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Article

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The Lead Lag Relationship Between Spot and Futures Markets in the Energy Sector

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ABSTRACT

This paper investigates the lead-lag relationship between spot and futures markets of the most representative energy sources under three different scenarios using the vector error correction model. Additionally, a ratio of speed of adjustment was built in order to establish the market contribution of both spot and futures markets on price innovation. The empirical findings indicate an important leadership and contribution of futures market in relation to price discovery regardless of oil shocks, business cycle and transaction costs. Nevertheless, an improvement in spot markets' contribution to price discovery is observed during recession periods rather than expansion periods.

Keywords: Future Price, Spot Price, Price Discovery, Lead Lag Relationship, Energy
JEL Classification: G13

1. INTRODUCTION

Many researchers have supported the thesis of futures being the primary locus of price innovation and leading spot market to equilibrium (Bowe and Domuta, 2001; Ng and Pirrong, 1996; Tse et al., 2006; Tse and Xiang, 2005); while other empirical works have advocated opposite results (Chiou-Wei et al., 2013) or bidirectional feedback between both markets (Bekiros and Diks, 2008; Kaufmann and Ullman, 2009).

Extensive literature has been dedicated to analyzing the long-run relationship among futures and spot prices in various markets (Chan, 1992; Chu et al., 1999; Ivanov et al., 2013; Min and Najand, 1999; Tse et al., 2006). In the energy sector, causality among futures and spot markets has been also widely documented by several researchers due to the great volatility inherent in them and its significant importance for the global economy. Results on empirical studies have reported either unidirectional leadership (Ng and Pirrong, 1996; Schwarz and Szakmary, 1994) or a bidirectional influence of spot and futures markets on price discovery (Bekiros and Diks, 2008; Hammoudeh et al., 2003).

However, there is no study provides a comparison of the leadership of price discovery between spot and futures markets in the energy sector under different structural breaks, including oil crises and the business cycle. Moreover, although abundant studies exist looking at the different factors during the business cycle and the impact that those features on commodity prices (Fama and French, 1988; Gorton and Rouwenhorst, 2006; Hess et al., 2008; Pindyck, 2001), none of them addressed the lead-lag relationship between spot and futures markets over the business cycle. Previous studies also examined whether causality can be found in energy sources after transaction costs (Fleming et al., 1996; Frino and West, 2003; Kim et al., 1999), but their primary focus on causality relies on different indexes and not on energy sources.

In accordance with the background and motivation presented, the current study aims to focus on addressing the following key objectives: (1) To examine the dynamic between futures and spot markets in four energy sectors, (2) to investigate the lead-lag relationship between spot and futures markets during oil crises versus non-crises periods and to determine which of them contributes the most toward price discovery within each sample, (3) to examine causality or the lead-lag relationship between spot and futures markets over the business cycle (recession versus expansion periods) and to define which market is the primary source of price discovery over both periods, and (4) to investigate the lead-lag relationship between spot and futures markets under different levels of transaction costs.

2. LITERATURE REVIEW

2.1. Previous Studies on Lead-lag Relationship

Using different methodologies, scholars have reported different results in analyzing the long-run relationship among futures and spot prices in various markets.

Studies of Chan (1992) and Chu et al. (1999) measured causality on the US market by using the S and P 500 index as a proxy. Chan sampled the major market index (MMI) cash market and S and P 500 index futures from 1984 to 1987 to identify futures market as the dominant market despite the type of news, information and trading activity. Chu et al. modeled spot and futures indexes of the S and P 500 and SPDRs and they found that futures indexes influence spot and SPDRs on price adjustment and not vice versa. Tse et al. (2006) investigated to what extent the inclusion of derivative instruments on the DJIA index influence the index in terms of price innovation. By using intraday trades and quotes of the exchange trade fund (ETF), E-mini futures and regular futures, these scholars found that each instrument independently contributes on a large or small scale to price discovery, jointly leading DJIA to adjust on price.

