Spillovers between non-commercial traders' activity and spot prices? Analysis of the financialization mechanism in the crude oil market

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Abstract

Purpose – The purpose of this stud is to analyze the financialization effect on oil prices.
Design/methodology/approach – This study applied the technique of multibreak point analysis with Bai and Perron test plus VAR methodology.
Findings – Findings revealed that there was no effect on oil prices.
Originality/value – To the best of the author's knowledge, this is the first paper combining the multibreakpoint analysis with VAR for the period analyzed in the present work.

Keywords Financialization, Oil prices, Multibreakpoint analysis, VAR models, Linear cointegration, Threshold cointegration

Paper type Research paper

1. Introduction

From the early 2000s onwards, commodity futures markets experienced remarkable changes in their regulatory framework as well as in the nature (and the number) of active professional operators (Domanski and Heath, 2007). The increasing integration between futures markets and those of other financial assets has been commonly referred to as the "financialization of commodity markets." Since the 2008 testimony to the US Senate by hedge fund manager Michael Masters, the debate about the possibility that financialization process could be considered the major driver of the 2007–2008 oil bubble gained greater and greater attention. Following this claim (usually mentioned as "Masters' hypothesis"), some commentators and scholars have theorized that financial markets can systematically act as a conduit in transmitting shocks to spot prices through futures. The purpose and the research hypothesis of this paper are to investigate whether the increased involvement of financial investors in trading futures markets exerted a systematic and decisive influence on the physical oil prices "boom."

Aware that the empirical analysis could be considered somewhat finalized to the particular time span covered by the dataset, we intentionally select a period of analysis with

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the aim of detecting plausible, recursive and specific traces of the effects of this supposed financial influence on physical prices. Undoubtedly, there is a marked difference between the period when the new rules came into effect fueling the debate about their influence on oil prices (2000–2010) and the last few years (2018–2022) characterized by unprecedented and extraordinary events. Suffice it to say that oil reached negative (!) prices in April 2020 for the first time in history due to the Covid-19 crisis. For these reasons, we anticipate the period (starting from 1995) in line with the availability of the data provided by official sources and, at the same time, we exclude the last four years (2018–2022) which have no objective connections with the hottest phase of the debate. The more selective the time span, the more evident should be the eventual presence of the phenomenon.

The novelty of our approach lies in the adoption of a multiple breakpoint methodology to identify and enhance partitioned and statistically relevant sub-intervals of the entire sample, within which the dynamic behavior of the variables is studied.

Our findings do not suggest the existence of distortions induced by a potential transmission channel that starts from financial markets and reaches oil spot quotes.

The rest of the paper is structured as follows. Section 2 briefly reviews the main literature on the financialization in the commodity markets and presents the presumed theoretical mechanism of transmission of effects from futures to spot prices through non-commercial investment activity. Section 3 provides the data and methodology descriptions. Section 4 presents and comments on the empirical results. Finally, Section 5 concludes the study.

2. Related literature on the financialization and its potential mechanism affecting commodity prices

At the beginning of the 2000s, commodity markets experienced significant changes both in regulatory systems and in the nature of the market operators.

As far as the first aspect is concerned, the main innovation pertained to 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, in addition to the traditional presence of specialists labeled as commercial hedgers (farmers, producers and consumers who typically trade futures to hedge the spot price risks inherent in their business activity), there was a massive entry of non-commercial traders. In this group are included institutional financial operators like Hedge Funds (HF), Swaps Dealers, Commodity Index Funds (CIF) and Commodity Index Traders (CITs, among the other pension funds and insurance companies). Because they have little or no specific interest in actually producing or consuming the commodities, and making extensive use of leverage, they are also often called “speculators” (Tilton *et al.*, 2011). This presence has fuelled the debates and concerns about the effect on physical prices of purely financial factors arising from trade. Thus, the core problems associated with financial integration lie primarily in the overall economic impacts exerted by the activities of the new institutional investors who follow a different logic for their operations than traditional specialists (Boyd *et al.*, 2018).

Some strand of literature has been focused on the price instability deriving from the “herding behaviors” of speculators and, more in general, on the spillover effects that the growing deregulation has exerted on the markets (Engle and Rangle, 2008; Demirer *et al.*, 2015; Balcilar *et al.*, 2017). Volatility issues or indirect measures like convenience yield or risk-premiums have been investigated by Chang *et al.* (2010), Acharya *et al.* (2013), Hamilton and Wu (2014) and Scott *et al.* (2018).

For the period analyzed in the present work, shocks in the supply and/or demand and inherent effects on crude prices have been pointed out by Hamilton (2009a, b), Kilian (2009), Kisswani (2016), Tan and Ma (2017), Degiannakis *et al.* (2018) and Neves *et al.* (2021).

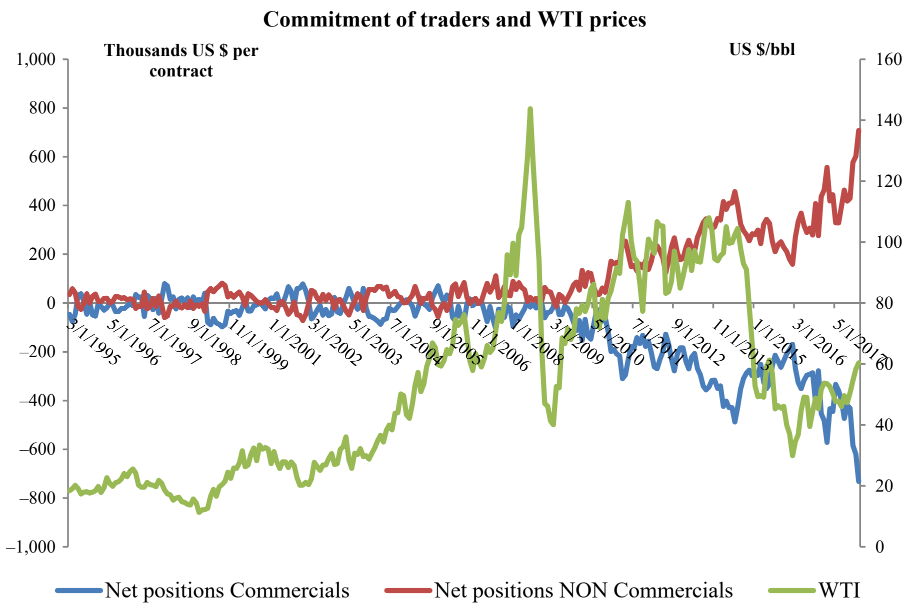
Interrelationships between prices and inventories have been investigated by Alquist and Kilian (2010), Killian and Lee (2014), Kilian and Murphy (2014), Jin (2019) and Gao *et al.* (2022).

From this perspective, the relevant topic is the interaction between the futures and the spot quotations, and how financialization impacts the physical price. The theoretical transmission financial channel has been described by Gilbert (2010a, b), Tang and Xiong (2012), Fattouh *et al.* (2013) and Henderson *et al.* (2015). It is generally argued that the impact mechanism on the physical market should find its roots in the increase in trading activity on behalf of non-commercial players (Mayer *et al.*, 2017). Three potential economic processes act as transmission channels (Cheng and Xiong, 2014).

The first economic mechanism finds its roots in the theory of storage wherein spot and futures prices are linked through the arbitrage process (Kaldor, 1939; Working, 1949; Brennan, 1958). Prices are influenced by the interest rates, the inventory costs and the nature of storage that control both the speed and the intensity towards an equilibrium. Forward prices assured by the market maker are the result of spot/physical price plus the interest rate and warehousing/insurance cost less convenience yield. From an economic point of view, the futures achieve the same result as the forwards by offering price certainty for a period in the future (Schofield, 2007).

The second process to develop futures markets is driven by the risk-sharing on behalf of commodity producers. With a typical risk-averse attitude, the producers tend to have net short positions on the futures markets (Figure 1) offering a premium to the potential risk-takers on the opposite (long) side of the market (Keynes, 1923, 1930; Hicks, 1939; Hirshleifer, 1988).

The third channel takes into account the market asymmetries. Due to lower transaction costs and greater liquidity (Geman and Smith, 2013), futures markets would act in transmitting feedback signals to both commodity demand and the spot price formation mechanism.



Source(s): Personal elaborations on Datastream (2021)

Figure 1.
Commitment of traders and WTI prices (monthly data)

The plausibility of this induced influence (and, thus, of a potential subsequent distortion) on the final physical prices is widely discussed, for example, in Tilton *et al.* (2011) or Gulley and Tilton (2014). On this aspect, it is argued that an increase in long demand can induce adjustments on hedgers' trading positions through a derived counter-demand of short contracts leading to subsequent higher risk premiums that bring future prices back to the original level. On the theory of storage, the increase in long futures demand does not necessarily impact the convenience yield without leading to subsequent complementary adjustments of inventories and spot prices. While on the side of information asymmetries, the mechanism acts because futures market participants would follow spot prices because of the supposedly better-informed position of commercial traders (Mayer *et al.*, 2017). Increased market participation does not appear to be a harbinger of positive aspects. Singleton (2014) fosters that a strong presence of informational frictions emphasizes expectation heterogeneity, and the relevance of the noise brought into the markets through the investors' trading activity is highlighted by Sockin and Xiong (2015).

Interestingly, Haase *et al.* (2016) reviewing one hundred papers on the subject, found that the number of authors supporting the existence of a speculation effect are about the same as those fostering the opposite position. So, despite a great deal of analysis and explanations pointed out by literature, the real impact on the commodity price levels resulting from the increased financial investing by non-commercial traders remains a debated and unsolved question (Henderson *et al.*, 2015; Fantazzini, 2016).

