Volatility Spillover versus Contagion: Empirical Evidence from Crude Oil and Gasoline Markets

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Overview

This paper examines whether periods of high price volatility in the motor gasoline market are affected by the crude oil market, in the form of spillover or contagion, during the 1992 – 2007 period. We utilize models of conditional heteroscedasticity that contain Markov-switching parameters to examine volatility behaviors in both crude oil and gasoline markets. These analyses enable us to observe price volatility co-movements between these markets and are particularly important to understand the volatility behavior of petroleum products.

It is well known that the price of motor gasoline is mainly determined by the price of crude oil, since more than three-fourths of the price of gasoline is reflected by the price of crude oil. This leads reasonable expectations of highly correlated price volatility behaviors in these markets. Our empirical results, however, do not exhibit the volatility spillover and/or contagion from crude oil to motor gasoline price.

Methods

We utilize Markov-switching specifications of model (SWARCH) to endogenously detect different regimes of conditional variance. This model was proposed by Hamilton and Susmel (1994) and used to estimate interest rate volatility by Edwards and Susmel (2001). The Markov-switching specification of the autoregressive conditional heteroskedasticity should allow discrete shifts and changes of persistence in the ARCH and/or GARCH parameters in response to small and large shocks. In addition, this specification allows estimation of a transitional probability (P_{ij}), which represents the probability of a transition into state j when in state i, and magnitude of volatility at each state. The mean and variance specifications are as follows:

$$r_t = \mu + \varepsilon_t \tag{1}$$

$$\frac{\sigma_t^2}{\gamma_{st}} = \omega + \sum_{i=1}^{q} \alpha_i \left(\frac{\varepsilon_{t-i}^2}{\gamma_{st-i}} \right) \tag{2}$$

where $i = 1, 2, \ldots, q$; $s_t = 1, 2, \ldots, k$; and the γ_s are scale parameters that capture the change in regime. Here, γ_1 is normalized to 1 since one of the γ_s is unidentified. Therefore, the other value, γ_2, measures the ratio of the conditional variance in state 2 relative to that in state 1. When the observed return (r_t) is the outcome of unobserved random variable (s_t) that follows a Markov chain process, the probability for the return variable to switch regimes is:

$$\text{Prob}\,(s_t = j \,|\, s_{t-1} = i, s_{t-2} = k, \ldots., r_{t-1}, r_{t-2}, \ldots\ldots) = \text{Prob}\,(s_t = j \,|\, s_{t-1} = i) = P_{ij} \tag{3}$$

For example, if the market was in a high volatility state last period ($s_t = 2$), the probability to change to the low volatility state ($s_t = 1$) is a constant (P_{ij}). The transitional probability is a $K \times K$ matrix, and in this matrix, a sum of the conditional probabilities in each row is unity.

Results

We found that there are two different volatility structure regimes in both the crude oil and gasoline market, since the model specification was not able to detect higher than two volatility states. Table 1 summarizes the transitional probabilities, magnitude of volatility levels, and the volatility persistency. In all estimations, whether the volatility is in a high or low environment, it is likely to stay in its current state, as measured by P_{11} and P_{22},. These results are consistent with findings in a previous study by Lee and Zyren (2007), which shows that there are different price behavior regimes having different volatilities. There are differences in the transitional probabilities when moving to a high volatility state from a low state (P_{12}) and when moving to a low volatility state from a high volatility state (P_{21}). Given P_{21} is greater than P_{12}, there is a greater chance that the high volatility state will most likely go back to the low volatility state rather than the converse.