On the other hand, opposing results were indicated by Ivanov et al. (2013), who also analyzed the ETF, futures and spot markets of different indexes in the United States from 2002 to 2011. Their findings suggested that spot rather than futures markets lead on price innovation. They stressed that a shift in dominance lies on the underlying linkage between ETF and spot market and also the arbitrage mechanism. Differences in the results reported by Tse et al. (2006) and Ivanov et al. (2013) might be due to the time period taken into consideration; however, these results might also suggest a time-varying dominance on price discovery between markets.

In the energy sector, empirical studies have reported causality among futures and spot markets could be either unidirectional or a bidirectional leadership on price discovery.

Supporters of the thesis of unidirectional influence include study by Schwarz and Szakmary (1994) that analyzed the long-run relationship between spot and futures prices in the crude oil, heating oil and gasoline sector from 1985 to 1991. Their results pointed out that a growing participation in futures have caused this market to become dominant in price discovery for all three products. This results were later confirmed by Ng and Pirrong (1996), who also investigated the price dynamic of two major refined energy commodities, heating oil and gasoline, from 1984 to 1990. They highlighted futures and spot markets as the bull and bear markets on prices respectively; in those cases where spot markets lead futures markets, the latter adjust faster to equilibrium.

In the natural gas sector, Tse and Xiang (2005) found that introduction of e-mini futures in 2002 in the sector enhanced the role of futures markets on price discovery, leading spot markets to equilibrium. Opposite findings were presented by Chiou-Wei et al. (2013), who stated that cash markets rather than derivate markets are dominant in price discovery. According to these scholars, shortage or surplus on the supply side would lead market participants to forecast future prices of the commodity.

Another stream of studies has found both markets to give essential information in the forecasting of future prices. In a daily basis analysis of the west Texas intermediate (WTI) of spot prices and future contracts under different maturities, Bekiros and Diks (2008) addressed a strong bidirectional causality on contracts with longer positions; only on those contracts whose maturity is less than a year was unidirectional causality found to running from future to spot prices.

Hammoudeh et al. (2003) tested for causality on three major energy commodities traded inside and outside the U.S. from 1986 to 2001. Their results identified a bi-directional causality in the heating oil and gasoline markets; in the case of crude oil, the futures market leads on price innovation. Beyond U.S boundaries, none of the above markets seem to lead, but rather influence each other (Bopp and Lady, 1991). A more recent study of Kaufmann and Ullman (2009) outlined a lead-lag relationship in the crude oil sector in international markets and show that both futures and spot markets contribute in the process of price innovation in the oil sector, as well as that market participants work together rather than independently in the formation of prices.

2.2. Lead-lag Relationship Analysis Framework

2.2.1. Oil crises versus non-oil crisis

Market conditions and political features of different countries along with the Organization of Petroleum Exporting Countries (OPEC) and non-OPEC organizations' strategies have exposed energy markets as the setting of different structural breaks. Under this context, and acknowledging that causality between futures and spot markets is highly influenced by market conditions and participants' behavior, a time-varying dominance in the role of price discovery could exist.

An earlier example is Foster (1996), who analyzed the WTI and Brent during the Gulf conflict in 1991, with findings that suggested a clear shift of dominance in price discovery prior to and after the conflict. Prior to the event, futures led spot markets to make adjustments in order to reach equilibrium; however, this dominance declined during and after the conflict, allowing spot markets to contribute to price innovation.

These results were confirmed by Silvério and Szklo (2012) who sampled the WTI from the 2001 to 2008 period, in which oil prices showed drastic movements in the market. Similar to Foster (1996), these scholars found that when uncertainty prevailed, contributions to price innovation are made by both spot and futures markets, in contrast to more stable periods in which futures lead.

Some scholars have pointed out that investors' behavior has a lot to do with explaining the existing dynamic between spot and futures markets before and after an oil crisis. In this vein, studies have argued that herding behavior and sentiment have an effect on prices during periods of high uncertainty. Theoretically, Nofsinger and Sias (1999) defined herding groups as those investors who omit their own information and trade in the same direction as others do. According to Gębka and Wohar (2013), traders in the oil market are more prone than those in other industries to display this type of behavior, especially under periods of stress, due to the implications of a shortage in the stream to the economic activity. Zouaoui et al.