This paper adds to the literature studying the effects of speculation on financial markets. Some examples can be found in Irwin *et al.* (2009), Stoll and Whaley (2010), Irwin and Sanders (2012), Bohl and Stephan (2013), Bohl *et al.* (2013), Miffre and Brooks (2013), Jovenal and Petrella (2015), Kim (2015) and Brunetti *et al.* (2016). More precisely, it can be counted within the strand of research works that analyze potential spillover effects and co-movements between futures and spot markets (Irwin and Sanders, 2011; Hache and Lantz, 2013; Knittel and Pindyck, 2016; Mayer *et al.*, 2017). It also adds to the literature that supports the idea that structural supply-demand factors are the most relevant in the oil price formation mechanism (Kilian and Murphy, 2014; Killian and Lee, 2014; Knittel and Pindyck, 2016; Focacci, 2019, 2021).

3. Data and methodology

3.1 Data description and processing

In order to pursue the aim of the research, we built a dataset including New York Mercantile Exchange (NYMEX) non-commercial net long positions. These are taken as proxies for non-commercial activity (labeled as TA) and calculated as the difference between the long and the short open interest only on futures. The time series are recorded within the US Commodities Futures Trading Commission (CFTC) Section of Commitment of Traders (COT) in Datastream (2021) starting from 1995 onwards. This indicator could be considered unreliable because of a general lack of classification of reciprocal positions (with particular reference to swaps dealers acting not as CITs). Aggregate definitions always suffer from differences and limitations (IMF, 2016), however, the same applies to any other potential direct indicator that can be drawn from the currently available archives. A more precise measure – such as Index Investment Data – does not seem appropriate in our case, since the figures are only available from 2007 onwards.

A further dataset is built by gathering the West Texas Intermediate (WTI) NYMEX futures quotations (Tuesday's close). For the present work, we select a sample of four among the most common delivering dates (2 months maturity, 3 months maturity, 6 months maturity and 12 months maturity continuous contract; hereafter labeled for brevity as CL2, CL3, CL6 and CL12). The front-month contract (CL1) has been excluded because its maturity is too close to that of spot quotations and it could be considered a proxy of physical prices due to frequent roll-over. All futures quotations are retrieved from Quandl (2021).

Finally, also the WTI spot prices are gathered from Datastream (2021). The quotation of oil is one of the most important macroeconomic factors in the world economy (Driesprong *et al.*, 2008) and the WTI is a world benchmark crude oil price (Chevallier and Ielpo, 2013).

Jointly, the whole dataset is a weekly time series (N = 1,159) covering the period from the last week of March 1995 (exactly on Tuesday, March 21, 1995) to the last week of May 2017 (on Tuesday, May 30, 2017). Processing more high-frequent daily data increases the likelihood of finding (spurious) causal relationships (Schwartz and Szakmary, 1994). On the contrary, the fewer number of observations of a monthly frequency sample significantly weakens the detection of the dynamic behavior of the non-commercial traders' activity. Thus, our choice is a reasonable trade-off between the two extreme positions.

3.2 Methodology

To reduce the number of potential combinations to be processed, we preliminarily conduct a cointegration analysis among the selected futures contracts (CL2, CL3, CL6 and CL12). For this aim, we adopt both the Engle-Granger two-step procedure (1987) and the Johansen test (Johansen, 1988; Johansen and Juselius, 1990). As a robustness check, a Hansen and Seo supLM test (2002) is proposed to investigate the existence of a non-linear threshold cointegration as a possible alternative to linear cointegration (Balke and Fomby, 1997). In Table 1, the overall results are summarized. They support the existence, both of a long-run linear relationship and of an instantaneous-symmetric adjustment among quotations.

Period (Johansen)	Futures	Lag order	Rank	Trace test	p-value	λ max	p-value
Mar 21, 1995–May 30, 2017	CL2-CL3-CL6-CL12	1	0	244.52	0.00	148.62	0.00
			1	95.90	0.00	69.88	0.00
			2	26.02	0.00	23.48	0.00
			3	2.54	0.11*	2.54	0.11*

Period (Engle-Granger)	Futures	Lag order	ADF	p-value
Mar 21, 1995–May 30, 2017	CL2	1	−1.69	0.76
	CL3	1	−1.61	0.79
	CL6	1	−1.46	0.84
	CL12	1	−1.25	0.90
	Residuals	1	−10.22	0.00*

Period (Hansen and Seo Sup LM Test)	Futures	Lag order	Test statistics	p-values	Nboot	Fixed regressor	Intercept
Mar 21, 1995–May 30, 2017	CL2 vs CL3	1	21.77	0.036*	1,000	yes	Yes
	CL3 vs CL6	1	19.26	0.121	1,000	yes	Yes
	CL6 vs CL12	1	13.55	0.587	1,000	yes	Yes
	CL3 vs CL12	1	18.10	0.172	1,000	yes	Yes
	CL2 vs CL12	1	18.18	0.157	1,000	yes	Yes
	CL2 vs CL6	1	19.52	0.082	1,000	yes	Yes

Note(s): * Indicates cointegration at 5% level
Lag order is defined with *BIC* criterion after first differencing values to achieve stationarity (Johansen test)
Source(s): Personal elaborations on Quandl (2021)

Table 1. Johansen, Engle-Granger and Hansen-Seo cointegration analyses of futures contracts

As far as the Hansen and Seo test is concerned, it should be noted that only the relationship between CL2 vs CL3 could be a non-linear one, but considering the whole set of combinations, this conclusion appears as very marginal. For these reasons, the CL2 can be used to represent all other futures in subsequent elaborations.

In Table 2, classical descriptive statistics are summarized for CL2, Ta and WTI. In addition, we report also to the most widespread formal unit root tests (Augmented Dickey–Fuller: ADF, Augmented Dickey–Fuller Generalized Least Squares Regression: ADF-GLS, Kwiatkowski–Phillips–Schmidt–Shin: KPSS and Phillips–Perron: PP). As can be appreciated, all variables have unit roots (except in one negligible case marked by an asterisk).

At this point, with the goal to investigate our hypothesis (i.e. the potential transmission effects originated by trading activity as proposed in Section 1 and explained in Section 2), we follow a double step. First, we apply the procedure to identify and locate breakpoints in the non-commercial traders' net positions.

This initial step is necessary to identify dynamic and meaningful deviations in financial strategies related to investor behavior through their net positions.

Second, to improve the analysis, we partition the entire time period (March 21, 1995–May 30, 2017) into appropriate intervals taking into account the detected breakpoints. This aspect is remarkable at least for a couple of reasons. The first one lies in the fact that it is the non-commercial investors' activity that is considered the main cause of distorting the market.

3.2.1 Lag order 7 for KPSS. Then, within each interval, we analyze the dynamic behavior of the variables and their consistency with the mechanism theorized along the chain: trading activities, futures price and spot markets.

As aforementioned, for addressing the first step, we apply the multiple breakpoint detection techniques proposed by Bai and Perron (1998, 2003). The statistical and econometric literature propose a wealth of works concerning typically designed single

Series	Non-commercial Net positions (TA)	Futures Two months (CL2)	WTI Spot
Mean	94,274	53.21	52.93
Median	37,874	48.08	47.01
Minimum	−71,928	11.26	10.82
Maximum	5.57×10^5	145.86	145.31
Stddev	1.28×10^5	30.70	30.50
Skewness	1.18	0.49	0.51
Kurtosis	0.38	−0.93	−0.92
N	1,159	1,159	1,159
Jarque–Bera test	278.24 $p < 0.05$	88.04 $p < 0.05$	91.37 $p < 0.05$
ADF with const	−1.74	−1.66	−2.07
p -value	0.41	0.45	0.26
ADF with const and trend	−1.76	−1.63	−4.37
p -value	0.72	0.78	0.00*
ADF_GLS τ	−1.89	−1.77	−1.48
Critical value	−2.89	−2.89	−2.89
KPSS test	9.16	9.36	10.24
Critical value	0.46	0.46	0.46
PP test Z τ	−1.81	−1.78	−1.76
p-value	0.37	0.39	0.40

Note(s): * Indicates stationarity at 5% level ($\alpha = 0.05$)
Testing down from 22 lags and BIC criterion for ADF and ADF-GLS
Source(s): Personal elaborations on Datastream (2021) and Quandl (2021)

Table 2.
Descriptive statistics of the series with unit root test

tests (also at an unknown date) or, at most, double change tests (for example and without pretension to exhaustion: Brown *et al.*, 1975; Banerjee *et al.*, 1992; Zivot and Andrews, 1992; Lumsdaine and Papell, 1997; Clemente *et al.*, 1998; Perron, 1997; Ohara, 1999; Lee and Strazicich, 2003; Papell and Prodan, 2003; Lütkepohl *et al.*, 2004).

Another widespread procedure has been proposed by Chow (1960). Nevertheless, also in this test, the null hypothesis must be exogenously specified and just for one single structural change.

Differently, the present breakpoint analysis allows the detection of multiple unknown dates in an endogenous manner. This feature is particularly important to trace out the dynamics of a phenomenon such as that covered by this work. The breakpoints in non-commercial net positions are the statistical evidence of the important changes in institutional investors' behavior. The need to consider more than one single break in time series when actually more than one change exists regardless of preconditions defined by the analyst has been outlined by several studies (Lumsdaine and Papell, 1997). The method consists in determining a number m of breakpoints where the coefficients of the fitting regression relationship shift from one stable relation to a different one. Hence, the starting regression model is expressed as follows:

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

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 the model (1) can be re-written as follows:

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

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 $t_{m+1} = n$.

