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The synchronized and long-lasting structural change on commodity markets: Evidence from high frequency data

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Abstract. This paper analyses the co-movements between the US stock market and several commodity futures between 1998 and 2011. It computes dynamic conditional correlations at (i) 1-hour, (ii) 5-minute, (iii) 10-second, and (iv) 1-second frequencies and documents a synchronized structural break, characterized by correlations that have significantly departed from zero to positive territories, since late September 2008. Our results support the idea that high frequency trading and algorithmic strategies have an effect on the behaviour of commodity prices.

JEL Classification: G10, G12, G13, G14, G23, O33

Keywords: Financialization, Cross-Market Linkages, Commodity, High Frequency, Structural Change

1. Introduction

Investing in commodities through futures markets gained importance among financial investors after the burst of the dot-com bubble. As investors looked for a new asset class to diversify their portfolio and reduce their risks, commodities futures looked attractive thanks to their returns, similar to but uncorrelated with those of equities (Gorton and Rouwenhorst, 2006).

Dissenting views exist on the costs and benefits of the growing financial investors' presence in commodity futures markets, which Domanski and Heath (2007) first coined as the "financialization" of commodity futures markets. The debates around this catchall term are multi-faceted because financialization encompasses a wide variety of investment strategy with plausibly heterogeneous effects. Yet, the discussions often boil down to whether and how the increasing existence of non-traditional participants has influenced return patterns in these markets.

For some observers, this overall evolution eases the price discovery problem; brings the price closer to its underlying fundamentals; provides liquidity; and transfers risks to agents who are better prepared to assume it (see e.g. Irwin and Sanders (2012) and references cited therein). For other observers, the financialization of commodity markets leads to price distortions. In this literature, one specific approach looks at the development of correlations between the returns on investments in different commodity futures or between commodities and other financial assets, with the underlying assumption that growing correlations between commodities and stock indices represent one manifestation of these price distortions (see e.g. UNCTAD, 2009, 2011; Büyükşahin, Haigh

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and Robe, 2010; Tang and Xiong, 2002; Başak and Pavlova, 2013).

Büyükşahin and Robe (2011, 2013) show that the correlations between the returns on commodity and equity indices on a *daily* basis increased after Lehman Brothers' demise and remained exceptionally high through the winter of 2010. Using non-public data between 2000 and 2010 from the Commodity Futures Trading Commission (CFTC), Büyükşahin and Robe (2011, 2013) find that hedge fund positions help predict these changes in the intensity of the correlation between the return of equity and energy indexes. Still, as first shown by Büyükşahin, Haigh and Robe, 2010, both short- and long-term co-movements between passive commodity and equity investments were generally weaker between 2003 and 2008—period in which commodity index trading grew sharply—than compared to the 1991-2002 period. Nevertheless, from the fall 2008 onwards, their positive correlations show a sharp increase to levels not previously reached and especially not maintained for so long in the course of the last decade.

In this paper, we use tick-level data from January 1998 to December 2011 to shed additional light on the persistent and synchronized structural change that started in late 2008. It is critical to go beyond daily data, which has so far been the standard in the literature. At daily, weekly or monthly frequencies, increased co-movements between commodity and equity returns could simply be the result from shocks that are common to both markets rather than a manifestation of the financialization of commodity markets. In contrast, it is harder to attribute a sustained increase in correlations at intraday frequencies to changes in common fundamentals insofar as the latter do not vary at high frequencies.[1]

We show that the structural break documented using daily data by Büyükşahin and Robe (2011, 2013) also appears at higher-than-daily frequencies. Our finding of positive intraday correlations between returns on equities and commodities indicates that commodity markets are now extensively integrated with financial markets.

