Financialisation of the crude oil market: do non-commercial traders influence spot prices?

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Abstract: Generally labelled by the term financialisation of commodity markets, integration between traditional financial asset and futures markets has spurred discussions about its supposed detrimental effect. In a revenue management perspective, commodities processors' resulting pricing policies may become more time-sensitive to physical quotations favouring potential instability in firm values. By using a recent developed multibreakpoint detection technique coupled with econometric Granger-causality, we attempt to contribute to existing literature by examining the direct relationships in the supposed influencing mechanism with a special focus on non-commercial activity.

Keywords: multibreakpoint analysis; Granger-causality; revenue management; financialisation; oil prices.

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Biographical notes: Antonio Focacci joined the Faculty of Economics of University of Bologna, since October 1996 and his main publications covered all the different kinds of typical academic productions: international journals, books and proceedings of congresses both at national and international level. He is an invited member of the editorial board of two international journals. He is also serving as a referee for various international peer-reviewed journals.

1 Introduction

From the early 2000s onwards, commodity futures markets experienced remarkable changes in the regulatory framework, the composition of professional operators and the nature of inherent activity. As far as the first aspect is concerned, main innovation pertained the introduction of the US Commodities Future Modernization Act (CFMA) in December 2000 (Gkanoutas-Leventis and Nesvetailova, 2015). For what concerns the composition of participants, beside traditional dominant presence of specialists (commercial hedgers, like farmers, producers and consumers), commodity markets witnessed a massive entrance of non-commercial traders (hedge funds, swaps dealers, commodity index funds, and mainly, commodity index traders among the other pension funds and insurance companies). Prudential estimates assess inflows of capitals grown from an about US $15 billions (Irwin and Sanders, 2011) to an overall amount well over US $300 billions in December 2015 (Baffes and Haniotis, 2016). Finally, the different nature of market participants changed also the nature of trades. In investing others' money and seeking overall portfolio diversification or positive returns (Cheng et al., 2015; Domanski and Heath, 2007; Erb and Campbell, 2006; Gorton and Rouwenhorst, 2006), newcomers financial policies were (and are) oriented towards taking positions on commodities (including related futures and options) treating these investments as an asset class just like stocks and bonds (Cheng and Xiong, 2014). Without a specific interest to actually producing or consuming, such institutional investors are also labelled as 'speculators'. Increased and derived integration among commodity futures markets and other financial markets has been the natural corollary of such a process widely known as 'financialisation of commodity markets'.

In order to investigate if merely financial influence is a real factor affecting oil prices, the main purpose of this study is to explore both commercial and non-commercial trading activity in the lead-lag relationship among core variables focusing the analysis on non-commercial financial domain considering its supposed 'dominant' role. We analyse neither volatility issues nor the price-inventory relationship considering they gained a detailed attention by specific literature (in Section 2, Table 1 reviewing dedicated contributions also to these topics is presented). In pursuing such aims, the paper proposes an empirical investigation of net long positions data (long position minus short position on WTI futures) as a proxy of financial activity jointly with spot and futures quotations at various maturities. This allows to empirically examine:

1 Whether investments on financial markets exerted statistically meaningful spillover effects on futures through a coherent direction of Granger-causality.

2 Consequently, between movements in futures and spot prices as empirical clues of a potential transmitting merely financial channel as advocated by a strand of literature.

To overcome potentially biased results, and being aware of the fact that empirical analysis could be considered as somewhat specific to the period covered by dataset, we employ a multibreakpoints detection econometric method to partitioning the total sample in endogenously distinguished sub-periods. Honestly speaking, time partition techniques are adopted also in other (very recent) empirical papers, but totally different approaches are adopted in such works. Mayer et al. (2017), for example, processed three-year windows without a specific statistical address. In further interesting literature, Adams and Glück (2015) employed a statistical methodology determining a substantial single 'cut-off' division between the pre and the post-financialisation period. Additionally, the current paper covers a wide time period with the aim to analyse a possible recursive and systematic trace of the effects of this evoked influence. As a matter of fact, whether such transfer funds mechanisms were effective just in the 2007–2008 oil price bubble as many commentators maintain, whatsoever tangible impact on crude prices should be taken with a grain of salt. Our results seem support this last intuition without evidencing a proper transmission channel from financial markets to spot quotations.

The rest of the paper is structured as follows. Section 2 briefly reviews the main literature on financialisation issues. Moreover, the supposed transmission mechanism from futures to spot prices ignited by non-commercial investment activity in the oil market is discussed. Section 3 provides data and methodology descriptions. Section 4 presents and comments the empirical results. Finally, Section 5 concludes.

2 Financialisation and its potential effects on commodity prices

Since the 2008 testimony to the US Senate by Hedge Fund Manager Michael Masters, some scholars have theorised the existence of an influential transmission channel of merely financial origin affecting commodity prices (oil quotations in our case) and their fundamental value. This potential channel would be generated by massive buy-side pressure from index funds, and more in general, by the increased resulting trading financial activity. Despite the relevance of non-commercial engagement, a generally overlooked question in the debate is that not only non-commercial investors are actively involved in the market. As a matter of fact also, traditional specialists as well as intermediaries have increased hedged positions against volatility and spot price risks. Nevertheless, current literature seems merely focused on non-commercial traders' potential destabilising influence (among others: Gilbert, 2010a; Mayer, 2012). The relevant aspect of the discussion raises a central question concerning the functioning of the interaction between futures and spot quotations. Whether such an impact was effective, firms' value and profits of commodities producers and consumers would be heavily subjects to variability affecting physical prices. Adopting a revenue management perspective and considering both the short-run fixed capacity in commodity production and demand changes caused by price fluctuations, firms' behaviour may be classified within a vertical and horizontal competition framework (Netessine and Shumsky, 2004).

Dedicated literature proposed both theoretical models and empirical analysis to portray different aspects of commodity markets' investments (Table 1). On this issue, the main focus is on the mechanism by which financialisation may affect physical price. It is generally argued that financial influence on physical market follows the subsequent chain: increased futures trading activities (especially on behalf of non-commercial players) force/induce futures price changes, which in turn and indirectly affect prices (and inherent volatility) in underlying commodity spot markets.

Cheng and Xiong (2014) ascribe such an influence to three potential main economic mechanisms acting as transmission channels along the chain. The first among them finds its roots in the theory of storage (Brennan, 1958; Telser, 1958; Working, 1949; Kaldor, 1939) wherein spot and futures prices are linked through an arbitrage process. Prices follow an adjustment path where interest rates, inventory costs and the nature of storage are the variables influencing speed and intensity towards an equilibrium. The second economic mechanism involves risk sharing as one of the original reasons for developing futures markets on behalf of commodity producers. Having at the same time a risk-averse attitude and a dominant role as participants, they tend both to have net short position on futures markets and to offer appropriate premium to potential risk-takers in the opposite side of the market (Hicks, 1939; Keynes, 1923). The third and last channel takes into account asymmetry of information existing between markets. Due to transaction costs and greatest liquidity than spot markets (Geman and Smith, 2013), futures markets would act in furnishing and transmitting feedback signals to commodity demand as well as to spot prices.