Within the m-partition, the least-squares estimates of the β_j lead to the Residual Sum of Squares (*RSS*) as follows:

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

with $rss(t_{j-1} + 1, \ t_j)$ as the minimal residual sum of squares in the j_{th} segment of the partition.

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

$$(t'_1, \ldots \ldots t'_m) = \underset{1 \leq t \leq m}{\operatorname{argmin}} RSS \tag{2}$$

The solutions to obtain the global minimization of the objective function in (2) are computationally burdensome for all $m > 2$ (even in the hypothesis to have a reasonable sample of size n). The order of the grid search would be of order $O(n^m)$. Thus, hierarchical algorithms have to be applied to do recursive portioning or joining the sub-samples. The segment sizes are determined with $h \times n$ observations, where h is a trimming bandwidth parameter selected to include the 10% of observations n within each segment. The threshold of $h = 0.10$ is set to force a better fine-tuning process and to follow the "movements" of traders. Examples of such applications are in the works of Bai (1997) and Sullivan (2002). Nonetheless, such algorithms will not necessarily find the solutions in terms of global minimizers. Therefore, applying an approach in dynamic programming of order $O(n^2)$ for each m time a change occurs is much 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 Bellman's principle (1952). In such a Bellman's environment, the stochastic event is analyzed by adopting a calculation strategy where each result is applied to the determination of the subsequent one. Hence, the recursive algorithm to achieve the optimal segmentation is derived from the following equation:

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

The same procedure applied for RSS can be implemented for the Schwarz Bayesian Information Criterion (BIC or SIC by various authors) (Schwarz, 1978):

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

Thus, we can count on two criteria to evaluate the whole detection procedure. More specific proofs and formal developments can be found in Bai and Perron (1998, 2003) as well as in Zeileis *et al.* (2002) for further computing details.

At this point, once the m shifts are detected, the partitions are obtained by segmenting the whole time series into intervals including a breakpoint and having as extreme the subsequent one. Breaks are both the boundaries (except for the starting and the finish date of the sample) and main events within each interval (Figure 2). Each partition is a "steady-state regime" and break dates identify the change among regimes. Since we are investigating whether financialization heavily impacts the markets, the inclusion of the break is central to avoid considering that breakpoints themselves are a direct consequence (or a function) of financialization. Within each interval, cointegration relationships are not taken into consideration since the number of observations is not sufficient for long-run equilibrium analysis.

Defined the various intervals to investigate, the second step regards the application of the VAR models between the series (employed alternatively as y and x within the two equations' system). The hypothesis to test is the mechanism: Trading activities (TA) → Futures (CL2) → spot price (WTI). In order to guarantee stationarity, first differences are calculated (Table 2 reports that variables are not stationary in levels). We select the BIC information criteria to determine the most appropriate VAR lag structure (p) in each model. The general discrete starting basic expression is as follows:

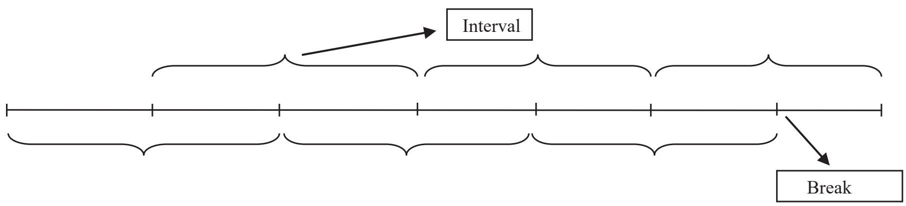


Figure 2.
Visual explanation of the definition of the intervals including breaks

Note(s): The figure has a merely illustrative purpose since partitions and intervals determined in our elaborations do not include the same number of obs

$$\Delta y_t = c_1 + \sum_{i=1}^{p} \partial_{1,i} \Delta y_{t-i} + \sum_{j=1}^{p} \gamma_{1,j} \Delta x_{t-j} + v_{\Delta y,t} \quad (3)$$

$$\Delta x_t = c_2 + \sum_{i=1}^{p} \partial_{2,i} \Delta y_{t-i} + \sum_{j=1}^{p} \gamma_{2,j} \Delta x_{t-j} + v_{\Delta x,t} \quad (4)$$

where $v_{\Delta y,t}$ and $v_{\Delta x,t}$ are errors.

Equivalently, corresponding vectors calculations implemented within a proper 2×2 system of equations can be represented as follows:

$$\mathbf{z}_t = \begin{pmatrix} \Delta y_t \\ \Delta x_t \end{pmatrix}, \mathrm{c} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix}, v = \begin{pmatrix} v_{\Delta y_t} \\ v_{\Delta x_t} \end{pmatrix}$$

where the p vectors and related 2×2 matrixes are as follows:

$$\mathbf{z}_{t-i} = \begin{pmatrix} \Delta y_{t-i} \\ \Delta x_{t-i} \end{pmatrix} \boldsymbol{A}_i = \begin{pmatrix} \delta_{1i} & \gamma_{1i} \\ \delta_{2i} & \gamma_{2i} \end{pmatrix} \text{for each } i = 1, 2, \ldots, p,$$

and the corresponding matrix formal expression of the discrete basic previous model is as follows:

$$\mathbf{z}_t = \mathbf{c} + \sum_{i=1}^{p} \boldsymbol{A}_i \mathbf{z}_{t-i} + \boldsymbol{\nu}\,.$$

To investigate the dynamic behavior of the trading activities *vs* futures prices within the relationship, in equations (3) and (4), y represents the net long positions for non-commercial trading activity (TA) and x represents the futures (CL2). While for the second relation (futures prices *vs* spot market prices), CL2 figures are paired with spot WTI quotations in a corresponding way. Under the assumption of applying one standard deviation shock in the current value of one of the variables to explore the mutual reaction of the response variable within each interval, we show corresponding impulse response functions as the output of the VAR models.

4. Empirical results and discussion

As stated in the previous section, the multiple breakpoint technique is applied for detecting meaningful movements in non-commercial trading activity (TA). Results are presented in Table 3. Incidentally, both lower values for the *RSS* and the *BIC* criteria coincide in suggesting an optimal identification of the breakpoint number m equal to 6. The accurate time identification and point definitions (as a sequential observation in the whole dataset) are resumed in the subsequent Table 4. Intervals including breakpoints are reported, as they have been explained in the previous section in Figure 2. In so doing, periods are naturally overlapping, and not equal to the $m+1$ partitions originated by the breakpoint analysis.

Highlighting the breakpoints with blue arrows, Figure 3 shows the same graph as Figure 1 omitting the net long trade positions for clarity. The estimated coefficients for the seven partitions derived from the breaks are listed in Table 5, while in Figure 4 the fitted linear regression models to non-commercial trading activity dataset are shown to highlight the magnitude in the changes of the regimes.

As argued above, breakpoints locate timely and relevant changes in the financial strategies of institutional investors. Combining Figure 2 and 3, for example, we can identify

m	TA BIC (10^4)	RSS (10^{12})
0	3,019	17,970
1	2,841	3,752
2	2,795	2,473
3	2,786	2,258
4	2,785	2,220
5	2,784	2,173
6*	2,784*	2,140*
7	2,786	2,149
8	2,791	2,220
9	2,809	2,570

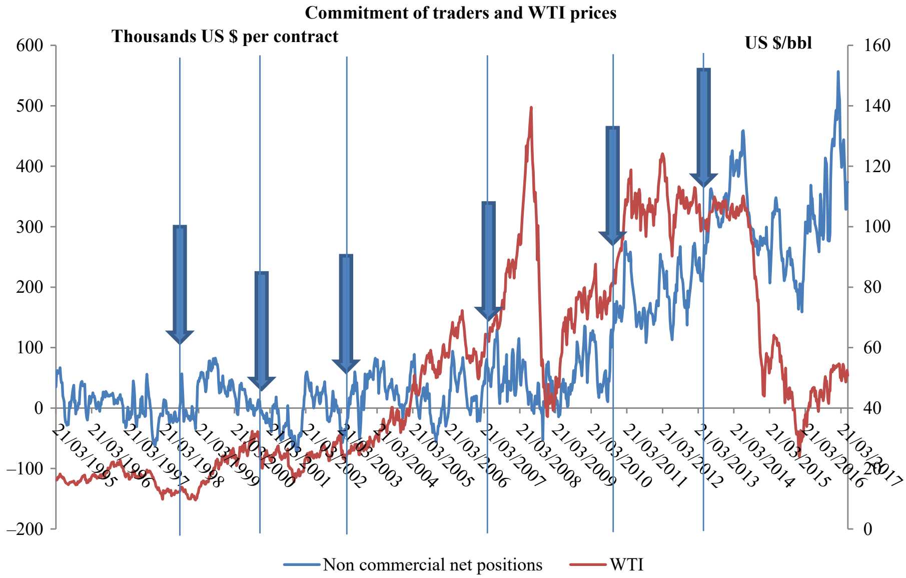
Note(s): *Indicates optimal number of breakpoint
Source(s): Personal elaboration on Datastream (2021)

Table 3.
Multiple breakpoint partition of TA

TA Date	Point	Intervals
15 Sep 98	183	21 Mar 1995–05 Dec 2000
05 Dec 00	299	15 Sep 1998–03 Jun 2006
03 Jun 03	429	05 Dec 2000–06 Mar 2007
06 Mar 07	625	03 Jun 2003–19 Oct 2010
19 Oct 10	814	06 Mar 2007–14 May 2013
14 May 13	948	19 Oct 2010–30 May 2017