In the case of crude oil, the most actively traded commodity, we observe the correlation increase at up to one-second intervals. Moreover, we find that this structural break is not confined to the energy sector. Indeed, it affects a wide range of soft commodities, including corn, soybeans, wheat, sugar, and live cattle. Historically, positive correlations between soft commodities and equities are less likely to last long since their respective fundamentals have little in common. Moreover, one should probably expect different correlation patterns between the equity market and each of these soft commodities, because all these soft commodities have their own respective fundamentals in terms of seasonality, geography, demand structure, etc. Yet, it could be argue that soft commodities could, to some extent, substitute for others. Moreover, there is empirical evidence that commodity-equity correlations fluctuate substantially over time over the U.S. business cycle (see e.g. Bhardwaj and Dunsby, 2012) and that a world-demand factor can drive the correlation between commodities and equities (see e.g. Alquist and Coibion, 2013; Büyükşahin and Robe, 2013).

Nevertheless, with these caveats in mind, we think that these findings have important implications for the debate on the financialization of commodity markets, which we discuss in the concluding section of this paper.

2. Data and Econometric methods

We analyse the co-movements between the US stock market and several commodity markets between January 1998 and December 2011, using data from the Thomson Reuters Tick History (TRTH) database. We study the correlation between one of the most liquid equity derivatives, the E-mini S&P 500 futures, and derivative contracts of commonly used benchmark for selected commodities, namely: light crude oil WTI (NYMEX), corn (CBOT), wheat (CBOT), sugar #11 (ICE - US), soybeans (CBOT) and live cattle (CME).[2]

Fig. 1 shows that the number of trades per year increased significantly owing to the emergence of electronic trading in mid-2000s amid the financialization of commodity futures markets. Overall, the

[1] Rather, it could reveal other factors linked to the financialization of commodity markets. For instance, Filimonov et al. (2013) found that the importance of short-term endogeneity for several commodity futures markets—defined as the relative number of price moves that are due to previous price changes to the total number of all price changes—has also increased significantly and coincided with the expansion of quantitative trading on commodity futures markets in the second half of the first decade of the 2000s.

[2] Each acronym stands for the exchange where a contract is traded: CBOT (Chicago Board of Trade), ICE - US (Intercontinental Exchange - United States), NYMEX (New York Mercantile Exchange), CME (Chicago Mercantile Exchange).

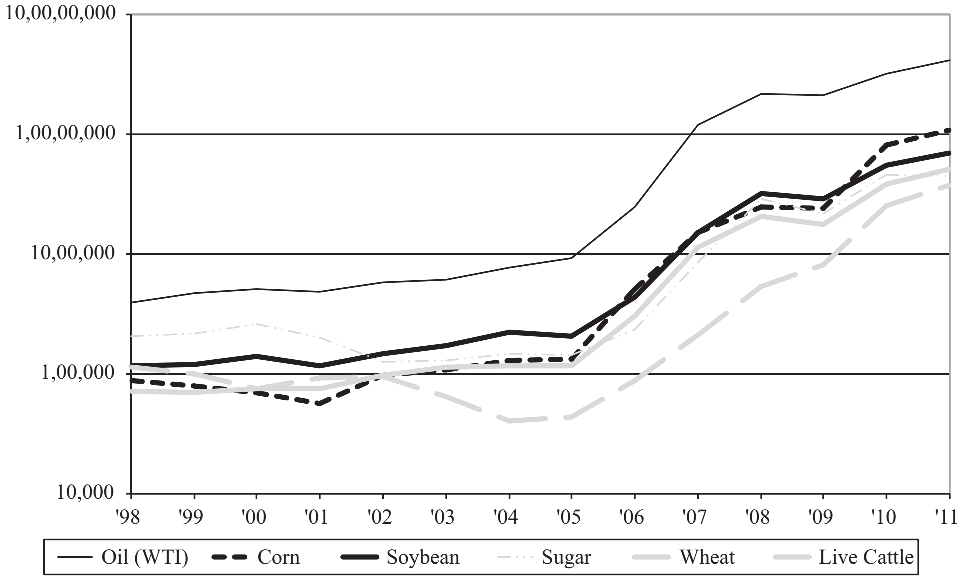

Fig. 1. Annual number of trades recorded in the Thomson Reuters Tick History database by commodity, 1998-2011. The y-axis is a logarithmic scale of base 10. The yearly data refer to the number of trade recorded between 1 January and 31 December of a particular year.

number of transactions for the considered commodity derivatives multiplied by a factor that ranged between 8 and 60 between 2005 and 2011.

