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Testing for adjustment costs and regime shifts in BRENT crude futures market

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ABSTRACT

This paper, using a threshold vector error-correction (TVECM) model, examines whether BRENT crude spot and futures oil prices are cointegrated. By employing this methodology we are able to evaluate the degree and dynamics of transaction costs resulting from various market imperfections. TVECM model is applied on daily spot and futures oil prices covering the period 1990–2009. The hypothesis we test is to what extent BRENT crude is indeed an integrated oil market in terms of threshold effects and adjustment costs. Our findings support that market follows a gradual integration path. We find that BRENT crude spot and futures are cointegrated, though two regimes are clearly identified. This implies that a threshold exists and it is indeed significant. Adjustment costs in the error correction are present, and they are valid at the typical regime that is the dominant, and as a result should not be ignored.

1. Introduction

An issue that has been extensively dealt in the literature concerns the long run relationship between spot and futures in energy markets. Serletis and Banack (1990), Quan (1992), and Schwartz and Szakmary (1994) test whether spot and futures prices for oil are linked in a long-run equilibrium relationship using simple cointegration analysis (see Granger, 1987 and Johansen, 1988). More recent studies, using new cointegration tests, examine whether the market efficiency hypothesis holds in energy futures market (see Silvapulle and Moosa, 1999; Peroni and McNown, 1998; McAleer and Sequeira, 2004) and also the cost of carry hypothesis (see McAleer and Sequeira, 2004). A drawback of such analysis is that this literature fails to account for possible structural breaks in the cointegrating vector, though clearly there is record of structural breaks in energy price data. This is so as the traditional cointegration analysis cointegrating vectors are assumed to be time invariant. This means that the long-run relationship between variables is assumed to remain stable over time. However, as pointed out by Hansen (1992), this might or might not be true in the presence of structural breaks. It is possible that if the long-run relationship between the series changed due to a break, then the time-invariant formulation of the cointegrating vector will no longer be appropriate. One early study that has employed a cointegration framework that is robust to structural breaks to examine whether there is a long-run relationship between crude spot and futures oil prices is Cunado and Perez de Gracia (2003). They employ the Gregory and Hansen (1996) residual-based cointegration test to examine whether there is a long-run relationship between various combinations of national oil prices, the world oil price, inflation rates and industrial production for 15 European countries. For most countries Cunado and Perez de Gracia (2003) could only establish a relationship between inflation and national oil prices. In a recent paper Maslyuk and Smyth (2009) also apply Gregory and Hansen (1996) test to energy spot and future prices for 17 OPEC and non-OPEC countries. They show that crude oil production is characterized by threshold effects.

The purpose of this article is to augment Cunado and Perez de Gracia (2003) and Maslyuk and Smyth (2009) so as to examine for the first time in the literature whether BRENT crude oil spot and futures prices are cointegrated employing the novel approach of threshold cointegration by Hansen and Seo (2002).

As reported in the literature (see Cunado and Perez de Gracia, 2003 and Maslyuk and Smyth, 2009), the BRENT crude oil spot and future market is subject to a threshold effect due to the existence of one regime. The underlying causes of the existence of one regime could be; structural changes, seasonal effects and last variations in demand and reserves. In this paper, departing from Cunado and Perez de Gracia (2003) and Maslyuk and Smyth (2009) we go a step further by testing for non-linearities and unit roots in BRENT crude spot and futures oil prices in terms of a Threshold Vector Error Correction Model (TVECM) that allows the existence of two regimes to be identified with a cointegrating vector and a threshold effect in the error correction term as proposed by Hansen and Seo (2002). The Hansen and Seo test augments previous studies (see Cunado and

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Perez de Gracia, 2003 and Maslyuk and Smyth, 2009) that opt for Gregory and Hansen's test as the latter limits the analysis of cointegration in the presence of a single regime shift.[1]

To this end our study departs from the existing literature (see for a review Maslyuk and Smyth, 2009) of traditional cointegration. By doing so, we are able to test whether there have been threshold effects in terms of different underlying regimes. A regime shift would be identified whether it occurs in the intercept, trend or the entire cointegration vector. Our analysis is based on monthly BRENT data from 1990 to 2009, which has well-developed spot and futures markets. Moreover, in the first step we use maximum likelihood estimation (MLE) of the threshold model. In the second step we test the presence of a threshold effect. Under the null hypothesis the model transforms to a linear VECM.

Our findings are of interest as they allow accounting for the effects of expectations on the underlying relationship between oil futures and spot.[2] Weak form efficiency in markets would imply that oil futures provide expectations about spot prices t' periods ahead (Chance, 1991). Along these lines Gulen (1998) argues that in case of cointegration oil future would be an unbiased predictor of spot. On the other hand, finding cointegration between oil futures and spot may not necessarily imply efficiency according to Hamilton (2007), Narayan et al. (2008) and Maslyuk and Smyth (2009). This is because the oil market could still be inefficient if market participants could take advantage of cointegration to earn risk adjusted excess returns. However, there is not much evidence to suggest that cointegration would lead to risk adjusted excess rates of return (Sanders et al., 2008).[3]

The rest of this article is structured as follows: Section 2 presents literature review and some stylized facts regarding the BRENT crude oil market. Section 3 presents the theoretical specification of the threshold vector error correction model for the BRENT crude oil market while Section 4 reports unit root tests, including potential structural breaks, the threshold cointegration analysis, whilst Section 5 offers some conclusions.

