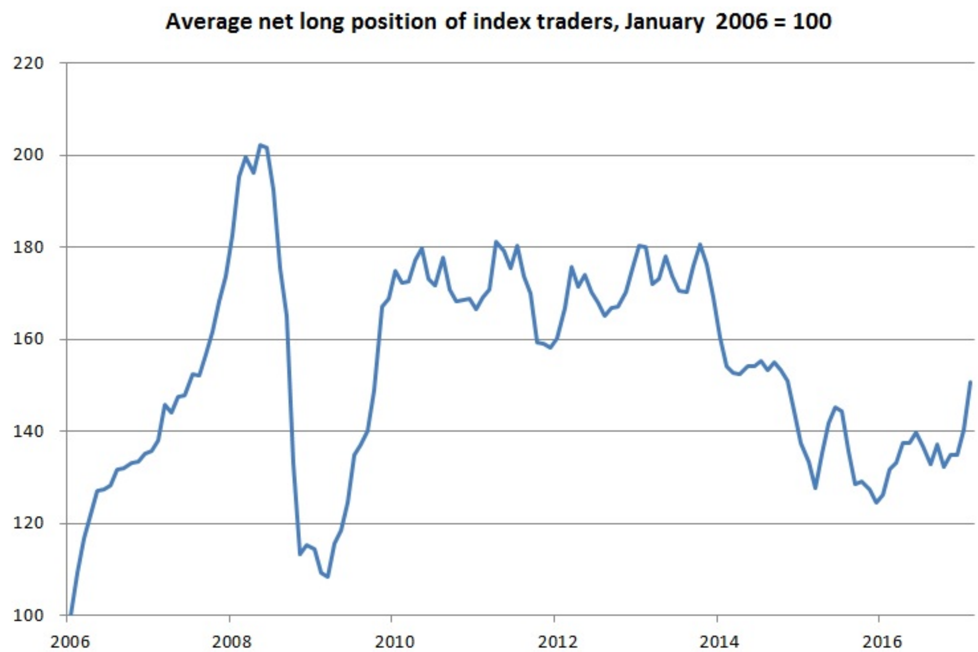

Figure 1. Net long positions of index traders averaged across 12 commodities. Net long positions are long less short positions, and long and short positions are the sum of positions on futures and options. For each commodity, the January 2006 observation is rescaled to 100. Sample is January 2006 – February 2017. Source: Supplement report of the Committment of Traders (COT) report.