Source(s): Personal elaboration on Datastream (2021)

Table 4.
Breakpoints time location and sub-intervals



Source(s): Personal elaborations on Datastream (2021)

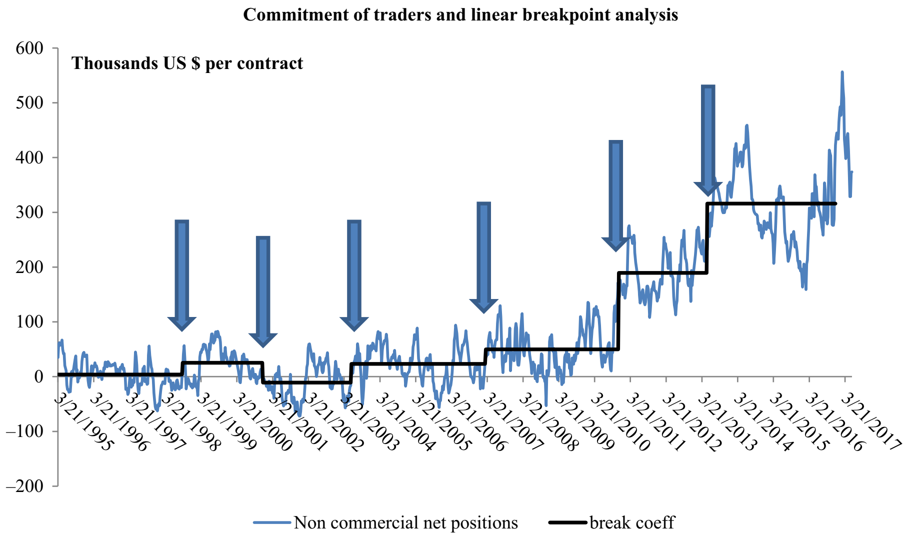
Figure 3.
Non-commercial commitment of traders with breakpoints and WTI prices (weekly data)

by the first blue arrow (on 15th September, 1998) a clear structural deviation from the stability of the mean in the linear model fitting the data. A higher coefficient was calculated in the period including the first and the second break (on 5th December 2000) highlighting the increasing involvement of financial investors in the market. The opposite holds for the subsequent interval between the second and the third break date (05th December 2000–03th June 2003, a lower coefficient expressing less interest from institutional investors). The end of the third sub-interval (on 3rd June 2003) records a reversal toward positive net volumes after a period where the negative values prevailed. An increasing decisive phase in TA overall trend begins on 6th March 2007 (break number 4). A marked sharp upturn occurs from the fifth breakpoint (on 19th October 2010) onwards. Curiously, it must be observed that CFMA was approved on 21st December 2000, and on 05th December 2000, a significant shift occurred. In fact, if such a disruptive and influential impact is credited to the new regulatory framework, it would be more logical to expect that the decisive change in the choices of financial operators occurs after its entry into force and not earlier. Notwithstanding, if the detected change foreruns the introduction of the new law, results may suggest – as an alternative interpretation – an anticipatory change in investors' strategies (coherent with rational

Period	Coefficient
21 Mar 1995–15 Sep 1998	3,857
15 Sep 1998–05 Dec 2000	25,436
05 Dec 2000–03 Jun 2003	−10,754
03 Jun 2003–06 Mar 2007	23,290
06 Mar 2007–19 Oct 2010	49,854
19 Oct 2010–14 May 2013	189,485
14 May 2013–30 May 2017	316,051

Source(s): Personal elaboration on Datastream (2021)

Table 5. Coefficients for the various partitioned sub-segments



Source(s): Personal elaborations on Datastream (2021)

Figure 4. Non-commercial commitment of traders with breakpoints and fitted models

expectations and the hypothesis of the efficiency of the markets). All things considered and reasonably assuming a certain degree of approximation of the estimation procedure (just two weeks in this case), December 2000 is indeed confirmed as a meaningful date in the analysis. Interestingly, Table 6 presented a comparison between the chronology of relevant events in oil price history and breakpoints detected in non-commercial behavior. Moreover, as can be noted from a visual inspection of Figure 3, there is not an exact correspondence between non-commercial trading strategies and oil price changes. As a matter of fact, there are periods where oil prices increased, despite that non-commercial trading activities experienced a concurrent sharp reduction and vice versa. Taking the fifth partition (06th March 2007–19th October 2010) as an example, the mean of TA involvement was significantly higher than the previous one (as confirmed by the linear model fitting the data). In the same time span, oil prices plunged sharply reaching significantly lower quotation levels than subsequent ones (Figure 4). Hence, a relationship between the TA net positions and the oil prices path is questionable also at this simple visual inspection level. Additionally, it can be observed that an earlier remarkable break is present (on 15th September 1998) well before the adoption of the CFMA.

The second step of the procedure regards the investigation of interactions among variables and their dynamic analysis through a VAR model within the intervals previously summarized in Table 4. First, we proceed to analyze the relationship between the non-commercial trading activities (TA) and the futures (CL2), and then we continue with the interactions between the futures (CL2) and the spot prices. Tables 7 and 8 present the essential statistics for the different models.

Additionally, the visual output of the stochastic behavior of variables is reported in Figures 5–16 through all the different impulse-responses diagrams (shaded area depicts the

Table 6. Breakpoints time location and main events in crude oil price history

TA Date	Point	Crude oil price history event
15 Sep 98	183	1999: Thailand, Indonesia and South Korea recover from the 1997 financial crisis
05 Dec 00	299	2000: CFMA, Housing market boom
03 Jun 03	429	2003 March: War in Iraq
06 Mar 07	625	2006 Feb: Breakdown of oil production due to Nigeria attacks
		2008: Global financial crisis
19 Oct 10	814	2010: Global debt crisis
14 May 13	948	2014: Strong production in the USA and Russia

Source(s): Personal elaboration on Datastream (2021), Kilian and Park (2009), Hamilton (2009a, b) and McGuire (2015)

Table 7. VAR (*p*) non-commercial trading activity (TA) and futures (CL2)

Non-commercial activity vs futures (TA vs CL2)	Lag order	Log L_τ	BIC
Interval (21st March 1995–05th December 2000)	1	−3540.51	23.96
Interval (15th September 1998–03rd June 2003)	1	−3023.67	24.82
Interval (05th December 2000–06th March 2007)	1	−4176.57	25.81
Interval (03rd June 2003–19th October 2010)	1	−5270.92	27.55
Interval (06th March 2007–14th May 2013)	1	−4499.25	28.05
Interval (19th October 2010–30th May 2017)	1	−4698.41	27.42

Note(s): p = lag order informed by *BIC* criterion; heteroskedasticity-robust standard errors L_T = likelihood function
Source(s): Personal elaborations on Datastream (2021) and Quandl (2021)

90% bootstrap confidence interval). Specifically, graphs from 5 to 10 regarding the analysis of the plausibility of the hypothesis that a financial strategy is able to promote the speculative mechanism through the influence exerted by institutional investors' trading activity on futures. Instead, diagrams from 11 to 16 explore the relationship that should affect the spot quotations through the influence exerted by the futures.

Reading each figure as a matrix, $\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$, the elements a_{12} and a_{21} depict mutual responses between variables focused on the analysis. Forecasting horizon is defined for 10 weeks. This time span can be considered as a reasonable one for evaluating professional investors' activity. The overall dynamic results do not show that trading activity significantly affects the quotation of the futures. As can be seen from the outcomes (except for 2 of the 6 cases discussed below), the effects of shocks on the adjustment path of the variables do not support the supposed mechanism whereby "trading activity affects futures." On the

Futures vs spot prices (CL2 vs spot)	Lag order	Log L_τ	BIC
Interval (21st March 1995–05th December 2000)	1	−726.31	5.01
Interval (15th September 1998–03rd June 2003)	1	−712.15	5.95
Interval (05th December 2000–06th March 2007)	1	−1194.84	7.46
Interval (03rd June 2003–19th October 2010)	2	−1777.29	9.44
Interval (06th March 2007–14th May 2013)	2	−1571.93	9.97
Interval (19th October 2010–30th May 2017)	1	−1522.40	8.95

Note(s): p = lag order informed by *BIC* criterion; heteroskedasticity-robust standard errors
L_T = likelihood function
Source(s): Personal elaborations on Datastream (2021) and Quandl (2021)

Table 8.
VAR (p) futures (CL2) and spot prices

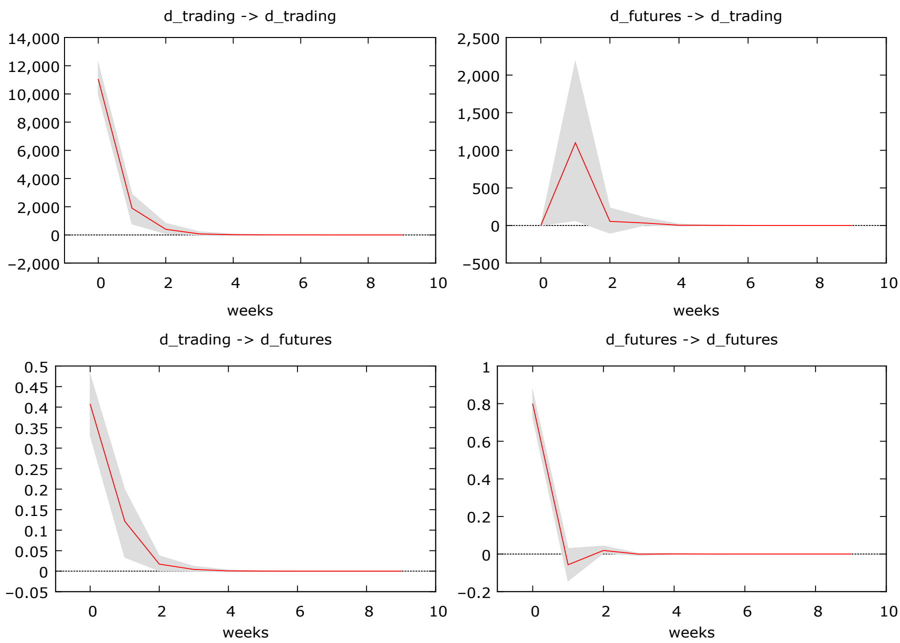


Figure 5.
Impulse-responses for non-commercial trading activity vs futures (Interval: 21st Mar 1995–05th Dec 2000)

