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Persistence in crude oil spot and futures prices☆

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ABSTRACT

This study investigates the degree of persistence in monthly Brent crude oil spot and futures prices (at one, two and three months to maturity). The main finding from the full sample shows that Brent crude oil spot, one, two and three months to maturity futures prices are characterized by a high degree of persistence without structural breaks. However, these prices are not highly persistent when structural breaks are taken into consideration. The analysis is repeated for four sub-periods delineated by the endogenously determined break points. The results obtained from the sub-period analysis indicate that oil price series are typically very persistent which is consistent with the efficient market hypothesis.

1. Introduction

Oil market is one of the largest and the most strategic commodity markets in the global economy. It is not only the basis for very broad and sophisticated financial markets but also has some important stochastic properties with implications on several economic activities such as forecasting, hedging, speculation, strategic planning, portfolio investment and decision making process about capital investment. The stochastic properties of crude oil prices have important repercussions on the entire economy because of the importance of energy for the other sectors of the economy. As a result of the interaction between key macroeconomic variables, the effect of the non-stationarity property of oil prices spreads throughout the economy [1]. Consequently, the oil price shocks affect the real economic activities [2–4]. For instance, oil price fluctuations influence the financial markets, the domestic inflation and further influence the economic growth, private consumption expenditure and other real variables of the economy. Wang [5] significantly study the effect of an energy shortage on the macroeconomy. Lardic and Mignon [6] study the long-term relationship between oil prices and economic activity, proxied by GDP. They show that economic activity reacts asymmetrically to oil price shocks. Rising oil prices seem to retard aggregate economic activity by more than falling oil prices stimulate it. Hanabusa [7] studies Japan, a country highly dependent on imported oil, and investigates the effects of oil price changes on macroeconomic activities. His results suggest that the high oil prices in 2004 had serious impacts on the Japanese economy. Oil price movements and shocks are responsible for the recession-stagnation of the economy [8–15], inflation [16,17], natural rate of unemployment [18], stock market indices [19,20], business cycles [21] and financial markets [22,23].

On the other hand, crude oil market itself is affected by many economic and non-economic factors such as demand–supply shocks, OPEC (Organization of the Petroleum Exporting Countries) policy, global political–economic risks and geopolitical risks. Thus, crude oil prices are affected by political shocks as well as demand

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and supply conditions. Both economic and political factors should be taken into account while investigating stochastic properties of oil prices. Management of such factors present significant challenges to the economic actors. Economic actors face significant challenges while managing manage the periods of significant fluctuations. During such periods such as the first decade of 2000s, managing risks and price discovery became vital for the economic actors. Albeit, there is a broad literature on price discovery which extends many areas including financial products [24–26], agricultural products [27–31] and oil products [32–35]. Various different approaches are employed in order to describe the price path of the crude oil prices. These approaches include deterministic trend models with upward or downward trend [36–40], models which emphasize cyclical behavior [41–44], local trends [45], shock-persistence or mean reversion [46,47]. It is widely agreed that high degree of volatility and strong seasonal components are important features of the crude oil prices. Understanding stochastic properties of oil prices has vital importance for the price discovery.

One of the most important stochastic properties of any series is whether it is stationary or non-stationary. As such unit root properties of crude oil prices are investigated widely. According to the efficient market hypothesis, the crude oil prices follow a random walk process. This implies that the oil market is efficient and there is no arbitrage opportunity for the investors. To investigate the unit root properties of crude oil prices several different approaches have been employed. First group of studies employ conventional unit root tests such as ADF (Augmented Dickey Fuller) thereafter test [48], PP (Phillips–Perron) thereafter [49] test and the KPSS (Kwiatkowski–Phillips–Schmidt–Shin) [50] stationarity test to investigate the unit root properties of the crude oil prices. These tests are mostly unable to reject non-stationarity of the crude oil prices [51–55].