2. Literature review

A number of earlier studies have addressed the efficiency of the oil futures market (e.g. Silvapulle and Moosa, 1999; Peroni and McNown, 1998; McAleer and Sequeira, 2004). Efficiency in oil markets states that the futures price is an unbiased predictor of the spot price, in the case of trading in crude oil futures at NYMEX (Gulen, 1998). However, the literature does not provide any clear consensus (Switzer and El-Khoury, 2006).

Abosedra and Baghestani (2004) paper evaluates the predictive accuracy of 1, 3, 6, 9, and 12-month ahead crude oil futures prices for 1991.01–2001.12. In addition to testing for unbiasedness, a 'naïve' forecasting model is constructed to generate comparable forecasts, as benchmarks. Empirical findings reveal that futures prices and 'naïve' forecasts are unbiased at all forecast horizons. However, the 1-, and 12-month ahead futures prices are the only forecasts outperforming the naive, suggesting their potential usefulness in policy making.

Switzer and El-Khoury (2006) test the efficiency of the oil futures during periods of extreme conditional volatility (1985–2005). Using cointegration techniques with monthly and daily data they find that futures prices are unbiased predictors of future spot prices, consistent with the speculative efficiency hypothesis during the recent episodes of extreme volatility from the onset of the Iraqi war until the formation of the new Iraqi government.

Wu and McCallum (2005) conducted a series of forecasting exercises and compare the performance of models that use oil futures and spot prices in an attempt to find the one that performs best. The aforementioned concluded that oil future prices contain important information about future oil price movements, especially in the short term. They noted though that prediction errors are still substantial and accurately predicting the future price of oil seems as elusive as ever.

Mehrara et al. (2009) study uses a GMDH neural network model with moving average crossover inputs to predict price in the crude oil futures market. The significant profitability of the GMDH model casts doubt on the efficiency of the oil futures market.

The TVECM has been applied to various financial and commodity prices but not to BRENT spot and future oil prices. Meyer (2004) applies a TVECM to pig prices in Germany and the Netherlands. He finds evidence of non-linearities. Chung et al. (2005) apply the version of Hansen and Seo (2002) to American Depository Receipts (ADRs), with symmetric regimes. They reject the null of no thresholds. Finally, Wu and Chen (2006) apply a symmetric TVECM model to quotations on the FW20 and the underlying WIG20 index on the Warsaw Stock Exchange. They find evidence of threshold non-linearities.

2.1. Stylized analysis of the BRENT crude oil market

This paper covers the period from January 1990 to November 2009.[4] Thus, the data embraces not only the low volatility period from mid '90s to early 2000 but also the highly volatile environment from the 2nd Iraq War (2003) to the historic high area of $145/barrel in July 2008 and the subsequent price collapse following the Lehman Brothers bankruptcy (9/2008).

It is evident that the oil price is governed by considerably different regimes: the 1980s and 1990s are characterized by a fairly volatile, but horizontal movement, while a bubble-type behaviour is present in the 2000s (Askari and Krichene, 2008).

The oil price cycle turned upwards in mid 1990s. The United States economy was strong and the Asian Pacific region was booming. From 1990 to 1997 world oil consumption increased 6.2 million barrels per day. Asian consumption accounted for all but 300,000 barrels per day of that gain and contributed to a price recovery that extended into 1997. Declining Russian production contributed to the price recovery. Between 1990 and 1996 Russian production declined over 5 million barrels per day. The price increases came to a rapid end in 1997 and 1998 when the impact of the economic crisis in Asia was either ignored or severely underestimated by OPEC, while the combination of lower consumption and higher OPEC production sent prices into a downward spiral. Oil prices returned to an upward path in early 1999 mainly due to OPEC production cuts while rebounding global economy sustained upward trend u p to late 2000. Since 2001, a slowing US economy and increases in non-OPEC production put downward pressure on prices along with negative consequences following the devastating September 11, 2001 (Williams, 2009).

The price of oil essentially started its long term uptrend in 2003 fuelled by low inventories in the U.S. and other OECD countries, weak US dollar trend, improving U.S. economic and rapidly growing Asian demand. The above coincided with the US military involvement in Iraq. Oil price trend steepened considerably from 2007 to mid 2008, since world demand was growing strongly and production remained rather rigid. Despite occasional dramatic news such as hurricanes in the Gulf of Mexico in September 2005, turmoil in Nigeria in 2006–2008, and ongoing strife in Iraq, global production has been remarkably stable. The big story has not been a dramatic reduction in supply of the kinds summarized but a failure of production to increase between 2005 and

[1] Note that, as a Referee pointed out, the non inclusion of structural breaks in the cointegration analysis would weaken the power of the CI test. Thus, earlier findings of cointegration in the energy market (see Serletis and Banack, 1990; Quan, 1992; Schwartz and Szakmary, 1994) appear plausible.

[2] For an alternative explanation see Leuthold et al. (1989), referring to the importance of the cost of storage.

[3] Note that Granger (1987) argues that cointegration between two prices reflects an inefficient market as there exist a common trend in the long-run, implying predictability. This in turn indicates that one market may be caused by another.

[4] Future prices relate to the 1st, 2nd and 3rd month ahead rolling delivery contract.