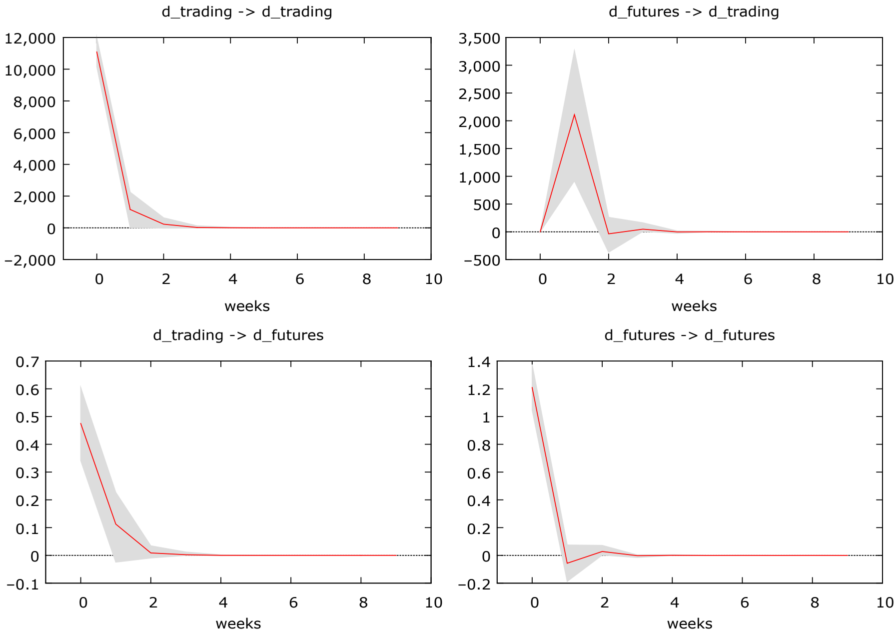


Figure 6.
Impulse-responses for non-commercial trading activity vs futures (Interval: 15th Sep 1998–03rd Jun 2003)

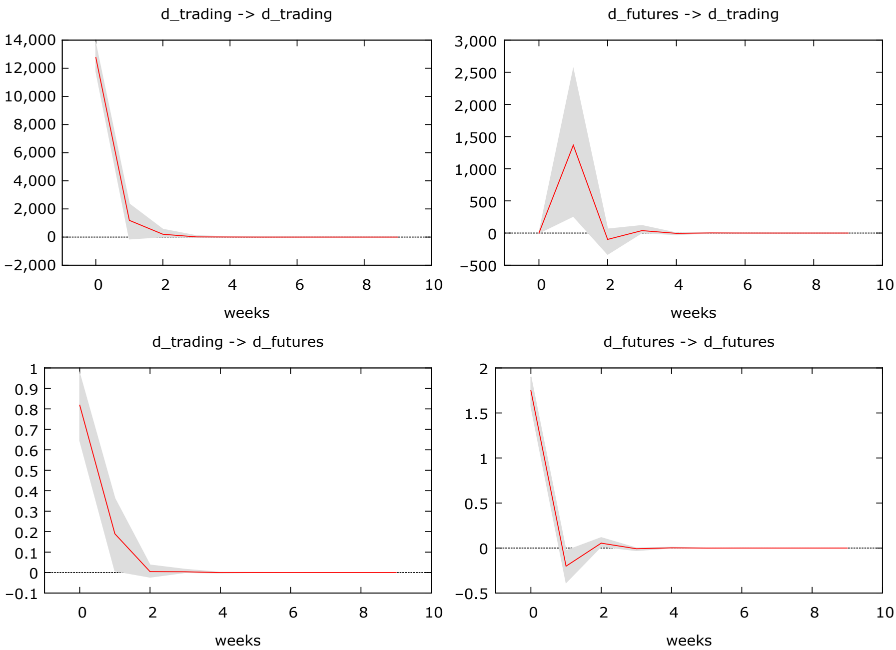


Figure 7.
Impulse-responses for non-commercial trading activity vs futures (Interval: 05th Dec 2000–06th Mar 2007)

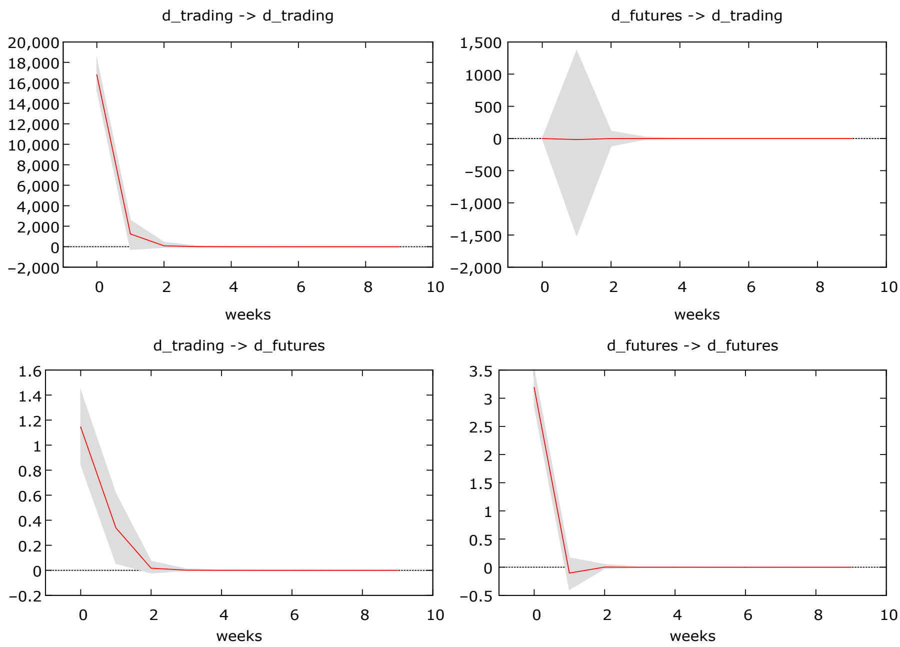


Figure 8.
Impulse-responses for non-commercial trading activity vs futures (Interval: 03rd Jun 2003–19th Oct 2010)

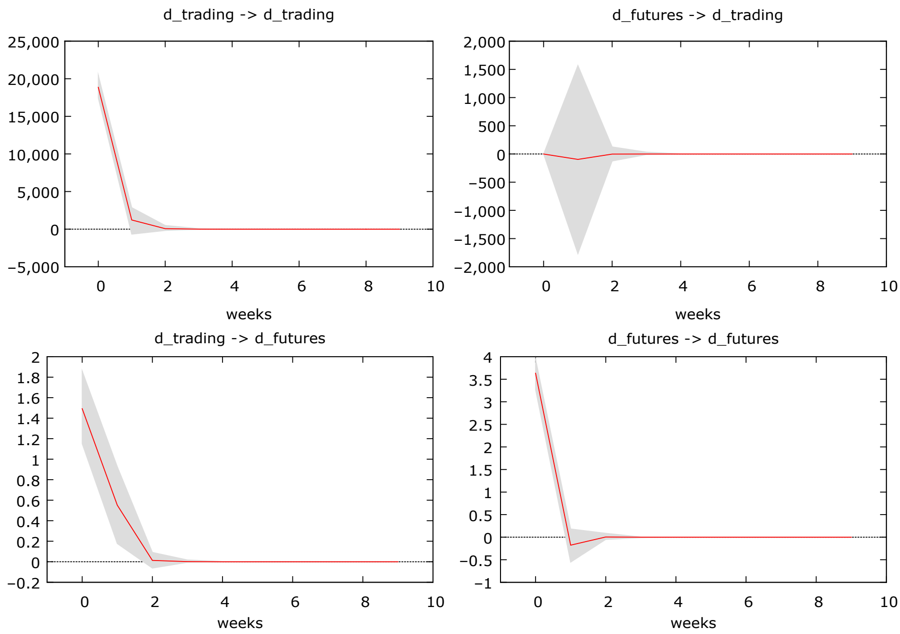


Figure 9.
Impulse-responses for non-commercial trading activity vs futures (Interval: 06th Mar 2007–14th May 2013)

