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The crucial relationship among energy commodity prices: Evidence from the Spanish electricity market

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ABSTRACT

The main purpose of this article is twofold to analyze: (a) the long-term relation among the commodities prices and between spot electricity market price and commodity prices, and (b) the short-term dynamics among commodity prices and between electricity prices and commodity prices. Data between 2002 and 2005 from the Spanish electricity market was used. Econometric methods were used in the analysis of the commodity spot price, namely the vector autoregression model, the vector error correction model and the granger causality test. The co-integration approach was used to analyze the long-term relationship between the common stochastic trends of four fossil fuel prices. One of the findings in the long-term relation is that the prices of fuel and the prices of Brent are intertwined, though the prices of Brent ten to "move" to reestablish the price equilibrium. Another finding is that the price of electricity is explained by the evolution of the natural gas series.

1. Introduction

The recent volatility of the price of crude oil–gas, fuel oil–coal, fuel oil–gas and gas–coal has led some to question whether or not a stable long-term relationship between the prices of crude oil and other commodities truly exists. However, in the long run, it is important to account for electricity generating technologies considering that fuels compete on a cost basis in electricity production. In order to understand why coal, crude oil and gas prices sometimes diverge from their long-term equilibrium, it is also important to control for various short-term factors that establish trends in the prices of electricity and other commodities.

Theories suggest that fuel substitution capabilities within the electricity sector, either at plant level or grid level, should contribute to the co-movement of commodity energy product prices. In addition, substitutability between crude oil, coal and gas products in the industrial sector, through direct use and cogeneration of electricity, can also influence the commodity price relationship. In Spain, the total electricity output consists of thermal power, hydroelectricity and nuclear power, among others. Thermal power accounts for over 80% of the total generating capacity whilst hydroelectricity accounts for around 15% (Crampes and Fabra, 2005). Therefore, the fluctuation of oil and coal prices has a great impact on the electric power industry.

Since 1997, Spain has gradually liberalized the electricity market. Therefore, fuel, gas and coal prices should fully reflect their resource costs, production costs, environmental costs, and market supply and demand situations. This is an adjustment of the irrational commodity prices in the market economy. An increase in the price of electricity could lead to an increase in the price level in the whole economy, since the connection between the prices of fuel, gas and electricity has not yet been implemented. The price of electricity does not reflect the increases of fuel prices. Thus, the increased costs caused by each commodity price should be absorbed by the power companies themselves.

Fuel cost is the most important cost item in thermal power plants, accounting for 70% of the variable costs (Crampes and Fabra, 2005). The increase in coal prices, especially when used for electricity generation, directly increases the operating costs of the enterprise and reduces corporate profits. Under such a dramatic price increase, the costs for electric power firms increased vastly, and many electric power companies incurred losses (Crampes and Fabra, 2005). In this case, an increase in the price of electricity in order to improve the operating conditions of power firms was a necessary measure. This ensures power supply and alleviates the coal–electricity price contradiction. It is also very important to analyze the impact of the coal price increase in the electric power sector, in particular, on the total costs for the electric power sector when the electricity price policy was being developed.

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A certain degree of non-constant volatility and a strong connection to the seasonal cycle are important characteristics of Spanish electricity spot market pricing. Mean reversion is known as the process by which prices return to a seasonal level after fluctuations. When there are particularly large increases, they are labeled jumps. In extreme cases, they are labeled spikes (Crampes and Fabra, 2005), which are abrupt or unanticipated price peaks that cross a certain threshold for a certain length of time. As referred by Jensen and Wobben (2009), these characteristics can be traced back to the cost of storing electricity and the fact that randomly occurring outages in generation and infrastructure capabilities have a more extreme effect on the price. However, Jensen and Wobben (2009), also refer to the fact that electricity markets are often able to correct strained supply conditions within 24 h, which is the time period between day-ahead auctions. This occurs due to additional imports and the activation of additional power sources.

Also important in spot market prices is the low installed price rate, usually 0 per unit. This is the case of Brent, oil, gas, carbon and fuel oil since they have limited storage capabilities.

This paper addresses the following questions: (1) is there a unique long-term relationship among commodity prices and between spot electricity price and commodity prices? If so, what is the nature of those relationships? (2) What are the short-term dynamics among commodity prices and between electricity prices and commodity prices? In what direction do they flow? (3) How important are the pricing strategies in each commodity market in explaining the variations in the Spanish spot electricity prices?