Table 1 Overview of main literature on the financialisation of the commodities

Strands of empirical literature on financialisation and related works	*Authors*
Increased co-movement among commodity prices	Silvennoinen and Thorp (2013), Büyükşahin et al. (2010)
Increased co-movement between commodity prices and stock prices	Büyükşahin and Robe (2014), Tang and Xiong (2012)
Influence of increased market participation of financial investors and futures trading positions on commodity prices	Henderson et al. (2015), Koch (2014), Tang and Xiong (2012), Gilbert (2010a, 2010b)
Relationship between futures and spot prices	Alquist et al. (2013), Hache and Lantz (2013)
Relationship between commodity prices and inventories	Kilian and Murphy (2014), Alquist and Kilian (2010)
Effect of supply and demand shocks	Knittel and Pindyck (2016), Jovenal and Petrella (2015), Kilian and Lee (2014), Kilian and Murphy (2014), Hamilton (2009a, 2009b), Kilian (2009), Krugman (2008)
Influence of time-varying risk premia	Hamilton and Wu (2014), Acharya et al. (2013), Etula (2013)
Asymmetric responses of stock movement on oil price changes (higher magnitude of positive performance with oil price decreases)	Nandha and Faff (2008), Bachmeier (2008)
Stabilising effect of speculation on financial markets	Brunetti et al. (2016), Kim (2015), Bohl and Stephan (2013), Bohl et al. (2013), Miffre and Brooks (2013), Irwin and Sanders (2012), Stoll and Whaley (2010), Irwin et al. (2009)
Relationship between monetary policy and commodity prices	Belke et al. (2013), Hamilton and Herrera (2004)
Increased market volatility due to 'herding behaviours' of speculators, and in general to the augmented participation of non-commercials with a lower degree of regulation	Balcilar et al. (2017), Demirer et al. (2015), Henderson et al. (2015), Koch (2014), Gilbert (2010a, 2010b), Rahi and Zingrand (2009), Teo (2009), Engle and Rangle (2008), Dennis and Strickland (2002), Chang et al. (2000), Nofsinger and Sias (1999)
Financial markets do not act a conduit in transmitting shocks to commodity spot prices	Lehecka (2015), Irwin and Sanders (2012)
Financial markets act a conduit in transmitting shocks to commodity spot prices	Basak and Pavlova (2016)
Undetermined results in financialisation literature about speculation effects	Fantazzini (2016), Haase et al. (2016), Henderson et al. (2015)
Increased risk spillovers and like-equity generated effects	Adams and Glück (2015), Creti et al. (2013), Du et al. (2011), Kaltalioglu and Soytas (2011), Boyson et al. (2010), Chang et al. (2010), Chong and Miffre (2010), Brunnermeier and Pedersen (2009), Park and Ratti (2008), Baffes (2007), Farooq and Hammoudeh (2007), Hammoudeh et al. (2004)
Increased noise and feedback in markets due to financial investors activity	Sockin and Xiong (2015), Singleton (2012)

The plausibility of an induced influence on final physical prices (and thus, of a potential subsequent distortion) caused by the introduced previous mechanism acting through a merely financial channel is discussed, for example, in Gulley and Tilton (2014) or Tilton et al. (2011). Additionally, Mayer et al. (2017) argue possible alternative actions of market participants able to completely exhaust the three potential transmission channels depicted by Cheng and Xiong (2014).

The aim of this study is to contributing to the debate in the evaluation of financialisation process by an empirical analysis of the behaviour of the variables directly referred to the mechanism. In more specific term, we are interested in investigating whether futures markets may have influenced spot prices in the context of an increased involvement of financial investors.

3 Data and methodology

3.1 Data description and processing

We built a dataset including both commercial and non-commercial net long positions on the New York Mercantile Exchange (NYMEX) as a proxy for respective activity in the futures markets. Such an indicator could be considered a challenging task because of a general lack in classifications of reciprocal positions (with particular reference to swaps dealers acting not as Commodity Index Traders). We are aware of obvious differences and limitations about trading positions and aggregated definitions. Nevertheless, the same holds for whatsoever other potential indicator adopted and retrievable in the available archives. As a matter of fact, a more precise measure – as could be the Index Investment Data – does not appear appropriate (sample data are available just from 2007 onwards). Thus, remaining in the confines of standard information measures widely used by academic research and industry professionals alike on this topic (Sanders et al., 2004), our choice is to process a longer dataset clarifying proper interpretation boundaries. Without pretension to be exhaustive, we attempt to integrate also the limitations in the IMF (2006) study on the commodity markets wherein data did not cover much of the period from 2006 onwards. Collected figures are recorded within the U.S. Commodities Futures Trading Commission (CFTC) Section of Commitment of Traders (COT) in Datastream (2017) starting from 1995 onwards. A further dataset is built by collecting WTI NYMEX futures quotations (Tuesday's close) regarding four different delivering dates (two months maturity, three months maturity, six months maturity and 12 months maturity continuous contract; hereafter, labelled for brevity as: CL2, CL3, CL6 and CL12). Because, the front-month contract (CL1) may be considered as a proxy for spot prices, we exclude it in the current elaboration. All futures quotations are retrieved from Quandl (2017) for the same time-span as net long positions previously mentioned. Finally, as far as crude figures are concerned, WTI spot prices are gathered from Datastream (2017) to represent the worldwide unified benchmark in oil quotations (Kuck and Schweikert, 2017; Ghassan and Alhajoj, 2016; Chevallier and Ielpo, 2013; Kaufman and Ullman, 2009). The whole dataset consists of a continuously weekly time series from the last week of March 1995 to the last week of May 2017 (N = 1,159). The rationale behind the choice considers that processing a higher frequent sample (i.e., daily data) increases the likelihood of finding (spurious) relationships (Schwartz and Szakmary, 1994). Conversely, a lower frequency sample (i.e., monthly data) has its own drawbacks in the number of observations neither appropriate nor statistically significant for the present elaboration considering we need to partition the whole time span in sub-periods.

For what concerns, data treatment and possible outliers, no formal theoretical evaluation is conducted both to detect and model them. Outlier analysis is a classical econometric technique adopted to analyse special events. Generally, it is implemented through iterative procedures for the case of changes in conditions occurring at unknown points of times. Nevertheless, potential over specification in the number of outliers is a related flaw (Box et al., 2016). Consisting in proper adjustments, whatsoever modelling technique – even if correctly applied – could be evaluated by critics as an artificial adjustment to emphasise or induce specific results.

3.2 Methodology

Having the goal to trace out (potential) transmission effects originated by speculative movements at the very final phase of transfer funds mechanisms resulting from investors' coordinated portfolio strategies exacerbated by the financialisation context as previously depicted, we follow a two-step analysis. In the first one, we locate different sub-periods wherein statistical properties of the series representing financial activity change in a significant manner. Secondly, we apply the Granger-causality methodology (Granger, 1969) to explore if one variable helps to predict the subsequent one following the coherence in the mechanism as supported by literature theorising the influencing chain:

trading activities → futures price → spot markets.

To investigate the (non-commercial) commitment on behalf of institutional investors, and its potential influencing behaviour on oil prices, we apply a recent and interesting technique proposed by Bai and Perron (2003, 1998) to dating multiple structural changes (or breakpoints, i.e., unexpected shifts) in time series data. Estimation in the present work allows for general forms of serial correlation and heteroskedasticity in the errors, different distributions for the errors and the regressors across segments, lagged dependent variables and trending regressors. In this case, such a multibreakpoint detection is required to capture the dynamic behaviour of trading activity. Statistical and econometric literature propose several works concerning typical designed (also at unknown date) single or, at most, double change tests (for example and without pretension to exhaustion: Lütkepohl et al., 2004; Lee and Strazicich, 2003; Papell and Prodan, 2003; Ohara, 1999; Clemente et al., 1998; Lumsdaine and Papell, 1997; Perron, 1997; Banerjee et al., 1992; Zivot and Andrews, 1992; Brown et al., 1975). A further and well-known procedure was proposed by Chow (1960). Nevertheless, its implementation needs the specification of an exogenous null hypothesis for (just) one structural change in data. The method, here briefly summarised starting from a standard linear regression model, determines m breakpoints within dataset, where the coefficients of the regression relationship shift from one stable relation to a different one. Hence, having the regression model expressed as:

$$y_t = x_t \beta_t + \varepsilon_t \text{ with } (t = 1, \ldots, n) \tag{1}$$

where at time t, y_t is the observed dependent variable, x_t is a vector of regressors ($k \times 1$), and β_t is the corresponding $k \times 1$ vector of regression coefficients varying over time. The hypothesis of the constancy of regression coefficients holds when:

$$H_0: \beta_t = \beta_0 \ (t = 1, \ldots, n)$$

and m reasonable breakpoints lead to $m + 1$ segments where model (1) can be re-proposed as:

$$y_t = x_t \beta_j + \varepsilon_t \text{ with } (t = t_{j-1} + 1, \ldots\ldots, t_j, \ j = 1, \ldots\ldots, m+1)$$

with j as the segment index and $T_{m,n} = \{ t_1, \ldots, t_m \}$ representing the set of breakpoints (or m-partition) having by convention $t_0 = 0$ and $t_{m+1} = n$.