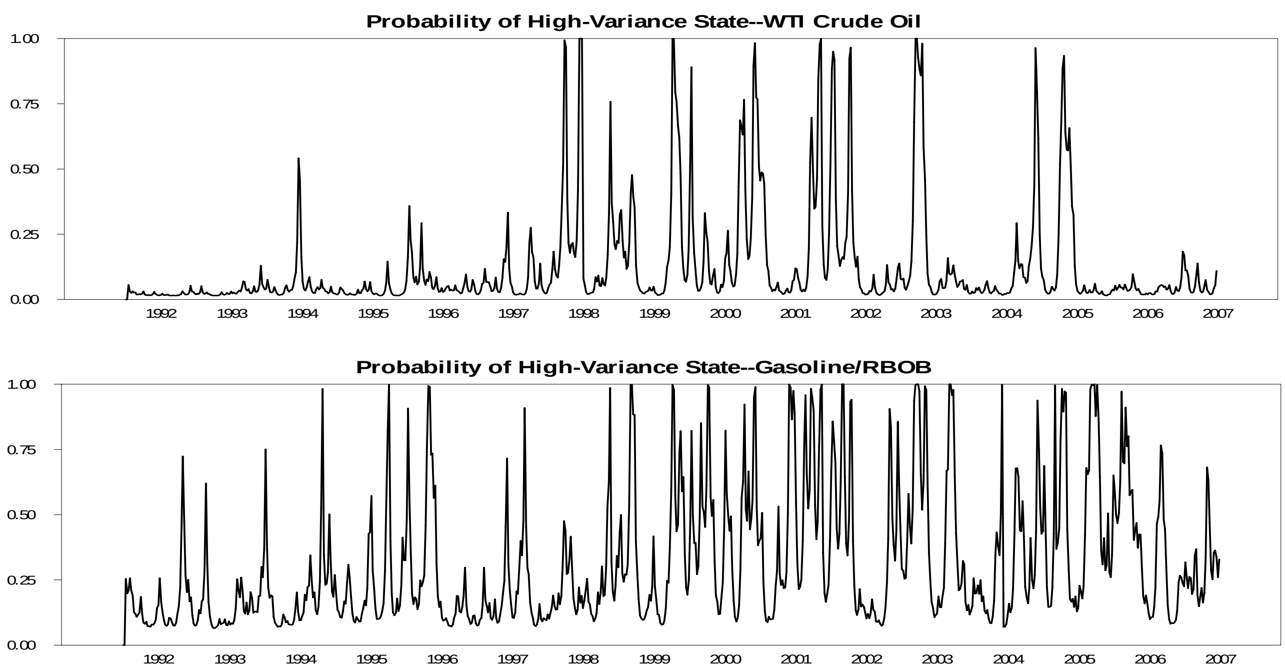
Volatility persistency (VP) in each state is measured by $VP_{S1} = (1 - P_{11})^{-1}$ *and* $VP_{S2} = (1 - P_{22})^{-1}$, and shows around 3 to 4 weeks for the nearby contracts in crude oil and gasoline markets, respectively. This shows that the duration of the high volatility regime relative to the low state is transitional and not sustainable. Examination of values for the scale parameters, γ_s, which capture the magnitude of change in regime, shows that the price variance of the crude of market is higher than that of motor gasoline. This scale parameter is the ratio of the conditional variance in the high volatile state relative to the low state. Thus, in this study of two regimes, γ_2 captures the estimated ratio of high to low volatility. The magnitude of estimated higher volatility relative to its low state is about 4.5 times for crude oil and 4 times gasoline nearby contracts.

Table 1: Transitional Probabilities

	Crude Oil	**Gasoline**
P_{11}	0.958	0.870
P_{12}	0.042	0.130
P_{21}	0.289	0.281
P_{22}	0.711	0.719
P_1	0.874	0.684
P_2	0.126	0.316
γ_2	4.558	3.877
VP_{S1} (wks)	24	8
VP_{S2} (wks)	3	4

As shown in Figure 1, the gasoline market reveals higher frequencies of a high variance state, and this pattern does not correlate with the crude oil market. This result is contradictory from what we all initially expected. In both markets, there are higher probabilities of being a high variance state after 1999. However, unlike the gasoline market, the oil market did not exhibit higher frequencies of regime changes during 2005 through 2007, even though we observed the highest oil prices in this period.

Figure 1: Probability of Regime Changes



Conclusions

In this paper, we used weekly nearby futures contracts for crude oil and gasoline date to analyze the volatility relationship, volatility spillover or contagion, between crude oil and gasoline. The study utilized a SWARCH specification to identify structural regime changes endogenously. This specification was able to estimate transitional probabilities as well as magnitudes of different volatility regimes. We also analyzed volatility co-movements in these markets. This study reached two main conclusions: (1) volatility persistency in the high regime is short lived with persistence of 3 to 4 weeks; and (2) there is no reason to believe that volatility of the crude oil market is transmitting to the gasoline market.