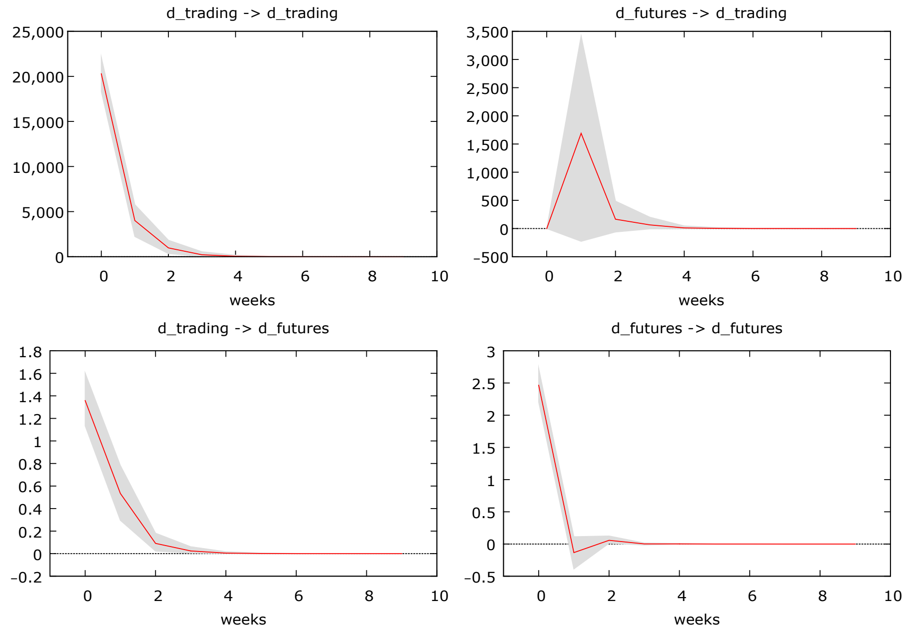


Figure 10.
Impulse-responses for non-commercial trading activity vs futures (Interval: 19th Oct 2010–30th May 2017)

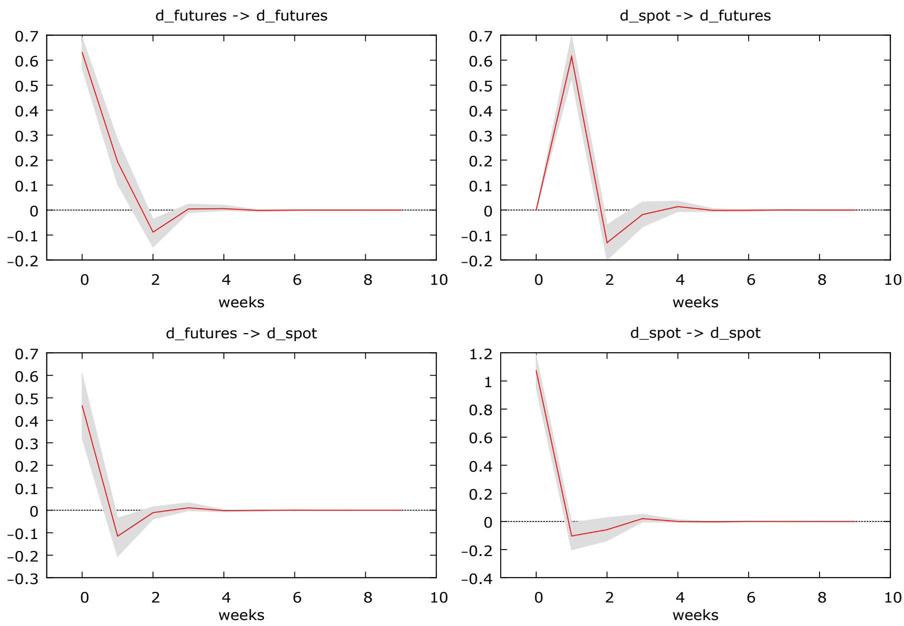


Figure 11.
Impulse-responses for futures vs spot (Interval: 21st Mar 1995–05th Dec 2000)

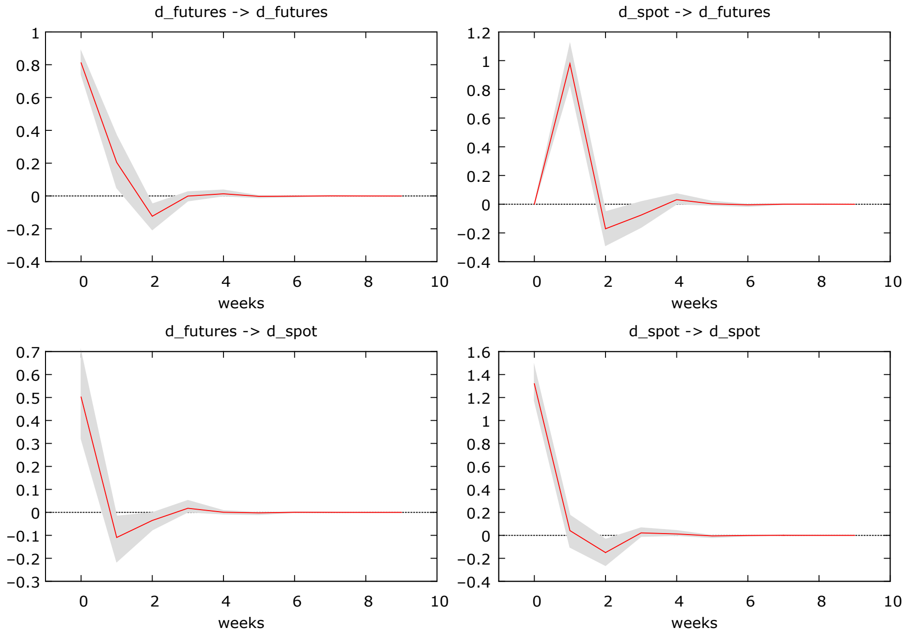


Figure 12.
Impulse-responses for futures vs spot (Interval: 15th Sep 1998–03rd Jun 2003)

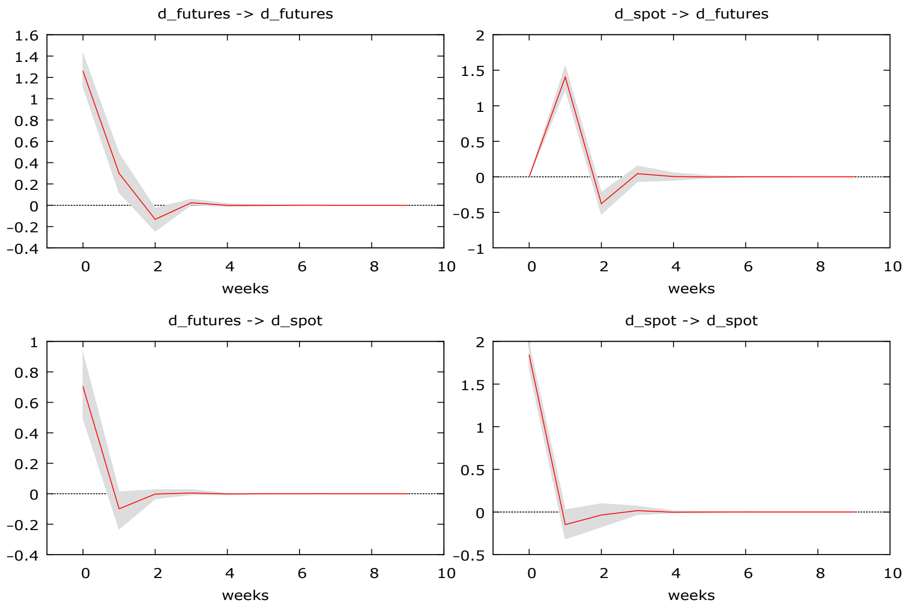


Figure 13.
Impulse-responses for futures vs spot (Interval: 05th Dec 2000–06th Mar 2007)

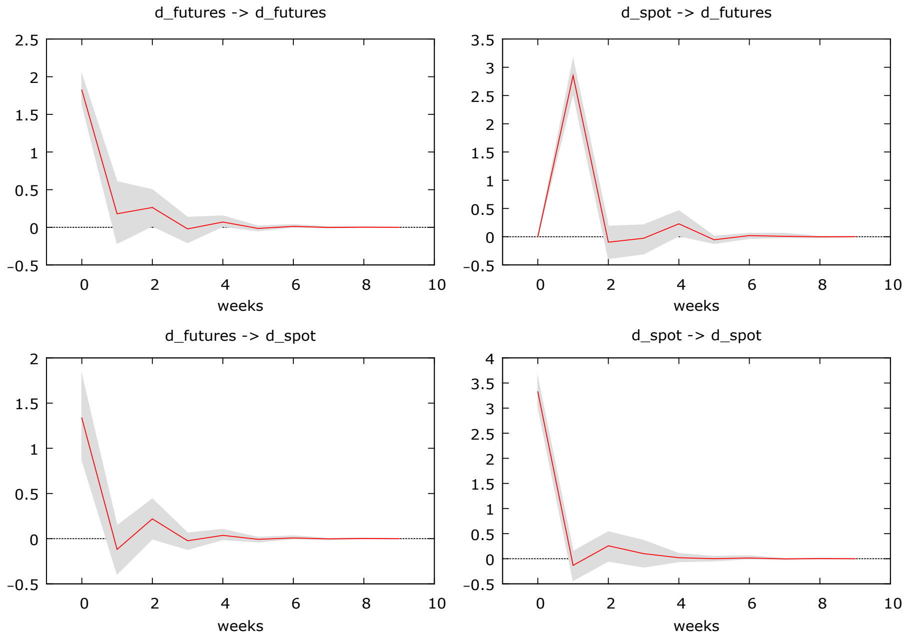


Figure 14.
Impulse-responses for futures vs spot (Interval: 03rd Jun 2003–19th Oct 2010)