The least-squares estimates of the β_j lead to the residual sum of squares (RSS) within the m-partition as:

$$RSS = \sum_{j=1}^{m+1} rss\left(t_{j-1} + 1, t_j\right)$$

where $rss(t_{j-1} + 1, t_j)$ is the minimal RSS in the j^{th} segment of the partition.

To locate and identify structural changes, it is necessary to find the breakpoints $t'_1, \ldots\ldots, t'_m$ from the minimisation the objective function over all partitions with $t_j - t_{j-1} \geq n_h \geq k$:

$$\left(t'_1, \ldots\ldots, t'_m\right) = \arg\min_{1 \leq t \leq m} RSS \quad (2)$$

The order of the grid search would be of order $O(n^m)$, with a sample size n and for all $m > 2$. Applications with examples of hierarchical algorithms to do recursive portioning or joining sub-samples where segment sizes have $h \times n$ observations can be found in works of Bai (1997) and Sullivan (2002). In these calculations, h represents the trimming bandwidth parameter including a x% of observations (n) within each segment (in our case, such a threshold h has been set equal to 0.10 to force a better fine-tuning process). Nevertheless, such algorithms will not necessarily find the solutions in terms of global minimisers, and the adoption of an approach in dynamic programming of order $O(n^2)$ for each m time a change occurs is easier to implement. Bai and Perron (2003) present a dynamic algorithm fit for pure and partial structural change models within an ordinary least squares (OLS) regression context able to obtain an optimal time-segmentation by the recursive solution of the problem following the Bellman's (1952) principle. In this typical Bellman's (1952) environment, the stochastic event is analysed by adopting a calculation procedure where each result is applied to the determination of the subsequent one. As a consequence, the recursive algorithm to achieve the optimal segmentation is derived from:

$$RSS\left(T_{m,n}\right) = \min_{mn_h \leq t \leq n-n_h} \left[RSS\left(T_{m-1,t}\right) + rss(t+1, n)\right].$$

The same procedure applied for RSS can be implemented also for the Schwarz (1978) Bayesian information criterion (BIC or SIC by various authors):

$$BIC = \ln\left(\frac{\sum_{t=1}^{n} \varepsilon_t^2}{n}\right) + \frac{p \ln(n)}{n}.$$

At this point, the procedure can be applied counting on two criteria to evaluate the breakpoints in time series. Specific formal further computing details can be found in Bai and Perron (1998, 2003) as well as in Zeileis et al. (2002).

Moreover, as far as the Granger-causality to ascertain potential impacts among selected variables is concerned, firstly we proceed by investigating if trading activity (both on behalf of commercial and non-commercial investors) may be of help in predicting movements in the futures markets. Consequently, variables are tested in both directions examining the lead-lag relationships. The null hypotheses are that each proxy for trading activity TA (for non-commercial) and/or TAC (for commercial) does not Granger-cause future quotations $CL(\theta j = 0$ for all $j)$ and vice versa. Accordingly, equations (3) and (4) are estimated:

$$\Delta TA_t = \phi_1 + \sum\nolimits_{i=1}^{m} \lambda_i \Delta TA_{t-i} + \sum\nolimits_{j=1}^{n} \theta_j \Delta CL_{t-j} + \varepsilon_t^{TA} \tag{3}$$

$$\Delta CL_t = \phi_2 + \sum\nolimits_{i=1}^{m} \lambda_i \Delta CL_{t-i} + \sum\nolimits_{j=1}^{n} \theta_j \Delta TA_{t-j} + \varepsilon_t^{CL} \tag{4}$$

where TA_t and TAC_t represent the weekly values of net long positions for non-commercial and commercial position as respective proxies for futures trading activity. In equations (3) and (4), they are interchangeably used firstly as TA_t with CL_t, then as TAC_t with CL_t. Analogously, the variable CL_t denotes the weekly futures contract quotation (various maturities are processed as previously specified). By the use of first differences (Δ), stationarity can be guaranteed, ϕ is the intercept and ε_t is the error term. The *RSS* of models are then compared using an *F*-test to reject the respective null hypothesis (an additional explanatory variable of the unrestricted model has no influence). To determine the most appropriate lag-structure (m, n) for each model, we select the *BIC* information criteria. Moreover, a vector error correction model (VECM) is used when variables contain unit roots with stationary and cointegrated first differences (Fanchon and Wendel, 1992). To this aim, error correction terms (ECT) α_{11} and α_{21} significance is considered in the long-run cointegration relationship estimating subsequent equations (5) and (6):

$$\Delta TA_t = \gamma_{10} + \alpha_{11}\left(TA_{t-1} - \beta_0 - \beta_1 CL_{t-1}\right) + v_t^{TA} \tag{5}$$

$$\Delta CL_t = \gamma_{20} + \alpha_{21}\left(TA_{t-1} - \beta_0 - \beta_1 CL_{t-1}\right) + v_t^{CL} \tag{6}$$

wherein $(TA_{t-1} - \beta_0 - \beta_1 CL_{t-1})$ is the cointegrating vector.

Finally, to complete the overall chain mechanism investigation, the same Granger methodology is adopted in testing the futures-spot coherence.

4 Empirical results

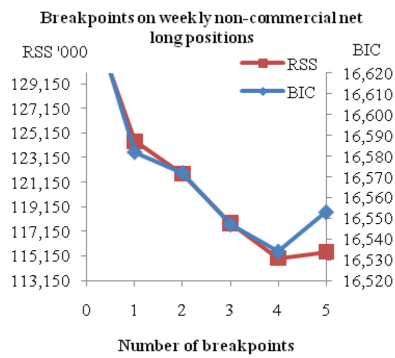
In order to develop present analysis, the very first step consists in locating breakpoints within the non-commercial activity by the multiple detection technique. This aspect is important for two reasons. Firstly, due to the (supposed) prevalent influence exerted by non-commercial trading activity on the market, the focus must be appropriately oriented. Secondly, the identification of changes in the statistical properties is meaningful to highlight important variations in the market participants' behaviour to derive relevant choices made in pursuing profitability and/or diversification goals. Results of such an optimal multiple breakpoints detection are represented in Table 2 and visualised in graph (Figure 1).

Table 2 Optimal partition with BIC and RSS

m	*BIC*	*RSS*
0	16,657	135,535,141
1	16,582	124,465,154
2	16,572	121,831,938
3	16,547	117,789,656
4	16,534	114,975,856
5	16,553	115,469,390

Source: Personal elaboration on Datastream (2017)

Figure 1 Breakpoint detection within non-commercial net-long positions (see online version for colours)



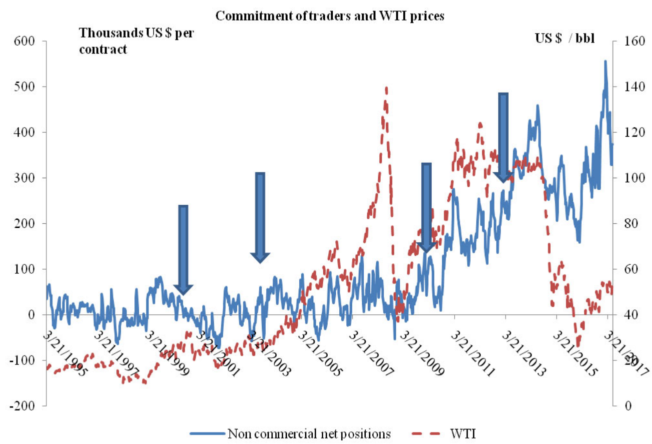
Source: Personal elaborations on Datastream (2017)

As can be appreciated by Figure 1, both the *RSS* and the *BIC* criteria agree with an optimal identification of four relevant breakpoints in the time series. Thus, five sub-periods are to analyse within the whole time framework. More in detail, the four breakpoints are located in the following dates: 25th Jul. 2000 (position 280 of the whole time series), 11th Nov. 2003 (position 452), 2nd March 2010 (position 781) and 18th Jun. 2013 (position 953). Correspondingly, the sub-samples are so defined: 21st March 1995–25th July 2000, 1st Aug. 2000–11th Nov. 2003, 18th Nov. 2003–2nd Mar. 2010, 9th Mar. 2010–18th Jun. 2013, and finally, 25th Jun. 2013–30th May 2017.