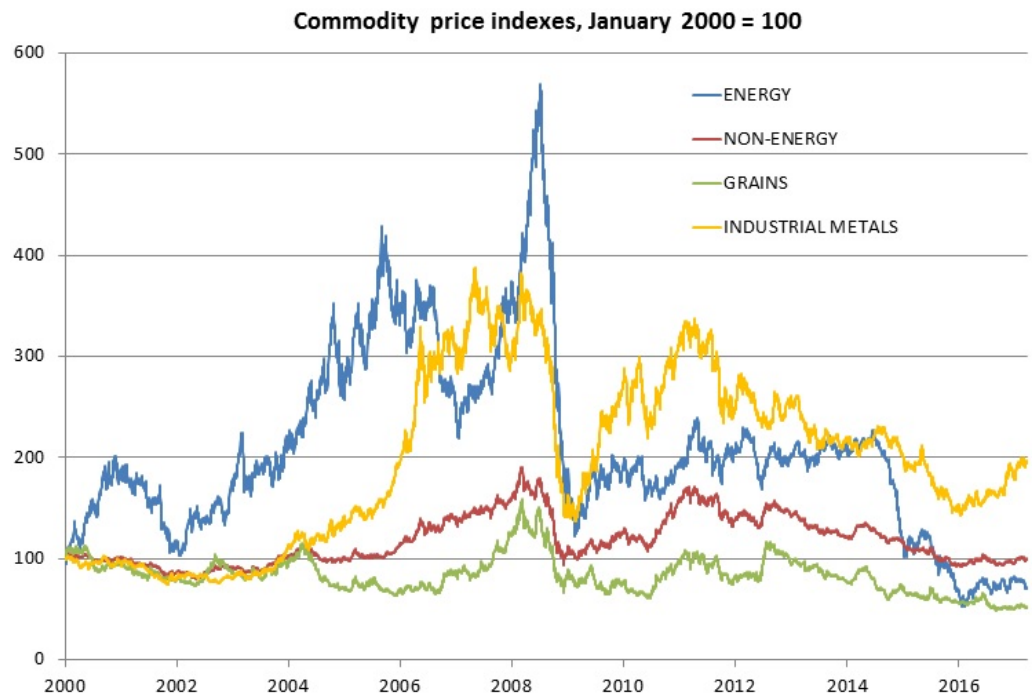

Figure 2. Commodity price indexes, January 2000 = 100. Sample is January 2000 – March 2017.

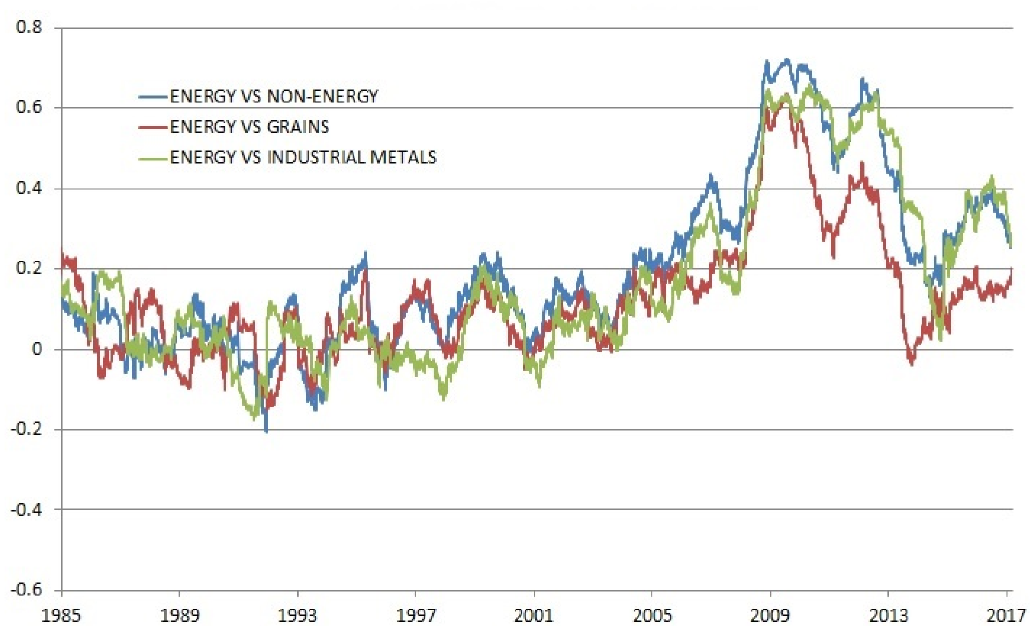

Figure 3. 250-day rolling correlations between daily returns of the S&P GSCI Energy Index with (1) the S&P GSCI Non-Energy Index (blue), (2) the S&P GSCI Grain Index (red) and (3) the S&P GSCI Industrial Metals Index (green). Sample is January 1985 – March 2017. Source: Datastream

