Linkage among the U.S. energy futures markets

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Overview

The study invetigates how the U.S. energy futures markets are interlinked by testing the price linkage among the NYMEX WTI crude oil, Brent crude oil, gasoline, heating oil, coal, natural gas, uranium, and ethanol futures prices. Along with testing the linkage among these U.S. energy futures markets, the study considers effects of structural break in times series.

Bachmeier and Griffin (2006) showed that the major U.S. energy source markets, such as crude oil, coal, and natural gas were very weakly linked and that there was not a primary energy market in the U.S. between 1991 and 2004. As shown in this study, the U.S. energy source markets may not be integrated as one market but it is likely that price linkage does exists between some of the major energy sources, such as between crude oil and coal or between natural gas and coal. However, at present, such price linkage among the current U.S. major energy sources has not been characterized in detail. This study fills this gap by examining and identifying the overall price linkage among the above mentioned U.S. energy futures prices. To our knowledge, there are no previous studies testing the overall linkage among the major U.S. energy source prices in which uranium and ethanol prices are included in the model.

Nearly 80% of the energy consumed in the U.S. came from non-renewable energy sources such as petroleum, natural gas, and coal in 2008 (EIA, 2008) and it is becoming important for the U.S. to find ways to increase the use of alternative energy sources. Understanding the linkage among the probable alternative energy source markets and the conventional oil related energy source markets is helpful for constructing an effective policy to change the types of major energy sources and reduce the dependence on fossil fuels. Hence to shed light on this issue this study invetigates the price linkage among the U.S. uranium, ethanol, and oil related futures prices.

Methods and Data

The Johansen method (Johansen and Juselius, 1990) is used for testing the price linkage among the NYMEX energy source futures prices. Many studies have used the Engle and Granger test for examining the price linkage (see Goodwin and Schroeder, 1991), but this study uses the Johansen method. Johansen method is more efficient when analyzing the variables of interest as endogenous in the model and is more useful in a multivariate framework. Darrat (1998) suggests that the Johansen test has an advantage over the Engle and Granger test even in a bivariate cointegration framework because the Johansen test does not require Gaussian errors. All price series used in this study need to be integrated at the same order for the series to be cointegrated (Quan, 1992). Before performing the cointegration tests, all price series are tested for their stationarity by the augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests.

The Bai-Perron (1998) test is used to identify the structural breaks in the series. The Chow (1960) test has long been the major method for determining structural change in time-series data, but it is inadequate when the break date is unknown (Rapach and Wohar, 2006). Quandt (1960) and Andrews and Ploberger (1994) developed a method based on the Chow test for testing structural breaks when the break is unknown, but those methods were limited to testing one structural break and deficient in identifying the breakpoints when the series were nonstationary (Hansen, 2000). The Bai-Perron test overcomes these problems and is useful for finding breaks when the potential break date is unknown and the series tend to have more than one break. The natural logarithm of ratios between the energy prices is used for the Bai-Perron test because this test is specifically tested on single series. For example, the log of the price ratio between the prices of WTI crude oil and unleaded gasoline is used for testing whether breaks existed in the relationship of the two price series. The price ratios are obtained for all combinations of the eight price series used in the study, and the Bai-Perron test is conducted for all of those price ratios. After the breaks are determined by the Bai-Perron test, the two price series that will be used to test the price linkage are split into periods using the break dates. Then, the bivariate Johansen cointegration tests are performed on all combinations of energy prices for each period separated by the break dates. Unit root tests are performed on every energy price for each period that was identified as explained above. If those tests suggest that the price variables are not integrated of the

same order during the test period, it would mean that those variables are not cointegrated because cointegration tests require the test variables to be integrated of the same order (Quan, 1992).

The daily futures prices traded on the NYMEX are used for each price series. The daily price data is the continuation data created by taking the highest traded volume contract for each commodity and is obtained from the EODData, LLC. For all energy price series except for the uranium and ethanol futures markets, the period of the study is from July 2001 to May 2010. That term was selected because the coal futures market on the NYMEX opened in July 2001. The NYMEX launched the uranium futures market in May 2007 and started to trade ethanol in April 2008, so the terms used for these price series are from May 2007 to May 2010 and from April 2008 to May 2010, respectively. Hence, the cointegration and the Bai-Perron tests are conducted only after May 2007 and April 2008, when uranium and ethanol prices are involved.

Results and Conclusions

This study investigated whether market linkage exists among the major energy source markets in the U.S. when structural breaks are considered in price series. The results idicated that strong price linkage exists among the NYMEX WTI crude oil, Brent crude oil, gasoline, and heating oil futures markets but only weak linkage holds among these four oil-related markets, coal, natural gas, uranium, and ethanol futures markets. The price linkage among the four oil-related markets is not surprising because it is known from a previous study that price linkage exists among oil-related products (Asche et al., 2003) and it is common to find price relationships between input and output prices (Mjelde and Bessler, 2009) such as between crude oil and gasoline and heating oil prices. However, our finding that only weak linkage exists among the four oil-related products, coal, natural gas, uranium, and ethanol markets provides important empirical evidence that at the moment no primary energy source market exist in the U.S. and the major U.S. energy markets move independently. This implies that when applying market intervention policies for the U.S. energy market every U.S. major energy source market will have to be treated individually.

The test on price linkage when structural breaks are considered also suggested that the price linkage only exists among the oil-related energy markets and only weak linkage exists among the U.S. major energy source markets. Especially we found from this test that the uranium and ethanol futures prices have very weak linkage with other U.S. major energy source prices. This indicates that the U.S. energy market is still at a stage where none of the probable alternative energy source market plays the role as a substitute or a complement market for the fossil fuel energy market.

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