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Energy price transmissions during extreme movements☆

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ABSTRACT

This paper investigates price transmissions across European energy forward markets at distinct maturities during both normal times and extreme fluctuation periods. To this end, we rely on the traditional Granger causality test (in mean) and its multivariate extension in tail distribution developed by Candelon, Joëts, and Tokpavi (2013). Considering forward energy prices at 1, 10, 20, and 30 months, it turns out that no significant causality exists between markets at regular times whereas comovements are at play during extreme periods especially in bear markets. More precisely, energy prices comovements appear to be stronger at short horizons than at long horizons, testifying an eventual Samuelson mechanism in the maturity prices curve. Diversification strategies tend to be more efficient as maturity increases.

1. Introduction

Energy price dynamics are known to be frequently volatile with extensive amplitude affecting the whole economy (Edelstein and Kilian, 2007; Hamilton, 2003; Kilian, 2008a,b; Sadorsky, 1999, among others). In the literature, these fluctuations are attributed to both real and financial factors, such as international energy demand/supply conditions and market manipulation (Creti et al., 2013; Hamilton, 2009; Joëts, 2013; Kaufmann and Ullman, 2009; Kilian, 2008a,b; Kilian, 2009; Kilian and Murphy, 2012, forthcoming; Lombardi and Van Robays, 2011 among others), leading to extreme market risks for energy participants and governments. Moreover, energy markets have recently experienced significant developments likely to influence price dynamics. European gas and electricity markets, initially monopolistic, have become competitive due to the recent deregulation process, allowing the emergence of new contracts making prices more influenced by participants than regulators (Mjelde and Bessler, 2009). In this light, market volatility may increase and the quantification of the maximum prices appears to be primordial in risk management for one's ability to make proper investment, operational, and contractual decisions.

Due to the globalization process, economies are related to each other notably through trade and investment, so any news about economic fundamentals in one country most likely have implications in other countries (Ding et al., 2011; Lin et al., 1994, among others). From a general viewpoint, this perspective may obviously be extended to energy market behaviors which are known to be interrelated through production, substitution and competitive processes. Indeed, several studies have validated the fact that oil, gas, coal and electricity prices may be interconnected in the long run (Bachmeier and Griffin, 2006; Joëts and Mignon, 2011; Ma and Oxley, 2010; Mjelde and Bessler, 2009; Mohammadi, 2009, among others). However, previous analyses mainly focus on "regular" time[1] fluctuations without considering periods of extreme price movements (upward and downward) whereas energy prices are often characterized by intense dynamics. The general feeling along this way is that correlations between assets tend to be stronger during excessive fluctuation periods. This phenomenon, which has been largely studied in the financial literature[2] suggests that comovements are larger when we focus on large absolute-value returns, and seem more important in bear markets. Under this market-comovement scenario, price movements are driven by fads and a herd behavior may be transmittable across markets (in the sense of Black, 1986; Delong et al., 1990). High volatility is therefore coupled with highly interrelated markets making diversification almost impossible under uncertain movements. These comovements in absolute price changes are often associated with belief dispersion (Shalen, 1993) resulting in a lack of confidence in market fundamentals. When new information occurs, distinct prior beliefs give incitation to trade leading to price changes. When traders revise their prior beliefs according to new information, it takes time for the market to "resolve" these

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[1] Regular periods are subjectively defined by times of low fluctuations.

[2] See King and Wadhwani (1990), Lin et al. (1994), Longin and Solnik (1995), Karolyi and Stulz (1995), Longin and Solnik (2001), Ramchand and Susmel (1998), Ang and Bekaert (2002), Hong et al. (2007), Amira et al. (2011), and Ding et al. (2011) to name few.

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heterogeneous behaviors which contribute to volatility clustering (Lin et al., 1994; Shalen, 1993 among others). Thus, the diversification strategy aiming at limiting the impact of excessive movements would be almost impossible because of the market's integration, whereas it has more sense in "regular" times. As periods of extreme high energy prices have been proved to be economically detrimental (Oberndorfer, 2009; Sadorsky, 1999, among others), this paper proposes to extend this issue by analyzing energy price comovements during periods of erratic fluctuations. This phenomenon would have important macroeconomic and microeconomic implications since absence of diversification can lead to heavy potential losses for market participants and governments. For instance, from a macroeconomic viewpoint, a perfect perception of price movements and market risk are of primary importance for policy targeting of energy-importing or exporting countries. At a microeconomic level, the price behavior, market risk and their potential transmission mechanisms are relevant to evaluating real investment decisions using the well-known asset pricing model.