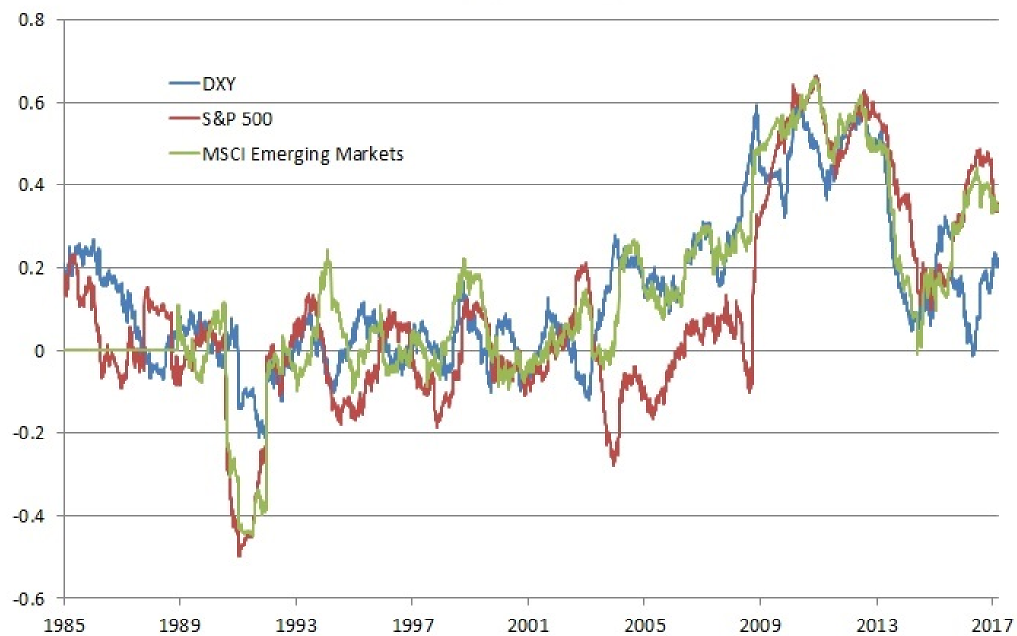

Figure 4. 250-day rolling correlation between daily returns of the S&P GSCI Total Return Index and (1) the Reuters DXY Dollar Index (a weighted index of the euro, Japanese yen, British pound, Canadian dollar, Swedish krona, and Swiss franc against the dollar) multiplied by -1 (blue line), (2) the S&P 500 Index (red line) and (3) the MSCI Emerging Market Index (green line). Sample is January 1985 – March 2017. Source: Datastream

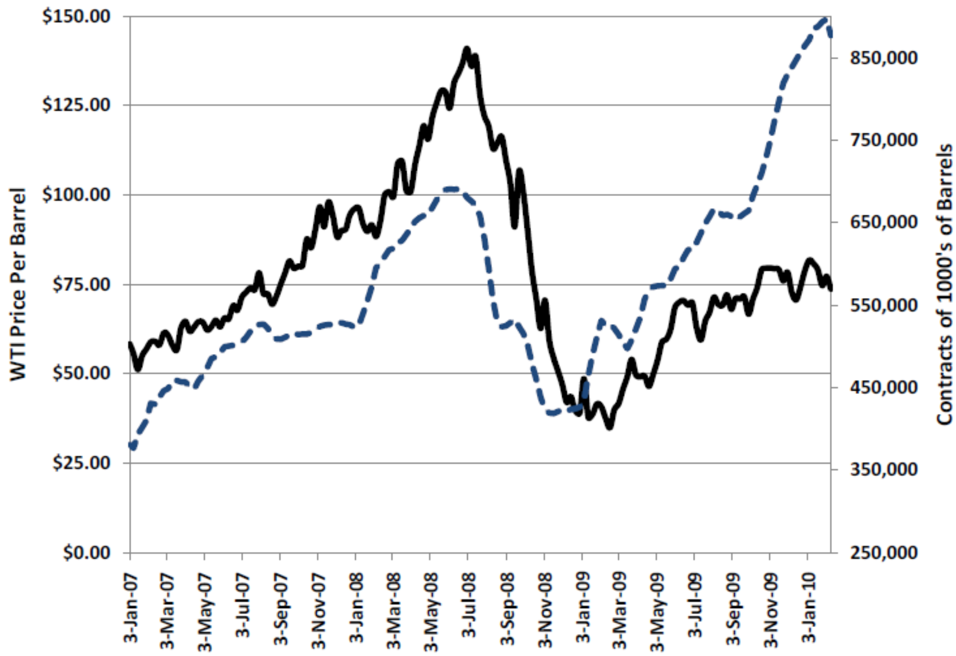

Figure 5. CITs long position on oil derivatives inferred from the Supplement to the COT report (dashed line, right sale) plotted against the front-month WTI futures price (solid line, left scale) taken from Singleton (2014).