(2011) further pointed out that in times of crisis, markets exhibiting both sentiment and high herding behavior are more liable to cause and experienced one. This is because investors not only ignore their private information but also base their decisions on mere assumptions rather than on reliable information, pushing prices far from their real value.

More recent studies by Büyükşahin and Harris (2011) and Kilian and Murphy (2013) investigated traders' behavior during two different oil shocks and found that awareness of political issues and anticipation of new participants on the market caused investors to overreact and increase their participation on the market in an attempt to secure the supply of the commodity, putting pressure on prices and leading them to collapse at a certain point. Such behavior was seen in the 2000's oil crisis where higher participation of speculative demand and noise traders led oil prices to burst at the end of 2008, dropping the price per barrel to 40 USD.

H_1: Bidirectional causality exists between futures and spot markets during oil crises, whereas in non-crisis periods futures lead spot markets to equilibrium, becoming the major source of price discovery.

2.2.2. Business cycle

Over time, economies have experienced different states, referred to as expansion and recession periods; this is also known as the business cycle. The National Bureau of Economic Research defines a recession as a slowdown in economic activity lasting more than a few months and visible in gross domestic product (GDP), production and employment rates. On the other hand, Hodrick and Prescott (1997) describe expansion periods as those in which growth is seen in outputs, production, investment, employment and consumption.

Empirical researchers have outlined the impact of cyclical movements of economies and monetary policies on the participation and fluctuation in commodity prices; such is the case of crude oil. According to Brown and Yücel (2002), eight out of nine recessions included a rise in oil prices, affecting those sectors using energy as a primary input in their production process; this scarcity of energy is eventually reflected in a decline in GDP and a boost in unemployment rates. Adoption of different monetary policies by policy makers across the business cycle has been held to be partially responsible for the drastic movements of prices between markets. While easy monetary policies in downturn periods incentivize investors to store higher levels of inventories at lower costs, a reallocation of their portfolios is observed once the economy shows signs of recovery and equilibrium is reached (Frankel, 2013; Hess et al., 2008).

Among the principal triggers for such dynamic among markets across different stages of the economy are interest rates and their impact on storable commodities and their prices. On the one hand, low interest rates in contraction periods would result in higher inventories, since the costs for holding the good is low; on the other hand, a reduction in inventory would result in a rise in interest rates, and traders would prefer to offer the goods on the market rather than keep them in storage at higher costs (Pindyck, 2001). In this vein, Hess et al. (2008) and Frankel (2013) argued that higher interest rates have an impact on commodity prices and traders' participation. Both researchers concluded that prices of and participation in commodities decline in periods of higher interest rates, since surges in storage costs would reduce the inventory demand and consequently would incentive investors to reallocate their portfolio from commodities to other markets like bonds.

In their research on the London metal exchange from 1972 to 1983, Fama and French (1988) found that both futures and spot prices experienced drastic movement in those periods with higher inventories than in those with lower inventories, in which variations in futures prices are less pronounced than those in spot prices. Hoffmann et al. (2013) further outlined that participation of individual investors over recession periods contributes to the fluctuation on prices between markets. These scholars concluded that while in downturn periods institutional investors become more conservative, for individual investors those market conditions represent a good opportunity to enter to the market. Hence, in contraction periods, due to the high volatility of prices and the entrance of participants into the market, we can expect to see both futures and spot markets equally making adjustments in their prices, and no leadership in price discovery can be attributed to either of them. In expansion periods, however, since price fluctuation decreases, it becomes more likely that one of them will lead the other to reach equilibrium. In this case, it is expected that futures markets lead spot markets to make adjustments on prices and not vice versa.