To compute co-movements, we consider only the price of working day "trades" from the tick data that we subsequently down sample, using sample means, to various frequencies: 1-hour, 5-minute, 10-second and 1-second. Then, we compute the log-return for these time series.[3] To compute the DCCs, we need time series without any gap. Thus, we listwise delete the periods for which the log-return on the equity or the considered commodity futures could not be computed because there was no single registered trade. Following Engel (2002) methodology the DCC model was based on a GARCH (1, 1).[4]

3. Results

3.1. Crude oil

Fig. 2 presents the evolution of the monthly average of the DCC between the WTI and the E-mini S&P 500 futures, at 1-day, 1-hour, 5-minute and 10-second between 1998 and 2011. While daily and hourly data exhibit positive DCCs between the S&P 500 and the WTI between 2006 and early 2008, DCCs have remained approximately within their historical range observed since 1998. Moreover, higher-frequency data hardly exhibit any significant and long-lasting departure from zero until early 2008.

For this reason, in Fig. 3, we focus on the 2007m1-2011m12 period. This allows us to compute meaningful 1-second frequency DCCs since we do not have enough observations for earlier periods.

While lower frequency data tend to exhibit stronger correlations, the series of Fig. 3 have similar patterns. At higher-than-hourly frequency, no persistent departure from zero appeared until the second quarter of 2008. At the 1-day and 1-hour frequency, the mean of the monthly average DCC between January 2007

[3]Since we compute the average price of all "trade" belonging to a certain time interval before computing the returns to the average price of the subsequent interval, the "bid-ask bounce" issue is not relevant in our case.

[4]As a robustness check, we also compute moving-window correlations with window widths set to 5 or 15 observations for each considered frequency. These unconditional estimates are presumably more sensitive to volatility changes than DCC. While this strategy may yield biased estimates of the true nature of the relationship between the variables (for a discussion, see Appendix 1 of Büyükşahin and Robe, 2010), computing moving-window correlations fails to constrain us from using time series without a gap. The patterns presented in this paper using DCC are robust when using this alternative strategy. Given the short time windows, this is unsurprising: significant volatility changes are very unlikely to occur.

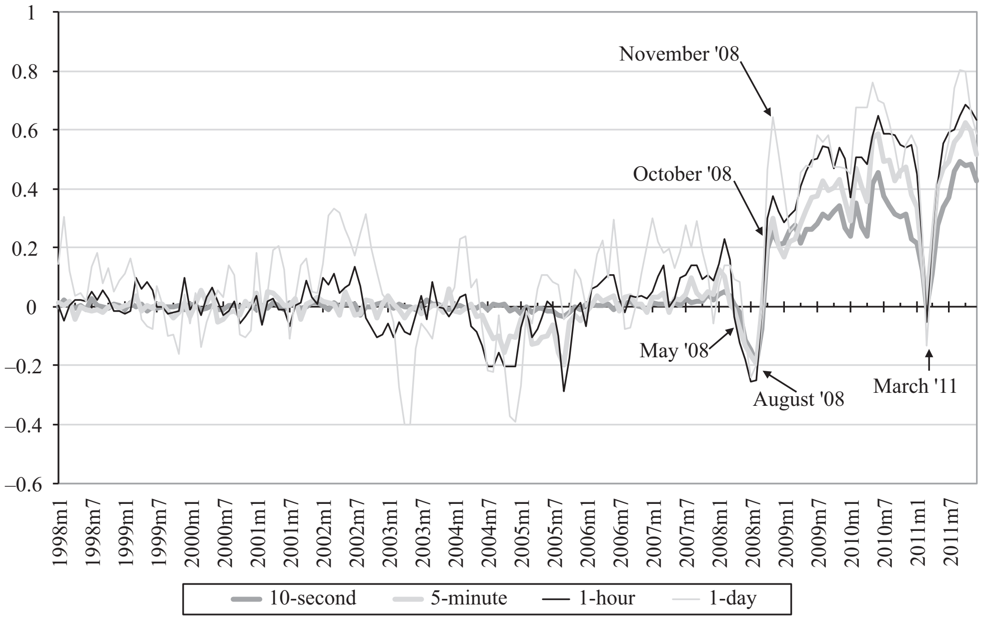

Fig. 2. Monthly average of dynamic conditional correlations between the returns on the WTI and the E-mini S&P 500 futures by frequency, 1998m1-2011m12. Each data point represents the monthly average of the dynamic conditional correlations between the returns on the WTI and the E-mini S&P 500 futures computed at a given frequency.