Breakpoints in non-commercial commitment of traders are visually identified by arrows in Figure 2.

From Figure 2, differences can be appreciated in the dynamic path of non-commercial activity exerted among various sub-periods. For example, the first arrow at the date of 25th July 2000 indicates a quite downturn in net long positions breaking visual stationarity of the series. In addition, a meaningful presence of negative positions in volumes as well as in time persistence is recorded in comparison with the second sub-period. Another example can be shown in the third sub-period where an uprising drift is present (with generally positive and more persistent net long positive positions). This is hardly to glimpse in the second one. Similar considerations are hence possible for the subsequent segments. Interestingly, in order to validate the methodology, some correspondences can be found with relevant events in crude oil price history as reported by the US Energy Information Administration (Creti et al., 2014; Kilian and Park, 2009; Hamilton, 2009a, 2009b). More in detail, these hold for the July 2000 and the November 2003 breakpoints as well as for the March 2010. Another aspect to outline is in the fact that CFMA was approved in December 2000 and, at the weekly value of 25th July 2000, the significant first breakpoint is identified marking the meaningful change with previous sub-period. This is an important point to outline, because if the new regulatory framework were so disruptive with past period, it would be reasonable to expect more rapid and evident changes in financial investor choices.

Figure 2 Non-commercial commitment of traders with breakpoints and WTI prices (weekly data) (see online version for colours)



Source: Personal elaborations on Datastream (2017)

The second step to carry on is the analysis of the lead-lag relationship among variables by the Granger-causality test. To investigate whether trading activities on financial markets exerted statistically meaningful spillover effects on futures through a coherent direction of Granger-causality, we will proceed by testing both non-commercial (labelled as TA) and commercial (labelled as TAC) net positions. Additionally, a cointegration assessment (within each partition) among the four different futures contracts is applied to investigate a possible similar stochastic trend between variables. This would reduce the number of relations to process. To test cointegration among selected futures, we adopt both the Johansen (1988) method, and the Engle-Granger two-step procedure (Engle and Granger, 1987). In the subsequent Tables 3 and 4, findings are summarised and succeed in reducing the number of cases to process due to cointegration relationships in the first, the third and the fifth sub-period. A complete overview of the further bidirectional Granger-causality tests for the various sub-periods can be found in Table 5.

Table 3 Johansen cointegration analysis of futures contracts

Sub-period	*Futures*	*Lag order*	*Rank*	*Trace test*	*p-value*	*λ max*	*p-value*
Mar. 21st 1995–Jul. 25th 2000	CL2-CL3-CL6-CL12	1	0	89.25	0.00	51.26	0.00
			1	37.99	0.00*	21.76	0.04*
			2	16.23	0.04	12.29	0.10
			3	3.94	0.05	3.94	0.05
Aug. 1st 2000–Nov. 11th 2003	CL2-CL3-CL6-CL12	1	0	52.07	0.02	24.46	0.12
			1	27.61	0.09	15.66	0.26
			2	11.96	0.16	7.88	0.40
			3	4.09	0.04	4.09	0.04
Nov. 18th 2003–Mar. 2nd 2010	CL2-CL3-CL6-CL12	1	0	121.45	0.00	79.19	0.00
			1	42.26	0.00	25.20	0.01*
			2	17.06	0.03*	13.58	0.06
			3	3.48	0.06	3.48	0.06
Mar. 9th 2010–Jun. 18th 2013	CL2-CL3-CL6-CL12	1	0	39.83	0.23	19.91	0.36
			1	19.93	0.44	11.17	0.64
			2	8.75	0.40	6.97	0.50
			3	1.78	0.18	1.78	0.18
Jun. 25th 2013–May 30th 2017	CL2-CL3-CL6-CL12	1	0	56.95	0.00	29.25	0.03*
			1	27.70	0.09*	17.42	0.16
			2	10.27	0.27	8.39	0.35
			3	1.88	0.17	1.88	0.17

Notes: *Indicates cointegration at 5% level.
Lag order is defined with BIC criterion since its appropriateness to large samples (Lütkepohl, 2005).
Source: Personal elaborations on Quandl (2017)

Table 4 Engle-Granger cointegration analysis of futures contracts

Sub-period	*Futures*	*Lag order*	*ADF*	*p-value*
Mar. 21st 1995–Jul. 25th 2000	CL2	1	–1.26	0.90
	CL3	1	–1.14	0.92
	CL6	1	–0.80	0.96
	CL12	1	–0.31	0.99
	Residuals	1	–4.97	0.01*
Aug. 1st 2000–Nov. 11th 2003	CL2	1	–2.56	0.10
	CL3	1	–2.57	0.10
	CL6	1	–2.35	0.16
	CL12	1	–2.13	0.23
	Residuals	1	–3.17	0.33
Nov. 18th 2003–Mar. 2nd 2010	CL2	1	–1.75	0.73
	CL3	1	–1.76	0.73
	CL6	1	–1.76	0.72
	CL12	1	–1.76	0.73
	Residuals	1	–6.95	0.00*
Mar. 9th 2010–Jun. 18th 2013	CL2	1	–2.51	0.11
	CL3	1	–2.49	0.12
	CL6	1	–2.50	0.12
	CL12	1	–2.50	0.11
	Residuals	1	–3.99	0.07
Jun. 25th 2013–May 30th 2017	CL2	2	–1.85	0.68
	CL3	2	–1.86	0.68
	CL6	2	–1.88	0.67
	CL12	2	–1.87	0.67
	Residuals	2	–6.60	0.00*

Notes: *Indicates cointegration at 5% level.
Lag order is defined with BIC criterion since its appropriateness to large samples (Lütkepohl, 2005).

Source: Personal elaborations on Quandl (2017)

Taking a closer look at the detailed results, we find that in the first three sub-periods (from 21st March 1995 to 2nd March 2010) futures quotations drive trading activity without difference between non-commercial and commercial side. Such dynamics support the idea that price changes attract investors into the market, not the way around. These findings do not hold true for the two last sub-periods (from 9th March 2010 to 30th May 2017). More in detail, in the partition from 9th March 2010 to 18th June 2013, 7 out of 8 cases confirm a reverse direction of the relationship wherein trading activity is correlated with futures quotations. The only discordant case is in the commercial side for the longest future maturity (12 months). In the last sub-period, opposite outcomes are evidenced between non-commercial and commercial positions. The non-commercial activity confirms a statistical significant driving role in futures quotations (3 out of 4 cases, with the exception of the longest 12 months maturity). The opposite holds for the commercial side.