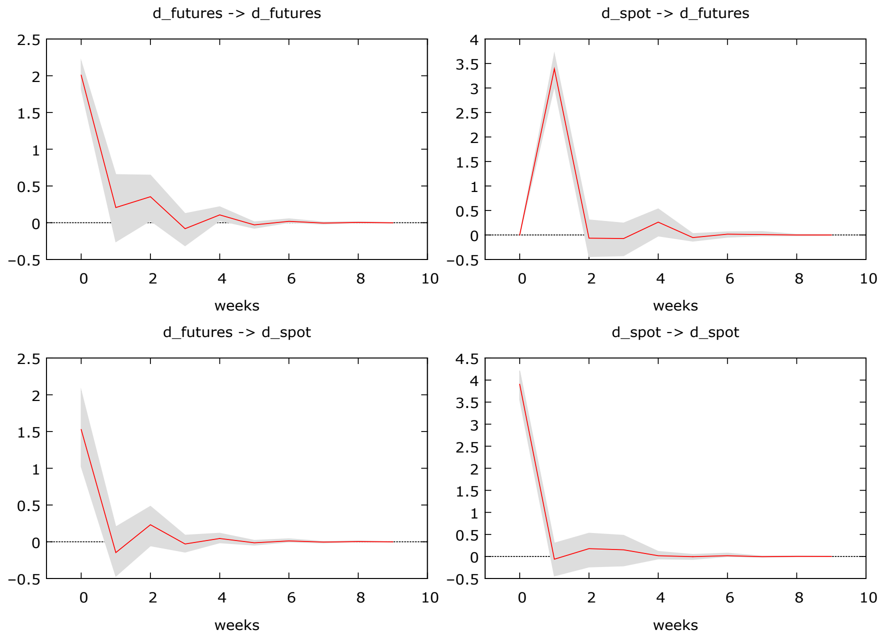


Figure 15.
Impulse-responses for futures vs spot (Interval: 06th Mar 2007–14th May 2013)

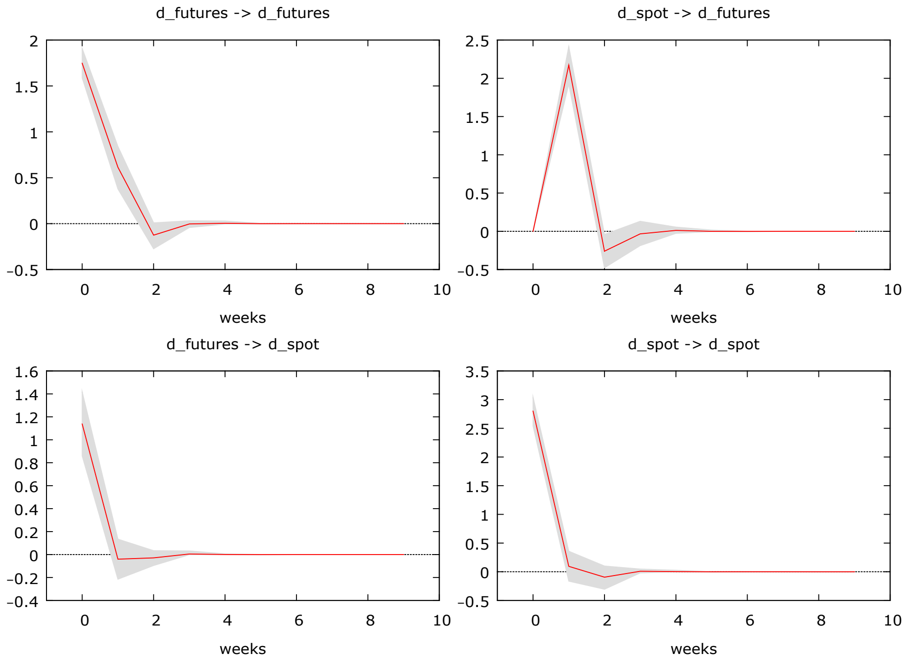


Figure 16.
Impulse-responses for futures vs spot (Interval: 19th Oct 2010–30th May 2017)

contrary, in all the sub-intervals considered the most plausible evidence is precisely the opposite one. So the TA activity is affected by future quotations and not the other way around. Essentially, the same findings are inferred for the hypothesized "futures drive spot quotations" relationship. Thus, also in these cases, there are no meaningful outcomes fostering the theoretical hypothesis of a financial spillover effect originated from shocks on futures toward spot quotations (and this holds in all the intervals). As aforementioned, interestingly and differently from the conventional opinion, just in two intervals (03rd Jun 2003–19th Oct 2010 and 06th Mar 2007–14th May 2013 depicted in Figures 8 and 9), we can appreciate a very weak effect that seems to support the idea of the influence of non-commercial trading activity on futures. Nevertheless, the opposite holds in the futures vs spot relationship. Dynamic behaviors suggest that both non-commercial trading and spot prices affected futures in these two specific cases. Since such intervals include the 2008 oil peak, generally taken as the paradigm of the Masters' hypothesis, they do deserve deeper attention. Hence, we proceed in investigating an additional interaction between non-commercial trading and spot. The essential statistics of the respective VAR models are resumed in Table 9. Reciprocal impulse-responses graphs are graphed in subsequent Figures 17 and 18.

Both additional diagrams confirm that spot quotes influence trading activity and not vice versa. Thus, a totally reverse relationship from the conventional narrative is suggested as the more plausible also for these intervals. These outcomes which seem not in line with the expectations formulated by the Masters' hypothesis are, on the other hand, perfectly consistent. Consequently, the VAR analysis shows a prevailing influence exerted by spot prices on trading activity, and not the way around. In general terms, it can be argued that these results are hardly consistent with the general public's perception that it is the increased participation of speculative investors that plays an important (or decisive) role in influencing the price mechanism in physical markets. Results suggest that the financial activity (or in pejorative terms the "speculation") has been influenced by spot prices. At this point, findings are more compatible with the strand of empirical literature advocating traditional economic mechanism (demand-supply imbalances) as the main driving force shaping crude oil price paths (among others Baumeister and Kilian, 2016; Killian and Lee, 2014; Kilian and Murphy, 2014; Irwin and Sanders, 2012). A spillover effect having a strictly financial origin on spot prices is not detectable from analysis of the dynamic relationship and behavior of the variables directly involved. As shown, neither TA nor futures affected spot oil prices. These outcomes are confirmed also in the period of the 2008 oil price peak through additional analysis of the behavior of the relationship between TA and spot prices. Our results do not confirm that "speculation" exerted a major influence during that period. They deviate from, among others, the theoretical modelization by Basak and Pavlova (2016) and the conclusions by Singleton (2014) and Tang and Xiong (2012). In fact, as pointed out in Section 2, it is generally argued that the impact of the financial mechanism on the physical market is to derive from the increase in trading activity on behalf of non-commercial players (called precisely "speculators"). Their activity is considered by "the Masters' hypothesis" as the main driver distorting the market.

Table 9. VAR (p) non-commercial trading activity (TA) and spot prices

Non-commercial activity vs spot prices (TA vs spot)	Lag order	Log L_τ	BIC
Interval (03rd June 2003–19th October 2010)	1	−5296.06	27.68
Interval (06th March 2007–14th May 2013)	1	−4521.06	28.19

Note(s): p = lag order informed by *BIC* criterion; heteroskedasticity-robust standard errors L_T = likelihood function
Source(s): Personal elaborations on Datastream (2021)

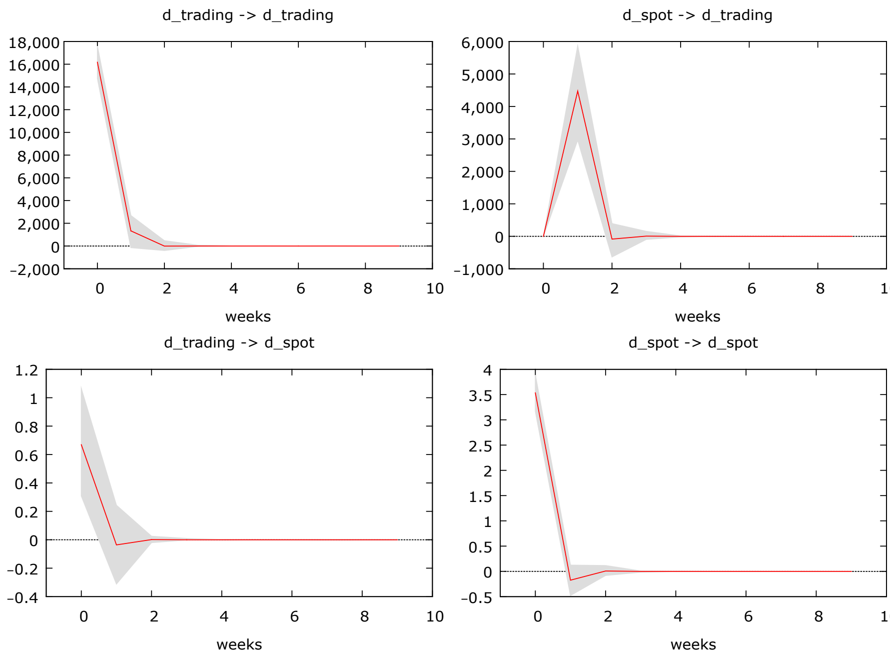


Figure 17. Impulse-responses for TA vs spot (Interval: 03rd Jun 2003–19th Oct 2010)