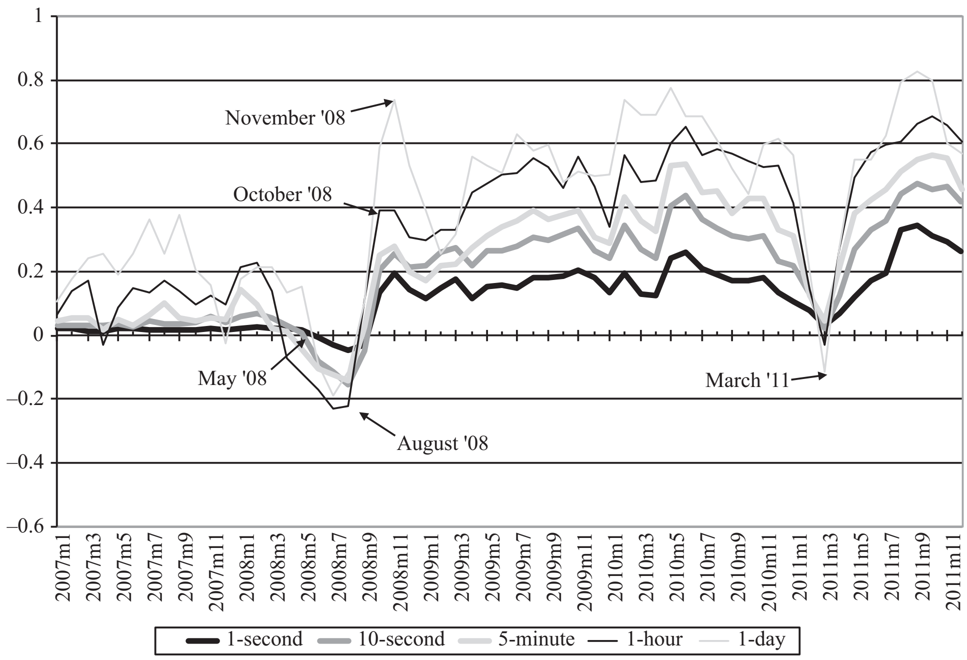

Fig. 3. Monthly average of dynamic conditional correlations between the returns on the WTI and the E-mini S&P 500 futures by frequency, 2007m1-2011m12. Each data point represents the monthly average of the dynamic conditional correlations between the returns on the WTI and the E-mini S&P 500 futures computed at a given frequency.