Regulation	Main regulatory changes	Impact on commodity traders
Basel III (worldwide) ▪ Scope: bank companies ▪ Full effect: 2018 ▪ Transition: from 2013	**Deleveraging of banks' balance sheets given new requirements** ▪ Maximum leverage ratio ▪ Minimum target capital ▪ Minimum liquidity ratio ▪ Credit-valuation adjustments	**Tightening access to financing as banks lower trade-finance exposures** ▪ Less availability of letters of credits, especially for higher-risk counterparties ▪ Difficulty to raise syndicated loans ▪ Higher costs across all trade-finance products
Dodd-Frank Act (US) ▪ Scope: "swap dealers" ▪ In effect from: July 2010[1] **EMIR[2] (EU)** ▪ Scope: all derivative trading[3] ▪ In effect from: 2013 **MiFID II[4] (EU)** ▪ Scope: systemic financial institutions[5] ▪ In effect from: 2014/15 earliest	**Stronger regulation of over-the-counter derivatives** ▪ Central clearing and reporting ▪ Capital and margin requirements ▪ Reporting to central trade repository ▪ Daily mark-to-market/collateral needs ▪ Trading on organized trading venues ▪ Position limits ▪ More regulatory oversight/intervention	**Increasing complexity and cost intensity of trading operating model** ▪ Systems and processes upgrades given new reporting requirements ▪ Increased working-capital needs (clearing fees, margin, collateral) ▪ Compliance upgrades (tracking trading thresholds, position limits, etc.)
Volcker Rule (US) ▪ Scope: banks, financial institutions ▪ In effect from: July 2010 ▪ Implementation from: Q4/2012[1]	**Limits to banks' trading activities** ▪ Ban of proprietary trading (financial, physical) ▪ Potential limits to banks' ownership/ control of physical trading assets (eg, storage)	**Changes to competitive set as banks exit/spin off commodity trading** ▪ Less market making, less hedging tools (further rising trade-finance costs) ▪ Banks to spin off commodity-trading units, potentially sell physical assets ▪ New opportunities for traders in paper trading, physical assets, M&A

1 Implementation from: Q4/2012 (further clarifications to rule likely after 2012 presidential election).
2 European Market Infrastructure Regulation.
3 Exemption: central clearing not required for trading by "nonfinancial" firms for hedging purposes or other trades below a certain clearing threshold.
4 The Markets in Financial Instruments Directive II.
5 Exemptions: commodity traders if trading is an "ancillary" business and dealing on own account and not a subsidiary of a financial group.

Figure 6. Summary table of key regulation affecting commodity traders. Source: McKinsey (2012)