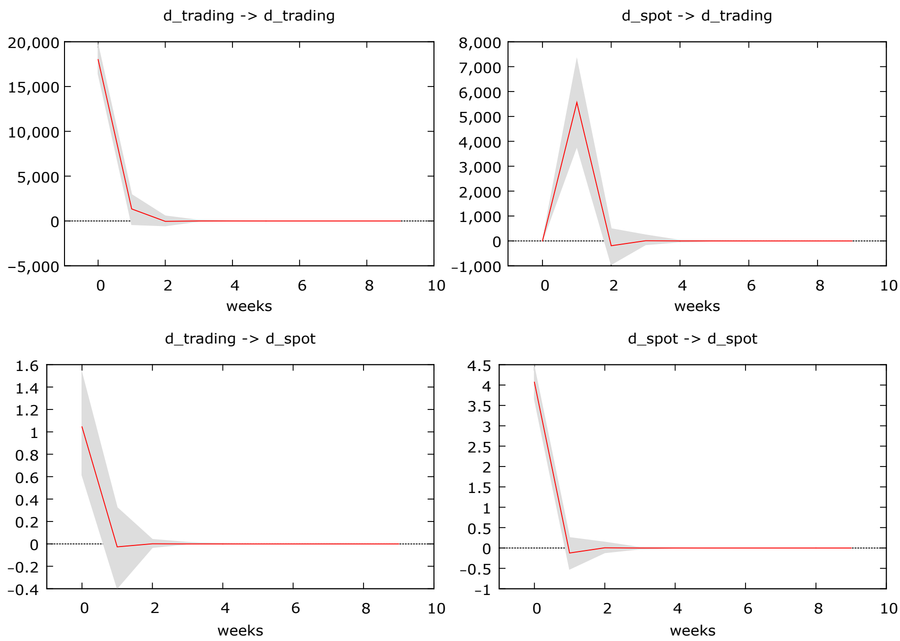


Figure 18.
Impulse-responses for TA vs spot (Interval: 06th Mar 2007–14th May 2013)

Without any claim to exhaustiveness, our work adds to the literature for its further and novel contribution related to a dynamic aspect that has never been explicitly considered until now under three different perspectives.

First and differently from the contributions exploring price volatility issues (Kim, 2015; Bohl and Stephan, 2013; Bohl *et al.*, 2013; Miffre and Brooks, 2013) and co-movements between oil prices and other commodities (Jovenal and Petrella, 2015), the present work involves also the direct futures-spot relationship. The current exploration includes also a specific analysis of the non-commercial trading activity related to the spot oil prices in the 2008 peak oil phase.

Second, in order to contribute to the available empirical literature investigating the mechanism of influence and potential spillover effects of futures on spot prices (Irwin and Sanders, 2011, 2012; Tang and Xiong, 2012; Hache and Lantz, 2013; Focacci, 2019, 2021), we add the multibreakpoint technique based on the Bai and Perron test that can detect the different sub-intervals where significant statistical changes in the activities of non-commercial traders have occurred. The main purpose of this part is to contextualize and identify as objectively as possible the phases in which this increase in activity occurred, in order to empirically test its potential effect on spot prices. Such identification is based on a robust statistical methodology. This is the very first application in such a context. Alternative explanations for identifying different phases of increased activity could be considered purely instrumental.

Third, to broaden Singleton (2014) and Brunetti's *et al.* (2016) analysis, we analyze a sample that includes both the period before and the period after the entry into force of the CFMA. This consideration applies also to those papers that we found consistent with our results and, in any case, include a much shorter time span (among the others, Irwin and Sanders, 2011). Such a choice is certainly supportive in comparing different regulatory frameworks.

The main (and logical) implications drawn are that economic factors drive price movements and are highly relevant for policymakers. Additionally, another implication to consider is the transmission mechanism linking physical and financial prices. More specifically, the idea is that if "speculation" does not affect spot prices (at least not in a major way), the exact opposite might be true. This has meaningful consequences for commercial traders (specialists) trying to hedge against excessive price oscillations that can damage their activities.

Limitations of the present research can be explicated as defined within the introductory section wherein attention has been paid to the empirical bound of each econometric analysis. In fact, the validity may be considered as finalized to the specific time span included in the data set. However, to limit the scope of any criticism, we included a large sample of data (1995–2017). Moreover, we selected this period to investigate and detect plausible traces of the effects of this alleged financial influence on spot prices covering the "boom" phase of oil prices as supporters of the Masters' hypothesis claim. This should allow for a better appreciation of the differences, if any, between the pre- and the post-financialization phase.

5. Conclusions

This paper aims to provide an empirical investigation of the plausible existence of a systematic effect in the distortion of oil spot prices resulting from the participation of institutional investors in the corresponding futures markets. Although this topic is not new to the field, the novelty in the approach lies in the technique adopted to capture the intrinsic behavior of non-commercials. Several literature contributions after the "so-called Masters' hypothesis" maintain that financial activity ignited by new institutional investors' portfolio management strategies exert a prominent role in distorting physical prices. Since institutional investors (speculators) are evoked as the main actors in this mechanism, we apply a multiple breakpoint statistical procedure to determine time intervals that can detect statistically significant changes in the net trading positions. The subsequent and meaningful structural shifts of statistical properties are assumed as proxies of their dynamic financial strategies. Thus, an endogenously "data-driven" approach is followed to explore interactions among relevant variables. At this point, a VAR analysis is proposed with the correspondent impulse-responses in appropriately derived time intervals. The results suggest that merely financial forces cannot be considered so influential and thus hardly they can be identified as significant systematic drivers of the whole process. Our findings do not support the plausibility of spillover effects from futures to crude oil spot prices. This holds along the whole time period object of investigation. In contrast, we found that it is generally spot prices that have the greatest impact on driving trading activity and not the other way around.

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.

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.

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.

Balke, N.S. and Fomby, T.B. (1997), "Threshold cointegration", *International Economic Review*, Vol. 38 No. 3, pp. 627-645.

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.

Baumeister, C. and Kilian, L. (2016), "Forty years of oil price fluctuations: why the price of oil may still surprise us", *Journal of Economic Perspectives*, Vol. 30 No. 1, pp. 139-160.

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.

Boyd, N.E., Harris, J.H. and Li, B. (2018), "An update on speculation and financialization in commodity markets", *Journal of Commodity Markets*, Vol. 10, pp. 91-104.

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.

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.

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

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

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.

Datastream (2021), (accessed June 2021).

Degiannakis, S., Filis, G. and Panagiotakopoulou, S. (2018), "Oil price shocks and uncertainty: how stable is their relationship over time?", *Economic Modelling*, Vol. 72, pp. 42-53.

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.

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

Driesprong, G., Jacobsen, B. and Maat, B. (2008), "Striking oil: another puzzle?", *Journal of Financial Economics*, Vol. 89 No. 2, pp. 307-327.

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.

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

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.

Focacci, A. (2019), "Financialisation of the crude oil market: do non commercial traders influence spot prices?", *International Journal of Revenue Management*, Vol. 11 Nos 1-2, pp. 54-75.

Focacci, A. (2021), "Have institutional investors stocks portfolio strategies affected oil prices in a financialization context?", *Studies in Economics and Finance*, Vol. 38 No. 5, pp. 1007-1039.

Gao, L., Hitzermann, S., Shaliastovic, I. and Xu, L. (2022), "Oil volatility risk", *Journal of Financial Economics*, Vol. 144 No. 2, pp. 456-491.

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.

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.

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

Hansen, B.E. and Seo, B. (2002), "Testing for two-regime threshold cointegration in vector error-correction models", *Journal of Econometrics*, Vol. 110 No. 2, pp. 293-318.

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.

Hirshleifer, D. (1988), "Residual risk, trading costs and commodity futures risk premia", *Review of Financial Studies*, Vol. 1 No. 2, pp. 173-193.

International Monetary Fund (2016), "The boom in nonfuel commodity prices: can it last?", *World Economic Outlook*, International Monetary Fund, Washington, pp. 139-169.

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.

Jin, X. (2019), "The role of market expectations in commodity price dynamics: evidence from oil data", *Journal of International Money and Finance*, Vol. 90, pp. 1-18.

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

Johansen, S. and Juselius, K. (1990), "Maximum likelihood estimation and inference on cointegration with application to demand for money", *Oxford Bulletin of Economics and Statistics*, Vol. 52 No. 2, pp. 169-210.

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.

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, Macmillan, London, pp. 255-266.

Keynes, J.M. (1930), *A Treatise on Money*, Vol. 2, 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 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.

Killian, 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.

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

Kisswani, K.M. (2016), "Does OPEC act as a cartel? Empirical investigation of coordination behavior", *Energy Policy*, Vol. 97, pp. 171-180.

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.

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.

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.

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.

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.

McGuire, A. (2015), "25 important events in crude oil price history since 1862", available at: http://wallstreetexaminer.com (accessed 22 July 2015).

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

Neves, E., Oliveira, V., Leite, J. and Henriques, C. (2021), "The global business cycle and speculative demand for crude oil", *China Finance Review International*, Vol. 11 No. 4, pp. 502-521.

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.

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

Quandl (2021), (accessed June 2021).

Schofield, N.C. (2007), *Commodity Derivatives-Markets and Applications*, John Wiley & Sons, Chichester.

Schwartz, T.V. and Szakmary, A.C. (1994), "Price discovery in petroleum markets: arbitrage, cointegration, 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.

Scott, M., Scott, H.I., Sanders, D.R. and Smith, A. (2018), "Financialization and the returns to commodity investments", *Journal of Commodity Markets*, Vol. 10, pp. 22-28.

Singleton, K. (2014), "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.

Tan, X. and Ma, X. (2017), "The impact of macroeconomic uncertainty on international commodity prices: empirical analysis based on TVAR model", *China Finance Review International*, Vol. 7 No. 2, pp. 163-184.

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

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.

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