One of the problems with DF type unit root tests is their low power in the case of trend stationary processes with structural breaks [56]. As discussed above, the oil prices are affected by both economic and political shocks. Barring the reasons of the shocks, the structural breaks are an important aspect of the oil price series. Therefore, in order to examine whether the crude oil prices are trend stationary or difference stationary we must take the structural breaks into account. Ignoring structural breaks leads to overestimated prediction of persistence [57–59]. Structural breaks in the means of oil prices are taken into account by several studies including [60–62]. Gulen [60–62] asserts that conventional unit root tests are not appropriate for investigation of unit root properties of the oil prices. Gulen employs Perron's [56] ADF-type unit root test with one exogenously, specified, a priori, structural break represented by a dummy variable. The results of these studies are mixed and the non-stationarity can be rejected only for some of the series. Other studies consider the endogenously determined structural breaks. Serletis [19,63] employ Zivot and Andrews [43] ADF-type unit root test with one endogenous structural break to analyze the unit root properties of oil prices. Both of these studies reveal that oil price series can be described as difference stationary. There are also several studies that take into account the possibility of multiple structural breaks in oil price series. Lee et al. [64,65] employ LS (Lee and Strazicich) [66,67] unit root test, that allow two endogenously determined structural breaks with and without a quadratic trend in the data-generating mechanism in order to analyze the stochastic properties of crude oil prices. Lee et al. [64,65] reject the unit root hypothesis and define the oil prices as a stationary process around deterministic trends with structural breaks. According to these results it can be argued that incorporation of structural breaks may change the results of the analysis about the stationarity of the series.

The literature is far from a consensus on the unit root properties of crude oil prices, which may result from low power of unit root tests especially in small samples [42]. In addition there are two major problems with the unit root tests. First, they cannot distinguish unit root and near unit root processes from each other [68]. Next, the results may be affected by the choice of lags. Therefore, the results differ depending on the method, data frequency and the data span. Further investigations are necessary in order to better understand the stochastic properties of crude oil prices, which is the main consideration of this paper.

The term persistence is related to the memory properties of time series. It refers to how long the effect of a shock lasts. The longer the memory of a time series, the higher is its persistency. Time series with a unit root means that the effect of a shock lasts forever. A non-stationary but persistent time series displays long memory behavior. If oil price series is highly persistent, even a small shock will influence the future realization of this series for a very long time on account of lags in the effect of monetary policy on the economy. Oil price series exhibiting substantial persistence could stay substantially above or below the sample mean for extended periods of time. If the effect of a shock dies out in a short time, a more aggressive policy response may be destabilizing, which is inappropriate. A persistent increase in the oil price means that there is a positive terms-of-trade shock in an oil-exporting country. It can create a persistent real appreciation of the exchange rate which puts decreasing pressure on the prices via less-expensive imports. However, the wealth effect of this kind of persistent change in the oil price applies increasing pressure on prices, as well. Moreover, the increasing liquidity in the oil-futures market allow using long-term futures contracts to have more consistent estimates of the persistence of oil price shocks and so does the expanding range of actively traded maturities [69]. Given this, the persistence of oil price shocks is an important actor on the economy and the commodity market. For that reason, examining the measure of persistence of oil price shocks is of great significance empirically.

Conventional unit root tests which merely concentrate on testing the null hypothesis provide only limited information on the degree of persistence in oil price series [70]. Unit root tests investigate whether the sum of AR (autoregressive) coefficients of a series is unity or less than unity, which could not reveal the persistency of a series. This article contributes to the literature on the persistency of oil prices by incorporating multiple structural breaks in the form of level and trend shifts at endogenously determined dates into the analysis. This enables us to reach additional evidence and better understanding about the stochastic properties of oil prices in comparison to the previous studies based on random walk hypothesis. In order to do this, following the methodology of Ref. [71], we first extend the number of structural breaks to three which was only two in their article. In other words, this paper contributes to the previous work on the degree of persistence, by providing additional evidence on the oil market efficiency, by incorporating three structural breaks into the analysis. Moreover, a recently developed econometric procedure by Hansen [72] which is the grid-bootstrap method is employed to estimate the 95% confidence intervals for the sum of the AR coefficients in AR representations of Brend oil price series by allowing multiple structural breaks in the form of level and trend shifts at three endogenously determined dates which are one of the basic characteristics of the crude oil price series. In addition to the sum of the AR coefficients and their confidence interval, the persistence through half-life, that is the number of years required for a shock to oil price series to dissipate by one-half, is also measured.