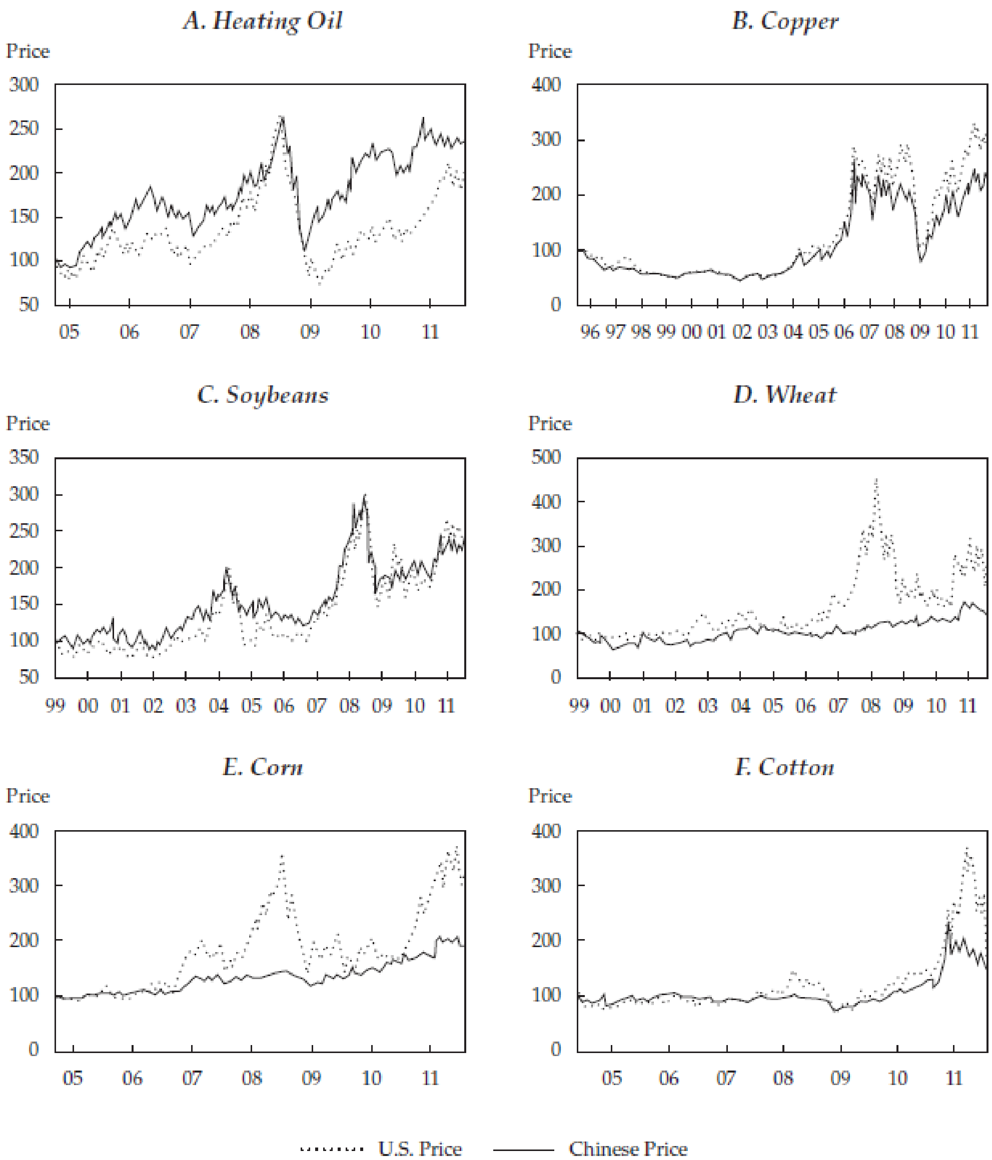

Figure 7. Normalized Commodity Prices in China and the United States, taken by Tang and Xiong (2012).