Inflation over the business cycle also influences participation of investors in commodities and their prices. In this regard, Gorton and Rouwenhorst (2006) suggested a positive relation between inflation and commodities prices. These scholars stressed that unlike stocks and bonds, commodities (especially futures prices) are directly correlated to inflation and move according to it, giving them a unique advantage over other markets as a hedge tool against unexpected variability in purchasing power. Therefore, higher allocation on commodity portfolios would be observed as inflation increases, elevating the demand of the good and eventually leading to a rise in prices. Hess et al. (2008) addressed the behavior of two commodity indices over the business cycles in the US from 1985 to 2005; in line with Gorton and Rouwenhorst, they stressed that movements in commodity prices are indeed positively correlated to inflation but also to the news indicating the state of recovery of the economy.

H_2: In recession periods, bidirectional causality exists between futures and spot markets, while in expansion periods, unidirectional causality from futures to spot markets exists.

2.2.3. Transaction costs

Scholars have outlined that differences in transaction costs between spot and futures markets can lead one of them to be the major locus of price discovery. Fleming et al. (1996) stressed that markets displaying lower costs react more quickly to information than do those with higher transaction costs, thereby becoming the major source of price innovation. In this regard, due to its liquidity and market-wide information, futures rather than spot markets are likely to provide investors with lower trading costs. Nevertheless, as Li (2010) pointed out, traders on this market would only participate if the amount resulting from the difference between them and spot prices (basis) is enough to cover all the associated trading cost and still a profit refers as risk premium can be made.

In a study of the S and P 500 futures and S and P 100 option with their respective in the stock market, Fleming et al. (1996) concluded that because investors are eager to pursue higher returns at lower costs, trading activities were more concentrated on futures and option markets than on in the cash markets. Therefore, derivatives, unlike spot markets, lead in price innovation, since information is first traded on markets offering investors the opportunity to trade at a lower cost. They further highlighted brokers' commissions, bid/ask spread and price concession as the major factors influencing the magnitude of trading costs.

Kim et al. (1999), using intraday data from January 1986 to July 1991 of futures and cash indexes, found that differences in trading costs on markets are the major trigger in determining the leadership in price discovery. They argued that if the trading cost hypothesis presented by Fleming et al. (1996) is valid, leadership in price innovation could be documented not only between futures and spot markets but across them as well. In this sense, these scholars sampled different indexes with same microstructure, including the S and P 500, NYSE composite and MMI futures and their respective cash indexes. Their findings suggested that, among futures indexes, the S and P 500 is the leader in price discovery, since a lower bid/ask spread on these indexes is a reflection of their lower trading costs. Moreover, across cash indexes, MMI is said to have the largest capitalization in comparison with the other three indexes, and hence lower transaction costs are associated with it, meaning that MMI leads the other cash indexes to price equilibrium and not vice versa.

In a later study, Frino and West (2003) outlined that regimes on brokers' commissions and margin requirements on different exchanges trading futures contracts based on the same fundamental also influence informed traders to display their private information in one market over the other. In this vein, by sampling the Nikkei 225 futures traded on the Osaka security exchange (OSE) and on the Singapore international monetary exchange (SIMEX), these scholars found higher participation of investors in the SIMEX Nikkei futures than in the OSE Nikkei futures, since trading costs in the former were lower than in the latter. Indeed, while in Japan brokers' commissions are fixed and margins requirements are significantly higher, in Singapore both commissions and margin requirements are negotiable and much lower. Therefore, even though both SIMEX and OSE futures lead the Nikkei cash market, when comparing the feedback between both futures exchanges, SIMEX impounds information more quickly than OSE futures, leading it to become the primary source of price discovery.

H_3: Transactions costs are higher in spot than in futures markets.