Table 5 Results of bidirectional Granger-causality tests for trading-futures relationships

Sub-period	*Future as an independent variable*			*Future as a dependent variable*	
	ECT/F	*p-value*		*ECT/F*	*p-value*
Mar. 21st 1995–Jul. 25th 2000					
Non-commercial					
(CL2 → TA)	*–0.11*	0.00*	(CL2 ← TA)	*0.00*	0.13
Commercial					
(CL2 → TAC)	*–0.12*	0.00*	(CL2 ← TAC)	*0.00*	0.09
Aug. 1st 2000–Nov. 11th 2003					
Non-commercial					
(CL2 → TA)	28.77	0.00*	(CL2 ← TA)	0.74	0.39
(CL3 → TA)	32.69	0.00*	(CL3 ← TA)	0.58	0.45
(CL6 → TA)	29.61	0.00*	(CL6 ← TA)	0.36	0.55
(CL12 → TA)	16.28	0.00*	(CL12 ← TA)	0.28	0.60
Commercial					
(CL2 → TAC)	48.37	0.00*	(CL2 ← TAC)	0.08	0.77
(CL3 → TAC)	53.19	0.00*	(CL3 ← TAC)	0.05	0.82
(CL6 → TAC)	46.99	0.00*	(CL6 ← TAC)	1.29	0.26
(CL12 → TAC)	27.56	0.00*	(CL12 ← TAC)	1.26	0.26
Nov. 18th 2003–Mar. 2nd 2010					
Non-commercial					
(CL2 → TA)	*–0.10*	0.00*	(CL2 ← TA)	*0.00*	0.28
Commercial					
(CL2 → TAC)	*–0.07*	0.00*	(CL2 ← TAC)	*0.00*	0.41
Mar. 9th 2010–Jun. 18th 2013					
Non-commercial					
(CL2 → TA)	1.45	0.23	(CL2 ← TA)	8.33	0.00*
(CL3 → TA)	1.66	0.20	(CL3 ← TA)	8.09	0.00*
(CL6 → TA)	2.34	0.13	(CL6 ← TA)	6.96	0.00*
(CL12 → TA)	3.01	0.08	(CL12 ← TA)	4.73	0.03*
Commercial					
(CL2 → TAC)	*160.37*	0.60	(CL2 ← TAC)	*–0.20*	0.00*
(CL3 → TAC)	*0.01*	0.68	(CL3 ← TAC)	*0.00*	0.00*
(CL6 → TAC)	*0.01*	0.74	(CL6 ← TAC)	*–1.83*	0.00*
(CL12 → TAC)	7.36	0.00*	(CL12 ← TAC)	3.66	0.06
Jun. 25th 2013–May 30th 2017					
Non-commercial					
(CL2 → TA)	3.85	0.05	(CL2 ← TA)	4.85	0.03*
Commercial					
(CL2 → TAC)	8.84	0.00*	(CL2 ← TAC)	1.76	0.19

Notes: *Denotes statistical 5% significance of the relationship. Italic figures are for the relationships where Granger-causality is evaluated by a VECM due to cointegration between first differenced variables. In such cases corresponding ECT terms are proposed.

Source: Personal elaborations on Datastream (2017) and Quandl (2017)

As far as the subsequent futures-spot relationship is concerned, results are summarised in Table 6.

Table 6 Results of bidirectional Granger-causality tests for futures-spot relationships

Sub-period	*Future as an independent variable*			*Future as a dependent variable*	
	ECT/F	*p-value*		*ECT/F*	*p-value*
Mar. 21st 1995–Jul. 25th 2000					
(CL2 → Spot)	*–0.08*	0.42	(CL2 ← Spot)	*0.36*	0.00*
Aug. 1st 2000–Nov. 11th 2003					
(CL2 → Spot)	33.02	0.00*	(CL2 ← Spot)	0.16	0.69
(CL3 → Spot)	32.41	0.00*	(CL3 ← Spot)	0.18	0.67
(CL6 → Spot)	27.58	0.00*	(CL6 ← Spot)	0.00	0.97
(CL12 → Spot)	21.88	0.00*	(CL12 ←Spot)	0.10	0.76
Nov. 18th 2003–Mar. 2nd 2010					
(CL2 → Spot)	*–0.08*	0.49	(CL2 ← Spot)	*0.35*	0.00*
Mar. 9th 2010–Jun. 18th 2013					
(CL2 → Spot)	0.63	0.53	(CL2 ← Spot)	216.37	0.00*
(CL3 → Spot)	0.44	0.64	(CL3 ← Spot)	208.05	0.00*
(CL6 → Spot)	0.29	0.75	(CL6 ← Spot)	189.25	0.00*
(CL12 → Spot)	0.42	0.52	(CL12 ← Spot)	271.83	0.00*
Jun. 25th 2013–May 30 2017					
(CL2 → Spot)	0.1	0.91	(CL2 ← Spot)	181.16	0.00*

Notes: *Denotes statistical 5% significance of the relationship. Italic figures are for the relationships where Granger-causality is evaluated by a VECM due to cointegration between first differenced variables. In such cases, corresponding ECT terms are proposed.

Source: Personal elaborations on Datastream (2017) and Quandl (2017)

For what concern this last elaboration, we find substantially unidirectional relationships. In all partitions but one (the second sub-period) spot prices drive futures quotations. Such outcomes are hardly compatible with the advocated and supposed relevant influence of futures on physical/spot prices. At best, they are not so statistically relevant in larger part of the observed period. Overall combined results are presented in Table 7. About these findings, we can note that sub-periods, Aug. 1st 2000–Nov. 11th 2003 and Mar. 9th 2010–Jun. 18th 2013 (for both commercial and non-commercial activity), and Jun. 25th 2003–May 30th 2017 (for non-commercial only) have a contemporary priority in the order of the relationship between variables (i.e., for Aug. 1st 2000–Nov. 11th, futures drive both trading activity and spot; the statistical relevance is marked by a star in Table 7).

These outcomes need a supplementary investigation, and an additional Granger test is performed (detailed results are reported in Table 8).

Table 7 Overall findings in Granger-causal relationships among variables

Sub-period		*Term structure of future prices*
Mar. 21st 1995–Jul. 25th 2000		Contango
Non-commercial	Spot → future → TA	
Commercial	Spot → future → TAC	
Aug. 1st 2000–Nov. 11th 2003		Backwardation
Non-commercial	Future → TA	
	Future → spot	
	Future → spot → TA*	
Commercial	Future → TAC	
	Future → spot	
	Future → spot → TAC*	
Nov. 18th 2003–Mar. 2nd 2010		Contango
Non-commercial	Spot → future → TA	
Commercial	Spot → future → TAC	
Mar. 9th 2010–Jun. 18th 2013		Contango
Non-commercial	TA → future	
	Spot → future	
	Spot → TA → future*	
Commercial	TAC → future	
	Spot → future	
	Spot → TAC → future*	
Jun. 25th 2013–May 30th 2017		Backwardation
Non-commercial	TA → future (except for CL 12)	
	Spot → future	
	Spot → TA → future*	
Commercial	Spot → future → TAC	

Note: *Indicates the further Granger-causality test processed to get the whole sequence.

Source: Personal elaborations on Tables 5 and 6, Datastream (2017) and Quandl (2017)

As can be observed, findings suggest the evoked mechanism ‘trading activity → futures → spot’ supporting a theoretical financial spillover effects on spot quotations originated from trading activity is never evidenced in its ‘strong form’. On the contrary, in the first, the third and the last sub-periods (for commercial trading activity only), the opposite holds. This statistical evidence is more coherent with the idea of a trading activity following price movements on the spot markets than the way around. In the second partition, a ‘driving’ role of futures both on spot prices and on trading activity is present for non-commercial as well as for commercial. Hence, we can appreciate only a ‘weak’ financial pressure on physical quotations, and the supposed institutional investors influence is debatable considering that no difference between the non-commercial and commercial side is evident. Interestingly, the third sub-period (weekly quotation starting from Nov. 18th 2003 to Mar. 2nd 2010) includes the peak of oil prices. In the fourth sub-period, futures are forerun by spot quotations and trading activity (in this order). These results are hardly compatible with a theoretical explanation supporting the idea of a dominant influence of financial trading on physical markets. Finally, in the last sub-period, commercial and non-commercial findings are not univocal. Nevertheless, also in this case is very hard to foster a genuine financial induced impact on spot prices. At this point, except for the second partition where a (weak) coherence with a potential transmitting financial influencing channel from futures to spot quotations can be traced, overall econometric analysis shows that physical prices (spot) exert a prevailing attractive role towards investors for the most part of the investigated sample.