Open Interest by Maturity and Trader Category – Annual Averages

	Futures Only						Futures & Futures-equivalent Options					
Panel A: 2000	0-3 months	3-12 months	1-3 years	3+ years	Total		0-3 months	3-12 months	1-3 years	3+ years	Total	
Manufacturers	30,361	13,185	7,858	2,479	53,883		37,601	16,720	7,985	2,479	64,784	
Other Commercials	3,292	1,664	120	-	5,076		3,540	1,810	120	-	5,471	
Producers	11,131	6,733	2,413	899	21,176		15,575	9,947	2,494	899	28,915	
Dealers/Merchants	49,401	37,665	20,068	5,173	112,307		58,100	42,351	20,691	5,173	126,316	
Commodity Swap Dealers	41,155	42,206	40,682	9,090	133,132		68,684	77,563	53,300	9,091	208,637	
Unclassified Commercials	11,715	4,642	1,688	72	18,117		16,267	6,018	1,997	72	24,354	
Non-Registered	9,590	3,602	654	736	14,581		21,891	10,418	728	736	33,774	
Floor Brokers/Traders	6,320	12,250	6,432	443	25,445		22,695	23,083	7,819	443	54,039	
Hedge Funds	16,542	7,228	6,340	595	30,705		18,072	8,244	7,077	595	33,988	
Total	**179,505**	**129,175**	**86,256**	**19,487**	***414,423***		**262,425**	**196,155**	**102,210**	**19,488**	***580,278***	
Commercial	147,053	106,096	72,830	17,713	343,692		199,767	154,409	86,588	17,713	458,477	
Non-Commercial	32,452	23,080	13,426	1,774	70,731		62,658	41,745	15,623	1,775	121,800	
NonComm + Swap Dealers	73,606	65,286	54,107	10,864	203,863		131,342	119,308	68,923	10,865	330,438	
Panel B: 2004	0-3 months	3-12 months	1-3 years	3+ years	Total	Diff vs.2000	0-3 months	3-12 months	1-3 years	3+ years	Total	Diff vs.2000
Manufacturers	27,266	9,533	10,932	1,273	49,004	-9%	34,543	11,756	11,074	1,273	58,646	-9%
Other Commercials	2,031	328	-	1	2,360	-54%	2,935	909	36	1	3,882	-29%
Producers	11,119	2,897	486	1	14,503	-32%	12,463	3,190	501	1	16,155	-44%
Dealers/Merchants	78,364	55,359	25,046	13,683	172,452	54%	99,832	75,068	29,837	13,879	218,615	73%
Commodity Swap Dealers	64,812	78,102	55,763	23,352	222,029	67%	108,535	145,303	75,881	24,810	354,529	70%
Unclassified Commercials	120	539	2	-	661	-96%	126	583	3	-	713	-97%
Non-Registered	20,931	9,060	4,956	3,241	38,188	162%	41,808	25,532	6,879	3,241	77,460	129%
Floor Brokers/Traders	16,130	20,600	8,999	2,460	48,190	89%	58,512	52,444	9,731	2,460	123,146	128%
Hedge Funds	59,220	18,052	7,752	3,525	88,550	188%	74,950	29,117	10,857	3,538	118,463	249%
Total	**279,995**	**194,469**	**113,935**	**47,536**	***635,936***	53%	**433,704**	**343,904**	**144,798**	**49,202**	***971,609***	67%
Diff vs.2000	56%	51%	32%	144%	53%		65%	75%	42%	152%	67%	
Commercial	183,713	146,757	92,228	38,310	461,008	34%	258,434	236,811	117,332	39,963	652,539	42%
Non-Commercial	96,282	47,713	21,707	9,226	174,928	147%	175,270	107,093	27,467	9,240	319,069	162%
NonComm + Swap Dealers	161,094	125,814	77,470	32,578	396,957	95%	283,805	252,397	103,348	34,049	673,598	104%
Panel C: 2008	0-3 months	3-12 months	1-3 years	3+ years	Total	Diff vs.2000	0-3 months	3-12 months	1-3 years	3+ years	Total	Diff vs.2000
Manufacturers	21,990	8,265	4,978	189	35,423	-34%	26,874	10,069	5,355	189	42,487	-34%
Other Commercials	861	373	170	-	1,404	-72%	1,000	387	170	-	1,556	-72%
Producers	13,233	2,490	386	-	16,109	-24%	15,196	3,261	523	-	18,980	-34%
Dealers/Merchants	86,349	63,208	43,399	9,844	202,800	81%	147,277	118,306	62,819	14,635	343,037	172%
Commodity Swap Dealers	126,363	135,701	128,288	49,876	440,227	231%	217,358	343,346	292,534	94,713	947,952	354%
Unclassified Commercials	-	-	-	-	-	-100%	-	-	-	-	-	-100%
Non-Registered	74,951	41,741	23,072	8,116	147,880	914%	191,023	179,688	52,800	11,414	434,925	1188%
Floor Brokers/Traders	23,018	24,402	2,393	1,103	50,916	100%	139,676	147,703	10,736	1,103	299,218	454%
Hedge Funds	125,066	145,722	76,899	24,692	372,378	1113%	181,590	252,291	137,939	38,314	610,134	1695%
Total	**471,830**	**421,903**	**279,585**	**93,820**	***1,267,137***	206%	**919,992**	**1,055,052**	**562,877**	**160,369**	***2,698,289***	365%
Diff vs.2000	163%	227%	224%	381%	206%		251%	438%	451%	723%	365%	
All Commercials	248,795	210,037	177,221	59,909	695,963	102%	407,704	475,369	361,401	109,538	1,354,012	195%
All Non-Commercials	223,034	211,865	102,364	33,911	571,174	708%	512,288	579,682	201,476	50,831	1,344,278	1004%
NonComm + Swap Dealers	349,397	347,566	230,652	83,786	1,011,401	396%	729,646	923,029	494,010	145,545	2,292,230	594%