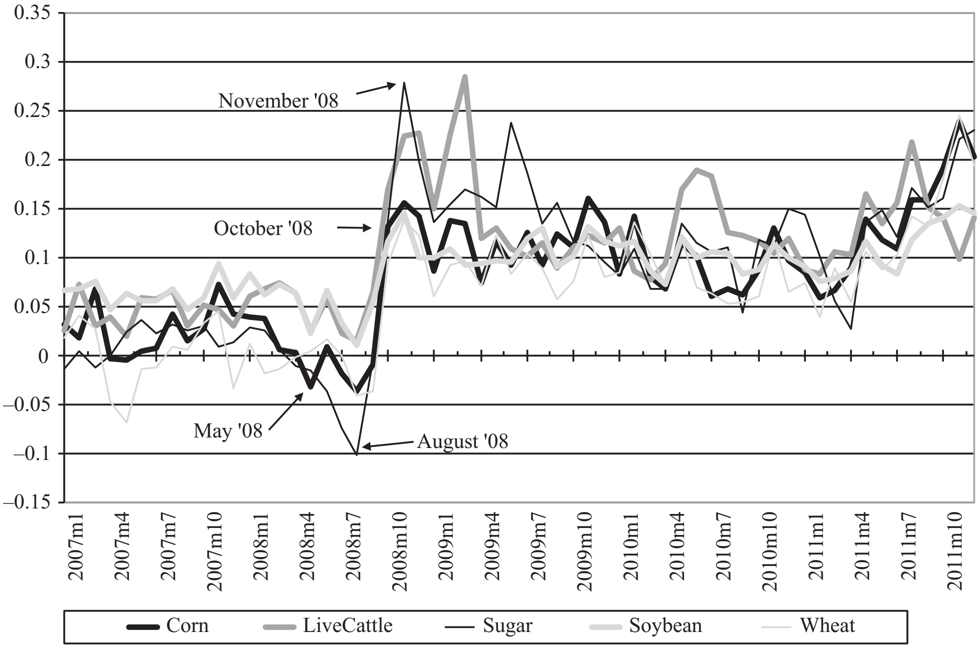

Fig. 4. Monthly average of dynamic conditional correlations between the returns on the selected soft commodities and the E-mini S&P 500 futures over 5-minute intervals, 2007m1-2011m12. Each data point represents the monthly average of the dynamic conditional correlations between the returns over 5 minutes on the given commodity and the E-mini S&P 500 futures.

and March 2008 equalled 0.21 and 0.13, respectively. At 5-minute, 10-second and 1-second frequencies, we obtain mean correlations that are even closer to zero: 0.06, 0.04 and 0.02, respectively. However, in the second quarter of 2008, correlations started moving away from zero. First, the DCCs showed a temporary U-shaped pattern, going in negative territory during the second and third quarter of 2008. Then, the DCCs sharply switched to positive territory in late September, early October 2008 (this was an extremely tense period on financial markets, following the collapse of Lehman Brothers). At the 10-second frequency, for instance, the monthly means of DCC increased sharply to 0.20 in October 2008, compared to an average of 0.04 between 2007m1 and 2008m4. Afterwards, this positive correlation persisted over time except for a brief interruption in February-April 2011, which coincided with the beginning of the uprising in Libya.[5] At the 10-second frequency, DCC remained at an average of 0.29 from November 2008 to January 2011. Later on, they moved back to previous levels and even increased up to a peak of 0.47 in September 2011.

[5]Büyükşahin and Robe (2011) also documented this pause with daily data.

3.2. *Soft commodities*

We find similar patterns for the correlation between the E-mini S&P 500 futures and five "soft" commodities: wheat, corn, soybeans, sugar, and live cattle. Fig. 4 illustrates this point using 5-minute intervals.[6] However, two differences arise. First, in contrast with the WTI, no interruption during the 2011m2-2011m4 period appears in the correlations. Second, the magnitude of the DCC is also smaller.

4. Discussion

The synchronized structural break that took place in 2008 is puzzling given the large number of commodities involved. The persistence of this trend—except from a temporary break for crude oil in early 2011 coinciding with a major supply shock—is also puzzling, though recent work by Bruno, Büyükşahin and Robe (2013) shows that daily, weekly and monthly correlations between equities and agriculture commodities partly receded in 2012. Because the increase

[6]Similar patterns were observed at lower frequency. At higher frequency, these could only be observed for corn, soybeans and wheat at 10-second, though the magnitude is smaller. At 1-second, there are too few observations to compute meaningful DCCs.

in trading activity was particularly acute between 2005 and 2007, but the jump in the high-frequency correlations only started in late September 2008, the sceptics about the financialization hypothesis would naturally question the existence of any relationship between these two phenomena. In addition, we cannot rule out the possibility that trading strategies of many kinds of extant traders started to interact differently with fundamentals amid widespread financial stress. Fully disentangling the mechanisms behind this structural break calls for further research.