Table 8 Supplementary Granger tests for getting relationships marked by a star in Table 7

Sub-period	*Spot as an independent variable*			*Spot as a dependent variable*	
	F	*p-value*		*F*	*p-value*
Aug. 1st 2000–Nov. 11th 2003					
Non-commercial					
(Spot → TA)	24.04	0.00*	(Spot ← TA)	0	0.96
Commercial					
(Spot → TAC)	39.18	0.00*	(Spot ← TAC)	0.08	0.78
Mar. 9th 2010–Jun. 18th 2013					
Non-commercial					
(Spot → TA)	34.12	0.00*	(Spot ← TA)	0.01	0.93
Commercial					
(Spot → TAC)	43.46	0.00*	(Spot ← TAC)	0.07	0.80
Jun. 25th 2013–May 30th 2017					
Non-commercial					
(Spot → TA)	57.96	0.00*	(Spot ← TA)	0.79	0.37

Note: *Denotes statistical 5% significance of the relationship.

Source: Personal elaborations on Datastream (2017) and Quandl (2017)

5 Conclusions

This paper aims to provide a further empirical investigation to explore if the increased trading activity on futures markets exerted a relevant role in the influence of crude spot prices path. A strand of literature fosters the hypothesis that financial trading (especially on behalf of new institutional investors) may affect physical prices. We try to empirically analyse consequential relationships among better available proxies of such variables in order to assess this intuition. We do not analyse returns' volatility issues because a wealth of dedicated literature is already existing on this topic. Indeed, our interest lies in the sequence considered at the foundation of the process finally affecting spot quotations through futures trading. By adopting a recent multibreakpoint technique with a special focus on non-commercial trading activity (due to its supposed dominant role in distorting spot prices), we apply a Granger-causality methodology. Our analysis showed that merely financial forces cannot be considered so influential. In a business perspective, it is not possible to consider horizontal and vertical revenue management models for pricing underlying fundamental assets (oil in the present case) and depict potential vulnerability in firm values related to more time-sensitive physical quotations. Such results are valid for all the different subsets of data indicated as appropriate partitions by the multibreakpoint statistical analysis. Honestly speaking, only one segment is the relevant exception. As a matter of fact, futures preceding spot prices in the Granger-causal test in weekly data from Aug. 1st 2000 to Nov. 11th 2003. At this point, we generally found that:

1 Spot prices have a major impact in driving trading activities both for non-commercial and commercial players, and not the way around.

2 The sequence of events coherent with a (supposed massive) transmission funds transfer speculative mechanism is statistically questioned.

Taken in their overview, such results are more consistent with all those econometric analysis where demand-supply structural factors are considered as main influential elements of the model of equilibrium in the cash and storage markets (under reasonable assumptions about price elasticities of supply and demand) as proposed by Knittel and Pindyck (2016), as well as with structural VAR results proposed by Kilian and Murphy (2014) and Kilian and Lee (2014). Notwithstanding their evocative appeal, hence, related speculative mechanisms are argued. They assume a more secondary role probably amplified, however, by irrational expectations, and an early hypertrophic development of financial industry.

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References

Acharya, V.V., Lochstoer, L.A. and Ramadorai, T. (2013) 'Limits to arbitrage and hedging: evidence from commodity markets', *Journal of Financial Economics*, Vol. 109, No. 2, pp.441–465.

Adams, Z. and Glück, T. (2015) 'Financialization in commodity markets: a passing trend or the new normal?', *Journal of Banking & Finance*, Vol. 60, pp.93–111.

Alquist, R. and Kilian, L. (2010) 'What do we learn from the price of crude oil futures?', *Journal of Applied Econometrics*, Vol. 25, No. 4, pp.539–573.

Alquist, R., Kilian, L. and Vigfusson, R.J. (2013) 'Forecasting the price of oil', in Elliott, G. and Timmermann, A. (Eds.): *Handbook of Economic Forecasting*, Vol. 2, Part A, pp.427–507, Elsevier, Amsterdam.

Bachmeier, L. (2008) 'Monetary policy and the transmission of oil shocks', *Journal of Macroeconomics*, Vol. 30, No. 4, pp.1738–1755.

Baffes, J. (2007) 'Oil spills on other commodities', *Resources Policy*, Vol. 32, No. 3, pp.126–134.

Baffes, J. and Haniotis, T. (2016) 'What explains agricultural price movements?', *Journal of Agricultural Economics*, Vol. 67, No. 3, pp.706–721.

Bai, J. (1997) 'Estimation of a change point in multiple regression models', *The Review of Economic and Statistics*, Vol. 79, No. 4, pp.551–563.

Bai, J. and Perron, P. (1998) 'Estimating and testing linear models with multiple structural changes', *Econometrica*, Vol. 66, No. 1, pp.47–78.

Bai, J. and Perron, P. (2003) 'Computation and analysis of multiple structural change models', *Journal of Applied Econometrics*, Vol. 18, No. 1, pp.1–22.

Balcilar, M., Demirer, R. and Ulussever, T. (2017) 'Does speculation in the oil market drive investor herding in emerging stock markets?', *Energy Economics*, Vol. 65, pp.50–63.

Banerjee, A., Lumsdaine, R.L. and Stock, J.H. (1992) 'Recursive and sequential tests of the unit root and trend break hypothesis: theory and international evidence', *Journal of Business and Economic Statistics*, Vol. 10, No. 3, pp.271–287.

Basak, S. and Pavlova, A. (2016) 'A model of financialization of commodities', *Journal of Finance*, Vol. 71, No. 4, pp.1511–1556.

Belke, A., Bordon, I.G. and Volz, U. (2013) 'Effects of global liquidity on commodity and food prices', *World Development*, Vol. 44, pp.31–43.

Bellman, R. (1952) 'On the theory of dynamic programming', *Proceedings of the National Academy of Science USA*, Vol. 38, No. 8, pp.716–719.

Bohl, M.T. and Stephan, P.M. (2013) 'Does futures speculation destabilize spot prices? New evidence for commodity markets', *Journal of Agricultural and Applied Economics*, Vol. 45, No. 4, pp.595–616.

Bohl, M.T., Javed, S. and Stephan, P.M. (2013) 'Do commodity index traders destabilize agricultural futures prices?', *Applied Economics Quarterly*, Vol. 59, No. 2, pp.125–148.

Box, G.E.P, Jenkins, G.M., Reinsel, G.C. and Ljung, G.M. (2016) *Time Series Analysis-Forecasting and Control*, 5th ed., Wiley, Hoboken, USA.

Boyson, N.M, Stahel, C.W. and Stulz, R.M. (2010) 'Hedge fund contagion and liquidity stocks', *Journal of Finance*, Vol. 65, No. 5, pp.1789–1816.

Brennan, M. (1958) 'The supply of storage', *American Economic Review*, Vol. 48, No. 1, pp.50–72.

Brown, R.L., Durbin, J. and Evans, J.M. (1975) 'Techniques for testing the constancy of regression relationships over time', *Journal of the Royal Statistical Society, Series B (Methodological)*, Vol. 37, No. 2, pp.149–192.

Brunetti, C., Büyükşahin, B. and Harris, J.H. (2016) 'Speculators, prices and market volatility', *Journal of Financial and Quantitative Analysis*, Vol. 51, No. 5, pp.1545–1574.

Brunnermeier, M.K. and Pedersen, L.H. (2009) 'Market liquidity and funding liquidity', *Review of Financial Studies*, Vol. 22, No. 6, pp.2201–2238.

Büyükşahin, B. and Robe, M.A. (2014) 'Speculators, commodities and cross-markets linkages', *Journal of International Money and Finance*, Vol. 42, pp.38–70.

Büyükşahin, B., Haigh, M.S. and Robe, M.A. (2010) 'Commodities and equities: ever a 'market for one'?', *The Journal of Alternative Investments*, Vol. 12, No. 3, pp.76–95.

Chang, C.L., McAleer, M. and Tansuchat, R. (2010) 'Analyzing and forecasting volatility spillovers, asymmetrics and hedging in major oil markets', *Energy Economics*, Vol. 32, No. 6, pp.1445–1455.