3. DATA AND METHODOLOGY

3.1. Data

The daily data is taken from the New York Mercantile Exchange in the periods of 1979-2013: Crude oil (from 1986), heating oil (from 1979), natural gas (from 1993) and gasoline (from 2005). Events such as the Iranian Revolution from 1979 to 1980, the Gulf War from 1990 to 1991 and the third oil crisis in the early 2000s are modeled as the most recent oil crises since 1979. In terms of business cycle incidents, the crisis from the 1980s, the dotcom bubble in 2001 and the subprime mortgages crisis of 2008 are used. To conduct the last scenario on transaction costs, the entire sample for each energy sector is modeled and different quantiles of the EC term are used as a representation of transaction cost levels.

3.2. Methodology

In order to study time series data, it is necessary to test for stationarity. To address this feature, a unit root test using natural logarithms of the variables is conducted; the most common test is the Augmented Dickey-Fuller (ADF), in which a null hypothesis for non-stationary variables is contrasted by an alternative hypothesis of stationarity; both hypotheses would be tested at levels and on first difference. In order to continue the process for causality, the data set must be non-stationary at levels and stationary after first difference; otherwise the series cannot be model. Lags on the test are selected using the Akaike information criteria (AIC).

$$\Delta P_f = \mu + \beta P_{t-1} + \varepsilon_t$$

If two or more individual series have unit root meaning, they are non-stationary; they become stationary after being linearly combined, in which case the non-stationary variables are said to be cointegrated (Hammoudeh et al., 2003). In other words, they share a common trend, and they will converge toward equilibrium in the long horizon (Li, 2009). In order to test for cointegration between variables, the study employs the Johansen test.

If the variables under consideration are found to have one or more cointegration vectors, vector error correction model (VECM) could be applied to test for causality between them. Following Ammer and Cai (2011), a VECM model is implemented to evaluate causality between spot and futures markets in each energy sector. Coefficients of the VECM are also used to determine each market's contribution toward price innovation:

$$\Delta P_{f,t} = \lambda_1 \left(P_{s,t-1} - \alpha - \beta P_{f,t-1}\right) + \sum_{j=1}^{k} y_{1j}.\Delta P_{s,t-j} + \sum_{j=1}^{k} \delta_{1j} \Delta P_{s,t-j} + \varepsilon_{1t} \quad (1)$$

$$\Delta P_{s,t} = \lambda_1 \left(P_{s,t-1} - \alpha - \beta P_{f,t-1}\right) + \sum_{j=1}^{k} y_{2j}.\Delta P_{s,t-j} + \sum_{j=1}^{k} \delta_{2j} \Delta P_{s,t-j} + \varepsilon_{2t} \quad (2)$$

Where $\Delta P_{f,t}$ and $\Delta P_{s,t}$ are the changes in futures and spot prices at time t.

$\lambda(P_{s,t-1}-\alpha-\beta P_{s,t-1})$ represents the error correction (EC) term. This term indicates the long-run relationship between futures and spot prices and serves as a measure of the deviation from the equilibrium between $\Delta P_{f,t}$ and $\Delta P_{s,t}$. When the EC term <0, then $P_{f,t}$ should decrease and $P_{s,t}$ should increase to return to the price equilibrium in the long-run; vice versa. The signs of the $\Delta P_{f,t}$ and

$\Delta P_{s,t}$ are expected to be positive and negative respectively. The rest of the equation controls for lags and additional dynamics in $\Delta P_{f,t}$ and $\Delta P_{s,t}$.

4. RESEARCH RESULTS

4.1. Data and Preliminary Comparative Analysis

Table 1 displays a descriptive statistic of spot and futures markets for all energy sources. The returns for each energy source are close to 0, and the standard deviation is close to 1. In addition, the skewness coefficients are showed to be negative for crude oil and heating oil and positive for natural gas and gasoline. The kurtosis coefficients in all cases significantly exceed the value of 3, suggesting that the distribution has leptokurtosis. This term also refers to the measure of the fatness of the tail of a distribution.

Table 2 provides the unit root and cointegration tests of futures and spot markets for all the energy sources. The empirical findings reveal that at levels both series (futures and spot prices) are non-stationary in all cases, showing the presence of unit root. Nevertheless, the data show to be stationary after first difference, rejecting the null hypothesis of unit root for all energy sources. The cointegration test indicates that both variables have at least one cointegration equation; therefore, both markets are correlated in the long run.