Still, in our view, these findings seem to suggest that certain facets of the financialization of commodities played a role in these synchronized structural changes, together with the rapid and widespread adoption of electronic trading in commodity markets from the mid-2000s onwards, as both paved the way for new types of market participants, which include actors with investment strategies that use algorithms at high frequency.[7] First, without the liquidity that financial investors have brought into commodity futures markets, it would most plausibly not have been possible to implement automated strategies at such speed. Second, high frequency trading is not the typical kind of activities of traditional participants. At times of great uncertainties accompanied by "Risk-on, risk-off" (RoRo) behaviours on financial markets, our findings suggest that the RoRo phenomenon could spread to commodity futures markets. This makes us think that in the years that have followed the collapse of Lehmann Brothers, *financial* investors' expectations have had a significant role in the price determination process of commodities.

The existence of cross-market correlations at high frequencies, even at 1-second intervals highlight the role of automated trading strategies on commodity futures markets. It is indeed unlikely that human traders can react systematically and continuously so quickly and in a synchronized way to new information.

These findings are important for at least two reasons. First, they question the diversification strategy and portfolio allocation in commodities pursued by financial investors. Second, they show that, as commodity markets become financialized, the prices of such products may become more prone to react to events in global financial markets.

[7]Note that the CFTC data used by Büyükşahin and Robe (2011) refer to end-of-day data. Thus, their analysis does not track the intraday activities and is therefore silent on market participants not holding position overnight, like intraday traders, such as many high frequency traders.

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References

Alquist, R., Coibion, O., 2013. The Comovement in Commodity Prices: Sources and Implications. Unpublished manuscript, Bank of Canada.

Başak, S., Pavlova, A., 2013. A Model of Financialization of Commodities. Unpublished manuscript, London Business School.

Bhardwaj, G., Dunsby, A., 2012.The Business Cycle and the Correlation between Stocks and Commodities. Unpublished manuscript, SummerHaven Investment Management.

Bruno, V.G., Büyükşahin, B., Robe, M.A., 2013. The Financialization of Food? Paper presented at the 2013 Meeting of the American Agricultural and Applied Economics Association, Washington, DC.

Büyükşahin, B., Haigh, M.S., Robe, M.A., 2010. Commodities and equities: Ever a 'Market of One'? J. Alternative. Invest. 12(3), 76–95.

Büyükşahin, B., Robe, M.A., 2010. Commodity Traders' Positions and Energy Prices: Evidence from the Recent Boom-Bust Cycle. Paper presented at the 2010 American Economic Association Meeting, Atlanta.

Büyükşahin, B., Robe, M.A., 2011. Does 'Paper Oil' Matter? Energy Markets' Financialization and Equity-Commodity Co-Movements. Unpublished manuscript, American University.

Büyükşahin, B., Robe, M.A., 2013. Speculators, commodities and cross-market linkages. J. Int. Money. Financ. Forthcoming, http://dx.doi.org/10.1016/j.jimonfin.2013.08.004.

Domanski, D., Heath, A., 2007, March. Financial investors and commodity markets. BIS Quart. Rev. 53–67.

Engel, R., 2002. Dynamic conditional correlation. J. Bus. Econ. Stat. 20(3), 339–350.

Filimonov, V., Bicchetti, D., Maystre, N., Sornette, D., 2013. Quantification of the high level of endogeneity and of structural regime shifts in commodity markets. J. Int. Money Financ. Forthcoming, http://dx.doi.org/10.1016/j.jimonfin.2013.08.010.

Gorton, G., Rouwenhorst, K.G., 2006. Facts and fantasies about commodity futures. Financ. Anal. J. 62(2), 47–68.

Irwin, S.H., Sanders, D.R., 2012. Financialization and structural change in commodity futures markets. J. Agr. Appl. Econ. 44(3), 371–396.

Tang, K., Xiong, W., 2012. Index investment and financialization of commodities. Financ. Anal. J. 68(6), 54–74.

UNCTAD, 2009. The Global Economic Crisis: Systemic Failures and Multilateral Remedies. United Nations, New York and Geneva.

UNCTAD, 2011. Price Formation in Financialized Commodity Markets: The Role of Information. United Nations, New York and Geneva.