To the best of our knowledge, the causal relationship among gas, oil, coal and fuel in the electric Spanish market has not yet been studied. The purpose of this paper is firstly, to analyze the causal relationship among commodity prices and secondly, to analyze if the price relation between gas, oil, coal and fuel capture possible different long or short-term dynamics on the prices of electricity. The existence of a co-integration relationship provides arbitraging opportunities among the various commodities. This is crucial for pricing electricity involving a couple of commodities as well as investments options. We investigate the price dynamics among commodity prices and between electricity and commodity prices as well as major sources (fuel oil, gas, coal, Brent) by estimating a causal model for the price dynamics. In this sense, Spanish reservoir levels and Spanish electricity production from wind mills are treated as exogenous variables. Moreover, if there is a short-term departure from the long-run equilibrium forces will act to bring prices back into their long-run equilibrium.

2. Relevant literature

The relationship between fuel fossil prices has been largely investigated using different sets of historical data and different methodologies. De Vany and Walls (1995) analyze the degree of regional co-integration in the North American gas markets and describe the dynamic evolution of the prices within these markets. These illustrate a growing level of interconnections between markets as well as an increase of the shock absorbing velocity of prices within gas markets, thus, decreasing the efficiency of arbitration mechanisms. On other hand, the Engle–Granger co-integration tests (Engle and Granger, 1987) have evidenced the integration of natural gas spot prices as well as, the expansion of access to gas reservations through network connections between regional American markets.

King and Cuc (1996) analyze the strength of the co-integration of spot prices between different gas producers' basins in eight regional markets in North America. These were studied between the mid-1980s to the mid-1990s. The inferred results on the analysis of the varying parameter indicate an emerging price convergence within regional markets allowing for the price arbitrage within the eight North American regional markets. However, the same results also demonstrate a blunt division of the East–West regional natural gas prices. Serletis and Herbert (1999) use North American natural gas, fuel oil and power prices from 1996 to 1997 to show that natural gas prices and fuel oil prices are co-integrated, whereas power price series appear to be stationary.

Asche et al. (2000) investigate the co-integration degree of gas markets for France, Germany and Belgium. Their results demonstrate that the national gas markets of France, Germany and Belgium are highly integrated. Between January 1990 and December 1999, they investigated the time series of Norwegian, Dutch and Russian gas and the export prices to Germany, concluding that the German market is integrated. The results of Johansen's multi-varied model show that the three gas supplier countries compete closely in the same markets as prices move in the same direction through time but in different levels of range.

Gjolberg (2001) examine the existence of a medium and long term correlation between electricity and fuel oil in Europe. However, natural gas, crude oil and electricity prices result in co-integration. Crude oil is identified as having a leading role between 1995 and 1998, in other words, during an interim period after the deregulation of the UK gas market in 1995.

Ewing et al. (2002) using daily indexes from April 1, 1996 to October 29, 1999, evidence the behavior of stock prices in major companies within the oil and natural gas markets. Their bivariate model indicates significant diffusion of volatility from the natural gas sector to the oil sector. They also demonstrate that volatility is often interpreted as a proxy for information flow.

Emery and Liu (2002), using daily data from March 29, 1996 to March 31, 2000, note that future prices of electricity and natural gas are co-integrated.

Asche et al. (2002) analyzed the integration of Norwegian, Dutch and Russian natural gas markets. For this purpose, they applied Johansen's multi-varied methodology in order to construct econometric models for monthly exportation prices from those countries to Germany (from January 1990 to December 1997). . The results demonstrate that the suppliers/producers of gas in the three markets compete between them in the German market. Furthermore, the prices of their long-term relations, although different in proportional price range levels, have a tendency to move in the same direction over time.

From April 1997 to July 2000, Bessembinder and Lemmon (2002) studied the volatility of the electricity market in Pennsylvania, New Jersey and Maryland (PJM), concluding that this volatility was approximately 34% per day. By comparing this value to the daily volatility of the S&P 500 profitability index, it is possible to conclude that the observed value of the volatility in the PJM market is higher than the observed value in S&P 500 index (5.7% a day on S&P 500 daily profitability during one of the most volatile months, October 1987).

Huisman and Mahieu (2003) demonstrate that the evolution of electricity prices present a high daily volatility. It is normal to observe daily volatilities of 29% in the electricity market as opposed to the annual volatility of 20% in financial assets.

Serletis and Rangel-Ruiz (2004) infer that deregulation has weakened the relationship between U.S. crude oil and natural gas prices, thus, rejecting the hypothesis of common and co-dependent cycles between the prices. This leads them to conclude that the prices have been "decoupled".

Goodstein (2004) reveals that forward market prices do not constitute a prediction for future price levels. Future prices, added with the spot prices, inform the market about the availability