4.2. Price Adjustments and Price Leadership Analysis

Table 3 indicates the parameters of the VECM for the whole sample on each energy source. In all cases, estimates of the EC term are negative and significant in the spot equation, suggesting that when disequilibrium arises among markets, the spot market adjusts to restore the equilibrium in the long run. These findings reinforce those of previous studies (Bowe and Domuta, 2001; Ng and Pirrong, 1996; Tse et al., 2006; Tse and Xiang, 2005). Estimates of the EC term for the futures equation are insignificant which indicates that spot prices do not influence future prices during the adjustment process in the long run. Following Ammer and Cai (2011), the present study builds a measure ($\lambda_2/[\lambda_2-\lambda_1]$), defined as the ratio of speed of adjustment, which estimates the contribution of each market provides to price discovery. The ratio has a lower bound of 0 and upper bound of 1; a value closer to 1 implies that futures have a greater relative contribution to price discovery than spot markets have. When the value is closer to ½, both markets contribute to price innovation and there is no clear evidence on which market leads the other. Results in Table 3 indicate an individual and an average ratio closer to 1 for all energy sources, implying that the futures market contributes more toward price innovation than the spot market does.

4.2.1. Oil crises versus non-oil crises

Table 4 displays the corresponding estimates of the VECM for oil crisis versus non-oil crisis periods. EC terms on futures markets (λ_1) over the crisis period are shown to be insignificant, while EC terms on spot markets (λ_2) are found to be significant at the 1% level. These results suggest that unidirectional causality running from futures to spot markets is found to exist, and the futures market causes spot prices to adjust in the long run and not vice versa. During crisis and non-crisis periods, the contribution of futures markets is more significant toward price discovery than the contribution of spot markets with individual ratios higher than 1. The contribution of futures is less pronounced in oil crisis periods than in non-crisis periods for three out of four energy sources.

Finally, with a minimum variation on the average ratio in crisis (86%) and non-crisis (85%) periods, suggesting that price innovation is carried out first by futures regardless of the scenario. Thus, futures are found to be the dominant market, while the spot market is the one receiving the information to make the respective adjustments on prices. These findings are in line with Foster (1996) and Silvério and Szklo (2012), specifically during the non-crisis period, where these scholars found that the futures market leads the spot market more than it lags it. Differences between the

Table 1: Summary statistics of return rates of futures and spot prices

Statistics	Crude oil		Heating oil		Natural gas		Gasoline	
	Future	Spot	Future	Spot	Future	Spot	Future	Spot
Mean	0.0479	0.0493	0.0388	0.0425	0.0743	0.1514	0.0540	0.0662
Maximum	0.1783	0.2121	0.1502	0.2645	0.3831	1.4000	0.1655	0.2366
Minimum	−0.3300	−0.3343	−0.3236	−0.3158	−0.3132	−0.7200	−0.1262	−0.1630
SD	0.0034	0.0037	0.0023	0.0031	0.0166	0.0933	0.0032	0.0057
Skewness	−0.3123	−0.2211	−0.8600	−0.0830	0.6164	6.6721	0.0457	0.4319
Kurtosis	13.315	13.8996	16.2364	16.7986	12.1850	162.1213	7.2233	10.1501

The sample taken by this study for each sector is as follows: For heating oil, the start date is September 1979; for crude oil, January 1986; for natural gas, November 1993; and for gasoline, October 2005. The end date for all of the above is December 31, 2013. The number of daily observations from each sector are as follows: 8,939 for heating oil, 7,304 for crude oil, 5,262 for natural gas and 2,138 for gasoline. SD: Standard deviation