Figure 8. Open interests in crude oil futures (left panel) and futures plus options (right panels), taken by Buyuksahin et al. (2009). Annual position averages for each trader category and maturity bucket are taken for the year 2000 (July-Dec.), 2004 (Jan.-Dec.), and 2008 (Jan.-Aug.)

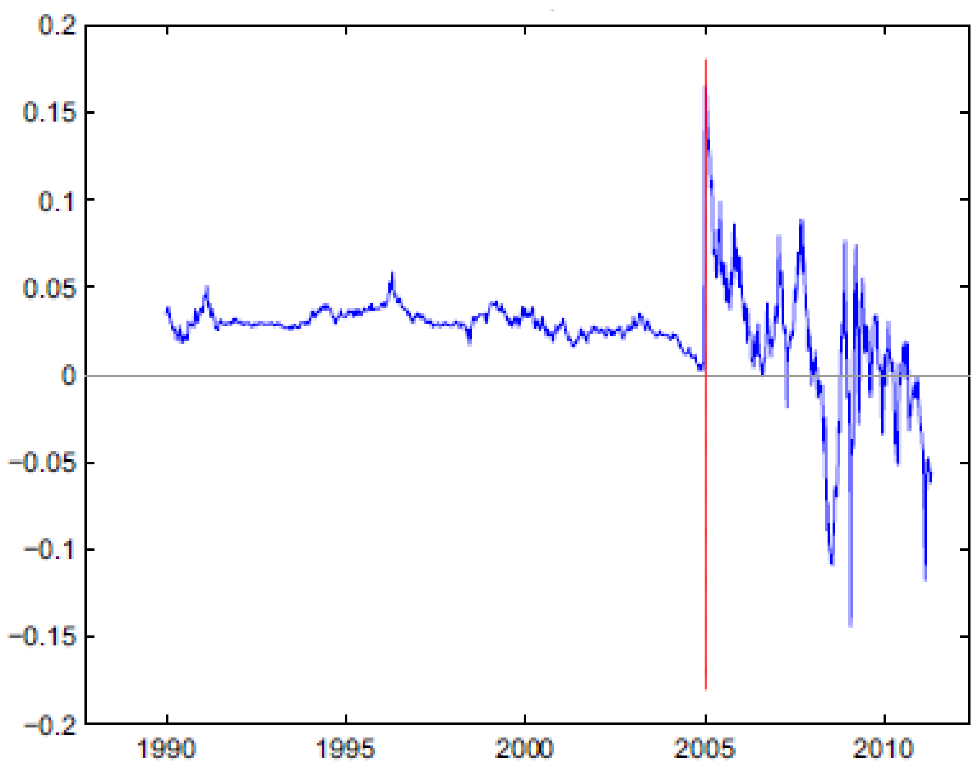

Figure 9. Risk premium on 8-week oil futures taken by Hamilton and Wu (2014): baseline model with sample split in 2005.