Stability in an Era of Instability: Regime Changes in the Market Relationship Between Liquefied Petroleum Gases, Oil and Natural Gas

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Overview

Since the turn of the twenty-first century, energy markets has experienced dramatic changes. One of the major developments after the introduction of U.S. shale gas, is the increase in U.S. LPG production which has attracted little attention in academic circles. This increase in U.S. supply from both tight oil and shale gas formations, has changed the market trade dynamics and turned the U.S. from a net importer of LPG to a net exporter. Being able to model energy prices is important to develop a clear understanding for both suppliers and consumers of the price movement. For consuming countries such as the U.S., approximate 7.45% of total GDP is used for energy in 2016. Adjustments in the price of energy will therefore have a impact on the macroeconomic output. Literature suggests that there are linkage between the fluctuation of energy prices and GDP and stock market (Hamilton, What is an oil shock?, 2003) (Kilian, 2006). EIA estimate that the world consumption of energy will go through a 48% increase between 2012 and 2040. For non-OECD countries it is expected that the demand for energy rises by 71% in the same time period in contrast to OECD countries where energy demand is expected to grow by 18% (EIA, 2016). In 2015 57% of all consumption derive from crude oil and NG. For suppliers it is essential to be able to perform risk assessment before production.

This paper motivates the use of the Markov Switching (MS) model of Hamilton (1989, 1990) in order to explore the direct links between four different petroleum products from the U.S. market. These are Liquefied Petroleum Gases (LPGs) represented by propane and butane from Mont Belvieu Texas (MB), West Texas Intermediate (WTI) crude and natural gas (NG) from Henry Hub. LPGs are byproducts from NG processing and crude refining.

Ever since the introduction of the cointegration methodology resources has been spend on analyzing the relationship between different energy prices in order to understand the complex interactions between energy markets. Especially the long-term relationship between crude oil and NG has been extensively analyzed (Brown & Yucel, 2009) (Ramberg & Parsons, 2010). Less attention has been given to the relationship between LPGs and WTI and NG. Oglend et al. (2015) look at the relationship between LPGs and crude and NG i the U.S. market. Prior to January 2009, they find a cointegration relationship but this weakens after a structural break in 2008/9. This motivates the use of non-linear approaches that are more robust to structural changes in the markets analyzed.

Methods

This paper incorporate the Engle-Granger (EG) cointegration methodology (Granger, 1981) (Engle & Granger, 1987) in the MS framework. By doing this we believe we are able to more accurately model the long-run relationship independent of the price characteristics of energy price series. The MS regression model allows for different model characteristics dependent on which regime the price is currently in. A regime shift could be permanent (structural break) due to permanent shifts in the economy, or temporary due to wars or other interim events. If cointegration relationship is established in a bivariate setup, we continue by estimating a Vector Error Correction Model (VECM) which enables us to interpret the speed at which the dependent variable adjust back to equilibrium after a disruption. The novelty of this method is that it has the potential to distinguish between lack of market integration and market integration under changing market conditions, something a linear model is not able to do. Distinguishing between these two outcomes is important for companies exposed to the markets, or policy makers evaluating the markets.

Results

Standard EG methodology on the bivariate relationships show we are not able to prove a CI(1,1) relationship between the LPGs and either oil or natural gas. We therefore continue with incorporating the MS model into the cointegration equations. In our analysis we incorporate the LPGs as endogenous variables, and WTI or NG as exogenous variables. We assume a two-regime model, although more regimes are possible.

Our results indicate that by accounting for regime shifts, all four variables are cointegrated in a bivariate setup. The probabilities in the transition matrix are all above 0.98 indicate that the holding time after entering a regime is large.

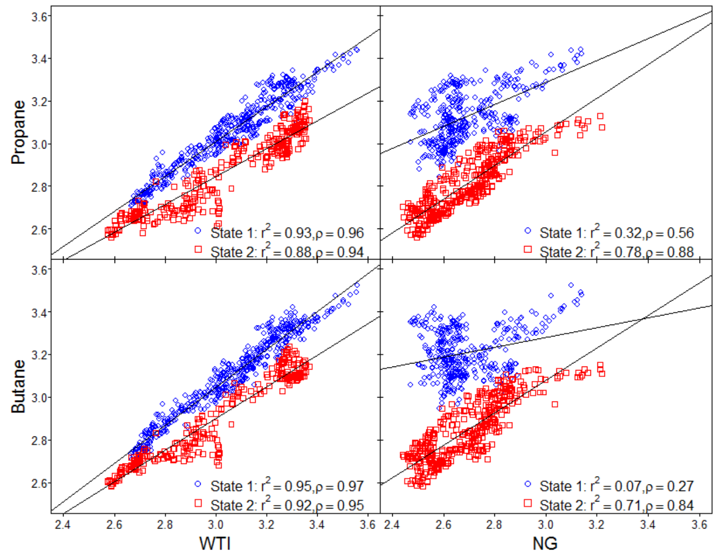

Figure 1: Scatter plot of the ordered par between the price series adjusted for regime shifts.

We include a scatter-plot of the log-price in Figure 1 displaying the relationships between LPGs on the y-axis and crude and NG on the explanatory x-axis. We have divided the points into which state the MS model has put them in with all smooth probabilities above 0.5 serving as state one. As indicated by the least-squares lines there are a clearly positive relationship between all four price series in both regimes after adjusting the long-term equilibrium model to regime shifts.

Conclusions

Based on the general assumption of integrated energy markets, this paper show that this is not the case for some energy commodities unless the possibility of regime shifts are taken into account. By incororating the Markov Switching methodology into the classical Engle-Granger cointegration methodology, we are able to model a long-term relationship between two liquefied petroleum gases, crude and natural gas from the U.S. market. Our results indicate that there is a long-term relationship between all four prices. A price shock to this market is therefore gradually adjusted back to equilibrium.

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