Table 2: Unit root and cointegration test of futures and spot prices

Tests	Crude oil		Heating oil		Natural gas		Gasoline	
	Future	Spot	Future	Spot	Future	Spot	Future	Spot
Log levels	0.4749	0.3991	−1.1870	−1.3382	−0.6124	−0.8369	−0.2008	−0.3293
% returns	−64.0216***	−87.0378***	−96.0362***	−94.2536***	−45.2192***	−66.2842***	−46.3725***	−35.4751***
EC term	−10.9328***		−10.2289***		−14.7532***		−7.6629***	

This study uses seven-order lag lengths in the ADF test for crude oil and natural gas, six-order lags for heating oil and eight-order lags for gasoline. The selections of the lags are defined according to the AIC criteria. ***Denotes the significance at 1% level. The current results indicate that both futures and spot prices are non-stationary at levels and stationary after first difference. Additionally, the cointegration test suggests that the EC term for futures and spot markets in all cases is stationary. Therefore, both series are said to be co-integrated current findings during oil crisis periods and those reported by these scholars might be due to the data and methodology used.

4.2.2. Recession versus expansion

Table 5 displays the corresponding estimates of the VECM over the business cycle. In terms of causality, estimates of the EC term over recession periods on futures markets (λ_1) are insignificant in all energy sources except natural gas. Spot market estimates (λ_2) are shown to be significant except heating oil. Evidence from this period suggests that the leadership of the futures market over the spot market in price adjustment is weaker and in the cases of heating oil and natural gas, non-causality and bidirectional causality are found to exist, respectively. Opposite results in expansion periods showed in this table also suggest that in the long run, futures lead spot markets to adjust prices to restore equilibrium. Therefore, strong evidence of unidirectional causality from futures to spot markets is found, and not vice versa.

In terms of price contribution, the futures market is shown to have greater influence than the spot market on price discovery. Furthermore, with average ratios of 55% in recession periods and 85% in expansion periods, this study shows, in line with Silvério and Szklo (2012) prices on futures and spot markets fluctuate the most in downturn periods, allowing spot markets to contribute on a major scale toward price innovation. The opposite picture is observed in expansion periods, where price discovery always occurs on futures markets.

4.2.3. Transaction costs

Table 6 displays the estimates of the EC term at different levels of transaction costs. The results show that, independent of its levels, the spot market is likely to display higher transaction costs and thus lower returns; the opposite can be observed of the futures market, where, even though returns are affected by transaction costs, these are not significant, and investors can still profit from this market. These results reinforce those found by Fleming et al. (1996) and Li (2010), who concluded that markets displaying lower costs react more quickly to information than those with higher transaction costs, thereby becoming the major source of price innovation.

5. CONCLUSION

This research investigates the existing causality and the market contribution toward price discovery between spot and futures markets on four energy sources. By using the estimate parameters of the VECM and the ratio of speed of adjustment, the present analysis is conducted under three different scenarios: Oil shocks, business cycle and transactions costs. The results show that, independent of oil shocks, business cycle and transaction costs, the futures market is a bias estimator and major contributor to price discovery. These findings reinforced previous studies measuring causality between spot and futures markets. Notably, in the gasoline sector, unlike other sources, the spot market is likely to react more quickly to new information, leading it to contribute at a major scale to price discovery.

Some other remarked results are the following: First, while the dominance of futures over spot markets does not significantly change during periods of oil crisis and afterwards, a decline in its leadership is found over the business cycle. Second, the spot market has more improvement in reflecting new information in recession periods than in expansion periods. Finally, regardless of different levels of transaction, the spot market displays higher costs and lower returns compared to the futures market. Even though returns on futures markets are affected by transaction costs, these do not have a significant impact as they do on spot returns.