Chang, E.C., Cheng, J.W. and Khorana, A. (2000) 'An examination of herd behavior in equity markets: an international perspective', *Journal of Banking and Finance*, Vol. 24, No. 10, pp.1651–1699.

Cheng, I.H. and Xiong, W. (2014) 'Financialization of commodity markets', *Annual Review of Financial Economics*, Vol. 6, pp.419–441.

Cheng, I.H., Kirilenko, A. and Xiong, W. (2015) 'Convective risk flows in commodity futures markets', *Review of Finance*, Vol. 19, No. 5, pp.1733–1781.

Chevallier, J. and Ielpo, F. (2013) *The Economics of Commodity Markets*, Wiley, Chichester.

Chong, J. and Miffre, J. (2010) 'Conditional correlation and volatility in commodity futures and traditional asset markets', *Journal of Alternative Investments*, Vol. 12, No. 3, pp.61–75.

Chow, G.C. (1960) 'Tests of equality between sets of coefficients in two linear regressions', *Econometrica*, Vol. 28, No. 3, pp.591–605.

Clemente, J., Montañes, A. and Reyes, M. (1998) 'Testing for a unit root in variables with a double change in mean', *Economic Letters*, Vol. 59, No. 2, pp.175–182.

Creti, A., Ftiti, Z. and Guesmi, K. (2014) 'Oil price and financial markets: multivariate dynamic frequency analysis', *Energy Policy*, Vol. 73, pp.245–258.

Creti, A., Joët, M. and Mignon, V. (2013) 'On the links between stock and commodity markets' volatility', *Energy Economics*, Vol. 37, pp.16–28.

Datastream (2017) (accessed June 2017).

Demirer, R., Lee, H.T. and Lien, D. (2015) 'Does the stock market drive herd behavior in commodity futures markets?', *International Review of Financial Analysis*, Vol. 39, pp.32–44.

Dennis, P. and Strickland, D. (2002) 'Who blinks in volatile markets, individuals or institutions?', *Journal of Finance*, Vol. 57, No. 5, pp.1923–1949.

Domanski, D. and Heath, A. (2007) 'Financial investors and commodity markets', *BIS Quarterly Review*, March, pp.53–67.

Du, X., Yu, C.L. and Hayes, D.J. (2011) 'Speculation and volatility spillover in the crude oil and agricultural commodity markets. A Bayesian analysis', *Energy Economics*, Vol. 33, No. 3, pp.497–503.

Engle, R.F. and Granger, C.W.J. (1987) 'Co-integration and error correction: representation, estimation and testing', *Econometrica*, Vol. 55, No. 2, pp.251–276.

Engle, R.F. and Rangle, J. (2008) 'The spline-GARCH model for low-frequency volatility and its global macroeconomic causes', *Review of Financial Studies*, Vol. 21, No. 3, pp.1187–1222.

Erb, C.B. and Campbell, R.H. (2006) 'The strategic and tactical value of commodity futures', *Financial Analysts Journal*, Vol. 62, No. 2, pp.69–97.

Etula, E. (2013) 'Broker-dealer risk appetite and commodity returns', *Journal of Financial Econometrics*, Vol. 11, No. 3, pp.486–521.

Fanchon, P. and Wendel, J. (1992) 'Estimating VAR models under non-stationarity and cointegration: alternative approaches for forecasting cattle prices', *Applied Economics*, Vol. 24, No. 2, pp.207–217.

Fantazzini, D. (2016) 'The oil price crash in 2014/2015: was there a (negative) financial bubble?', *Energy Policy*, Vol. 96, pp.383–396.

Farooq, M. and Hammoudeh, S. (2007) 'Shock and volatility transmission in the oil, US and Gulf equity markets', *International Review of Economics and Finance*, Vol. 16, No. 3, pp.357–368.

Fattouh, B., Kilian, L. and Mahadeva, L. (2013) 'The role of speculation in oil markets: what have we learned so far?', *The Energy Journal*, Vol. 34, No. 3, pp.7–33.

Geman, H. and Smith, W.O. (2013) 'Theory of storage, inventory and volatility in the LME base metals', *Resources Policy*, Vol. 38, No. 1, pp.18–28.

Ghassan, H.B. and Alhajoj, H.R. (2016) 'Long run dynamic volatilities between OPEC and non-OPEC crude oil prices', *Applied Energy*, Vol. 169, pp.384–394.

Gilbert, C.L. (2010a) *Speculative Influences on Commodity Futures Prices 2006–2008*, United Nations Conference on Trade and Development (UNCTAD).

Gilbert, C.L. (2010b) 'How to understand high food prices', *Journal of Agricultural Economy*, Vol. 61, No. 2, pp.398–425.

Gkanoutas-Leventis, A. and Nesvetailova, A. (2015) 'Financialisation, oil and the Great Recession', *Energy Policy*, Vol. 86, pp.891–902.

Gorton, G. and Rouwenhorst, K. (2006) 'Fact and fantasies about commodity futures', *Financial Analysis Journal*, Vol. 62, No. 2, pp.47–68.

Granger, C.W.J. (1969) 'Investigating causal relations by econometric models and cross-spectral methods', *Econometrica*, Vol. 37, No. 3, pp.424–438.

Gulley, A. and Tilton, J.E. (2014) 'The relationship between spot and futures prices: an empirical analysis', *Resources Policy*, Vol. 41, pp.109–112.

Haase, M., Zimmermann, Y.S. and Zimmermann, H. (2016) 'The impact of speculation on commodity futures markets – a review of the findings of 100 empirical studies', *Journal of Commodity Markets*, Vol. 3, No. 1, pp.1–15.

Hache, E. and Lantz, F. (2013) 'Speculative trading and oil price dynamic: a study of the WTI market', *Energy Economics*, Vol. 36, pp.334–340.

Hamilton, J.D. (2009a) *Causes and Consequences of the Oil Shock of 2007–09*, NBER Working Paper No. 15002, May.

Hamilton, J.D. (2009b) 'Understanding crude oil prices', *Energy Journal*, Vol. 30, No. 2, pp.179–206.

Hamilton, J.D. and Herrera, A.M. (2004) 'Oil shocks and aggregate macroeconomic behavior: the role of monetary policy', *Journal of Money, Credit, and Banking*, Vol. 36, No. 2, pp.265–286.

Hamilton, J.D. and Wu, J.C. (2014) 'Risk premia in crude oil futures prices', *Journal of International Money and Finance*, Vol. 42, pp.9–37.

Hammoudeh, S., Diboglu, S. and Aleisa, E. (2004) 'Relationship among US oil prices and oil industry equity indices', *International Review of Economics and Finance*, Vol. 13, No. 4, pp.427–453.

Henderson, B.J., Pearson, N.D. and Wang, L. (2015) 'New evidence on the financialization of commodity markets', *Review of Financial Studies*, Vol. 28, No. 5, pp.1285–1311.

Hicks, J.R. (1939) *Value and Capital*, Oxford University Press, Cambridge, UK.

International Monetary Fund (IMF) (2006) 'The boom in nonfuel commodity prices: can it last?', in *World Economic Outlook*, pp.139–169, International Monetary Fund, Washington.

Irwin, S.H. and Sanders, D.R. (2011) 'Index funds, financialization and commodity futures markets', *Applied Economics Perspectives and Policy*, Vol. 33, No. 1, pp.1–31.

Irwin, S.H. and Sanders, D.R. (2012) 'Testing the masters hypothesis in commodity futures markets', *Energy Economics*, Vol. 34, No. 1, pp.256–269.

Irwin, S.H., Sanders, D.R. and Merrin, R.P. (2009) 'Devil or angel? The role of speculation in the recent commodity price boom (and bust)', *Journal of Agricultural and Applied Economy*, Vol. 41, No. 2, pp.377–391.

Johansen, S. (1988) 'Statistical analysis of cointegrating vectors', *Journal of Economic Dynamics and Control*, Vol. 12, Nos. 2–3, pp.231–254.

Jovenal, L. and Petrella, P. (2015) 'Speculation in the oil market', *Journal of Applied Econometrics*, Vol. 30, No. 4, pp.621–649.