Table 3: VECM estimates

Energy sources	λ_1 (P value)	λ_2 (P value)	$\lambda_2/(\lambda_2-\lambda_1)$ (%)
Crude oil	0.0670 (0.10)	−0.3599 (0.00)***	84
Heating oil	0.0181 (0.02)**	−0.0817 (0.00)***	82
Natural gas	0.0002 (0.97)	−0.1164 (0.00)***	99
Gasoline	0.0365 (0.04)**	−0.1118 (0.00)***	75
Mean			85

*** and ** denotes significance at 1% and 5% level. With values above 50%, futures are concluded to be the market having a more relative contribution toward price discovery than spot markets. VECM: Vector error correction model

Table 4: VECM estimates oil crisis versus non-crisis

Energy sources	Oil crisis			Non-crisis		
	λ_1 (P value)	λ_2 (P value)	$\lambda_2/(\lambda_2-\lambda_1)$ (%)	λ_1 (P value)	λ_2 (P value)	$\lambda_2/(\lambda_2-\lambda_1)$ (%)
Crude oil	0.0218 (0.86)	−0.4990 (0.00)***	96	0.0913 (0.04)**	−0.3136 (0.00)***	77
Heating oil	0.0205 (0.48)	−0.0898 (0.00)***	81	0.0140 (0.08)	−0.0769 (0.00)***	85
Natural gas	0.0064 (0.70)	−0.1310 (0.00)***	95	0.0008 (0.92)	−0.1133 (0.00)***	99
Gasoline	0.0738 (0.03)**	−0.1756 (0.00)***	70	0.0201 (0.33)	−0.0781 (0.00)***	80
Mean			86			85

*** and ** denotes the significance at 1% and 5% level. With values above 50% futures markets dominate contribution to price discovery in both periods. Indeed, futures lead more than it lags spot markets. VECM: Vector error correction model

Table 5: VECM estimates over business cycle

Energy sources	Recession			Expansion		
	λ_1 (P value)	λ_2 (P value)	$\lambda_2/(\lambda_2-\lambda_1)$ (%)	λ_1 (P value)	λ_2 (P value)	$\lambda_2/(\lambda_2-\lambda_1)$ (%)
Crude oil	0.4016 (0.08)	−0.8396 (0.00)***	67	0.1463 (0.00)***	−0.2753 (0.00)***	65
Heating oil	0.0624 (0.37)	−0.0238 (0.73)	28	0.0189 (0.01)**	−0.0789 (0.00)***	81
Natural gas	0.2661 (0.00)***	−0.4444 (0.00)***	63	0.0007 (0.93)	−0.1218 (0.00)***	99
Gasoline	0.1354 (0.01)**	−0.2248 (0.00)***	62	0.0060 (0.75)	−0.0744 (0.00)***	93
Mean			55			85

*** and ** denotes the significance at 1% and 5% level. VECM: Vector error correction model

Table 6: Estimated coefficients of the EC term

Quantiles	Crude oil		Heating oil		Natural gas		Gasoline	
	Future	Spot	Future	Spot	Future	Spot	Future	Spot
25%	0.0656 (0.11)	−0.3614 (0.00)***	0.0115 (0.02)**	−0.0813 (0.00)***	0.0002 (0.97)	−0.1164 (0.00)***	0.0376 (0.03)**	−0.1127 (0.00)***
50%	0.0706 (0.08)	−0.3573 (0.00)***	0.0177 (0.02)**	−0.0812 (0.00)***	0.0003 (0.97)	−0.1157 (0.00)***	0.0385 (0.03)**	−0.1144 (0.00)***
75%	0.0637 (0.08)	−0.3622 (0.00)***	0.0183 (0.02)**	−0.0784 (0.00)***	0.0001 (0.89)	−0.113 (0.00)***	0.0540 (0.00)***	−0.1311 (0.00)***

*** and ** denotes the significance at 1% and 5% level. EC: Error correction

The current research have the following implications: First, investors might consider including energy futures contracts to maximize their portfolio and reduce their risk since the correlation between futures and other traditional assets such as stock and bond markets is negative or the independence among markets truly exists. Second, due to futures' flexibility to take long and short positions, investors have the opportunity to generate profit under a variety of economic environments, including both volatile and stable periods. For instance, in situations such as recessions, in which economies are more fragile and prices within markets fluctuate significantly, investors might take short (sell) positions. In contrast, during expansion periods in which prices are expected to rise, investors could take long (buy) positions and protect themselves against the impact of rising prices.

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