Kaldor, N. (1939) 'Speculation and economic stability', *Review of Economic Studies*, Vol. 7, No. 1, pp.1–27.

Kaltalioglu, M. and Soytas, U. (2011) 'Volatility spillover from oil food and agricultural raw material markets', *Modern Economy*, Vol. 2, No. 2, pp.71–76.

Kaufman, R.K. and Ullman, B. (2009) 'Oil price speculation, and fundamental: interpreting causal relations among spot and futures prices', *Energy Economics*, Vol. 31, No. 4, pp.550–558.

Keynes, J.M. (1923) 'Some aspects of commodity markets', *Manchester Guardian Commercial, European Reconstruction Series*, Section 13, 29 March, as reprinted in *Collected Writings of John Maynard Keynes*, Vol. 12, pp.255–266, MacMillan, London.

Kilian, L. (2009) 'Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market', *American Economics Review*, Vol. 99, No. 3, pp.1053–1069.

Kilian, L. and Lee, T.K. (2014) 'Quantifying the speculative component in the real price of oil: the role of global oil inventories', *Journal of International Money and Finance*, Vol. 42, pp.71–87.

Kilian, L. and Murphy, D.P. (2014) 'The role of inventories and speculative trading in the global market for crude oil', *Journal of Applied Econometrics*, Vol. 29, No. 3, pp.454–478.

Kilian, L. and Park, C. (2009) 'The impact of oil price shocks on the US stock market', *International Economic Review*, Vol. 50, No. 4, pp.1267–1287.

Kim, A. (2015) 'Does future speculation destabilize commodity markets?', *Journal of Futures Markets*, Vol. 35, No. 8, pp.696–714.

Knittel, C.R. and Pindyck, R.P. (2016) 'The simple economics of commodity price speculation', *American Economic Journal: Macroeconomics*, Vol. 8, No. 2, pp.85–110.

Koch, N. (2014) 'Tail events: a new approach to understanding extreme energy commodity prices', *Energy Economics*, Vol. 43, pp.195–205.

Krugman, P. (2008) 'Fuels on the hill', *The New York Times*, 27 June.

Kuck, K. and Schweikert, K. (2017) 'A Markov regime-switching model of crude oil market integration', *Journal of Commodity Markets*, Vol. 6, pp.16–31.

Lee, J. and Strazicich, M.C. (2003) 'Minimum Lagrange multiplier unit root test with two structural breaks', *Review of Economics and Statistics*, Vol. 85, No. 4, pp.1082–1089.

Lehecka, G.V. (2015) 'Do hedging and speculative pressures drive commodity prices, or the other way around?', *Empirical Economics*, Vol. 49, No. 2, pp.575–603.

Lumsdaine, R.L. and Papell, D.H. (1997) 'Multiple trend breaks and the unit root hypothesis', *Review of Economics and Statistics*, Vol. 79, No. 2, pp.212–218.

Lütkepohl, H. (2005) *New Introduction to Multiple Series Analysis*, Springer-Verlag, Berlin.

Lütkepohl, H., Saikkonen, P. and Trenkler, C. (2004) 'Testing for the cointegrating rank of a VAR process with level shift at unknown time', *Econometrica*, Vol. 72, No. 2, pp.647–662.

Mayer, H., Rathgeber, A. and Wanner, M. (2017) 'Financialization of metal markets: does futures trading influence spot prices and volatility?', *Resources Policy*, Vol. 53, pp.300–316.

Mayer, J. (2012) 'The growing financialization of commodity markets: divergences between index investors and money managers', *The Journal of Development Studies*, Vol. 48, No. 6, pp.751–767.

Miffre, J. and Brooks, C. (2013) 'Do long-short speculators destabilize commodity futures markets?', *International Review of Financial Analysis*, Vol. 30, pp.230–240.

Nandha, M. and Faff, R. (2008) 'Does oil move equity prices? A global view', *Energy Economics*, Vol. 30, No. 3, pp.986–997.

Netessine, S. and Shumsky, R. (2004) 'Revenue management games: horizontal and vertical competition', *Management Science*, Vol. 51, No. 2, pp.813–831.

Nofsinger, J. and Sias, R. (1999) 'Herding and feedback trading by institutional and individual investors', *Journal of Finance*, Vol. 54, No. 6, pp.2263–2295.

Ohara, H.I. (1999) 'A unit root test with multiple trend breaks: a theory and application to US and Japanese macroeconomic time series', *The Japanese Economic Review*, Vol. 50, No. 3, pp.266–290.

Papell, D.H. and Prodan, R. (2003) 'The uncertain unit root in US real GDP: evidence with restricted and unrestricted structural change', *Journal of Money, Credit and Banking*, Vol. 36, No. 3, pp.423–427.

Park, J. and Ratti, R.A. (2008) 'Oil price shocks and stocks markets in the US and 13 European countries', *Energy Economics*, Vol. 30, No. 5, pp.2587–2608.

Perron, P. (1997) 'Further evidence on breaking trend functions in macroeconomic variables', *Journal of Econometrics*, Vol. 80, No. 2, pp.355–385.

Quandl (2017) (accessed June 2017).

Rahi, R. and Zigrand, J.P. (2009) 'Strategic financial innovation in segmented markets', *Review of Financial Studies*, Vol. 22, No. 8, pp.2941–2971.

Sanders, D.R., Boris, K. and Manfredo, M. (2004) 'Hedgers, funds and small speculators in the energy futures markets: an analysis of the CFTC's Commitment of Traders reports', *Energy Economics*, Vol. 26, No. 3, pp.425–445.

Schwartz, T.V. and Szakmary, A.C. (1994) 'Price discovery in petroleum markets: arbitrage, coitegration, and the time interval of analysis', *Journal of Futures Markets*, Vol. 14, No. 2, pp.147–167.

Schwarz, G. (1978) 'Estimating the dimension of a model', *The Annals of Statistics*, Vol. 6, No. 2, pp.461–464.

Silvennoinen, A. and Thorp, S. (2013) 'Financialization, crisis and commodity correlation dynamics', *Journal of International Financial Markets, Institutions and Money*, Vol. 24, pp.42–65.

Singleton, K. (2012) 'Investor flows and the 2008 boom/bust in oil prices', *Management Science*, Vol. 60, No. 2, pp.300–318.

Sockin, M. and Xiong, W. (2015) 'Informational frictions and commodity markets', *Journal of Finance*, Vol. 70, No. 5, pp.2063–2098.

Stoll, H. and Whaley, R. (2010) 'Commodity index investing and commodity futures prices', *Journal of Applied Finance*, Vol. 20, No. 1, pp.7–46.

Sullivan, J.H. (2002) 'Estimating the locations of multiple change points in the mean', *Computational Statistics*, Vol. 17, No. 2, pp.289–296.

Tang, K. and Xiong, W. (2012) 'Index investment and financialization of commodities', *Financial Analysts Journal*, Vol. 68, No. 6, pp.54–74.

Telser, L. (1958) 'Futures trading and the storage of cotton and wheat', *Journal of Political Economy*, Vol. 66, No. 3, pp.233–255.

Teo, M. (2009) 'The geography of hedge funds', *Review of Financial Studies*, Vol. 22, No. 9, pp.3531–3561.

Tilton, J.E., Humphreys, D. and Radetzki, M. (2011) 'Investor demand and spot commodity prices', *Resources Policy*, Vol. 36, No. 3, pp.187–195.

Working, H. (1949) 'The theory of the price and storage', *American Economic Review*, Vol. 39, No. 6, pp.1254–1262.

Zeileis, A., Leisch, F., Hornik, K. and Kleiber, C. (2002) 'Strucchange: an R package for testing structural change in linear regression models', *Journal of Statistical Software*, Vol. 7, No. 2, pp.1–38.

Zivot, E. and Andrews, D.W.K. (1992) 'Further evidence on the great crash, the oil-price shock and the unit root hypothesis', *Journal of Business and Economic Statistics*, Vol. 10, No. 3, pp.251–270.