In order to apprehend extreme movements, the Value-at-Risk (VaR) approach is an important tool and is widely used in financial markets.[3] VaR is often used to measure market risk with a single numeric value by means of the probability distribution of a random variable. It is defined as the expected maximum loss over a target horizon for a given confidence interval (see Jorion, 2003). Due to the strong volatility of commodity markets, this methodology has been recently extended to oil markets—see, Cadebo and Moya (2003), Giot and Laurent (2003), Feng et al. (2004), Sadeghi and Shavvalpour (2006), and Fan et al. (2008)—and to the oil and gas markets—see, Aloui and Mabrouk (2010)— which evaluate the risk losses in WTI, Brent crude oil and gas markets using different techniques (Historical simulation standard approach, RiskMetrics (RM), variance–covariance method based on various GARCH models, among others). However, these methodologies are quite restrictive because they are based on several strong assumptions. For instance, the nonparametric historical simulation approach is based on a time-constant returns unconditional distribution and fractile. The parametric RM approach is based on the linear risk and the normality of price changes, which is not consistent with the market reality. Finally, GARCH methodologies suffer from the positivity and/or symmetry constraints often imposed on the coefficient parameters.[4] We improve this literature by considering extreme movements (upward and downward) of European oil, gas, coal and electricity markets using the semiparametric Conditional Autoregressive VaR (CAViaR) approach developed by Engle and Manganelli (2004), which is considered to be less restrictive than other methodologies.[5]

Despite the apparent market globalization, transmission effects among energy markets during extensive periods have been scarcely studied. Lin and Tamvakis (2001) first studied spillover effects among NYMEX and IPE crude oil contracts in both non-overlapping and simultaneous trading hours, and found significant transmission effects. However, they do not use the crucial information about the quantile of the distribution, which is of primary importance to apprehend tremendous variations.[6] More recently, Fan et al. (2008) evaluate the market risk of daily Brent and WTI crude oil returns from May 20th, 1987 to August 1st, 2006 using a GED–GARCH model. They examine the downside and upside extreme risk spillover between both markets using the Granger causality test developed by Hong et al. (2009). Results show that the VaR model based on GED method performs relatively well, and that the WTI and Brent returns have significant two-way causality effect in both downside and upside risks at 95% or 99% confidence levels. Further analysis reveals that at the confidence level of 99%, the WTI market risk information can help to forecast extreme Brent market risk when negative news occur, but the reverse effect does not exist. However, their results are based on a restrictive parametric GARCH approach which is again not consistent with market reality, and authors investigate risk spillover at specific confidence level (95% and 99%) while the information in tail distribution is of primary importance.[7] To overcome this problem, Candelon et al. (2013) (hereafter CJT) develop a multivariate extension of the Granger causality test in distribution tails and use this specification to investigate international market globalization during periods of extreme price movements of 32 crude oil weekly prices on the period from April 21, 2000 to October 20, 2011.

In this paper, our aim is to investigate energy price return transmissions during both "normal" and extreme fluctuation periods by using the traditional Granger causality test (in mean) and its multivariate CJT extension — the latter focusing on causality in distribution tails rather than quantile at specific level. Relying on European forward energy prices rather than spot data, we purge short-run demand and supply from noise that affects market fluctuations and account for both fundamental and speculative pressures (Joëts and Mignon, 2011).[8] Because comovements between markets can vary considerably over time and in order to see if diversification can be more profitable as maturity increases, we propose to investigate forward price transmission mechanisms at 1, 10, 20, and 30 months.

We find that energy price return relationships increase during periods of extreme movements, especially in bear markets circumstances. Indeed, while almost no causality exists during "normal" times, price comovements are higher during market downturns as compared to upturns. This phenomenon leads to asymmetric interactions in energy price returns, showing that energy markets behave as stock markets making diversification almost impossible during high volatility periods. However, this phenomenon tends to disappear as maturity increases, indicating that diversification could be more profitable at longer horizons (such as 20 and 30 months).

The rest of the paper is organized as follows. Section 2 describes the econometric methodology. The empirical part is provided in Section 3, and Section 4 concludes the article.

2. Model specification and extreme risk causality test

2.1. CAViaR model

Energy price returns are known to be extremely volatile with clustering phenomenon. These characteristics were well modeled by Engle (1982) and Bollerslev (1986) using ARCH and GARCH models. These models have become common tools to measure market risk using VaR approach due to their relative simplicity and various extensions. However, they are also well known for their limitations such as unrealistic parametric assumptions (normality or i.i.d returns). To overcome these issues, we rely on the semiparametric CAViaR approach developed by Engle and Manganelli (2004) to estimate energy VaR models which does not require any of the extreme assumptions invoked by existing methodologies. In short, this approach has the particularity to estimate directly VaRs using an autoregressive specification for the quantiles rather than inverting a conditional distribution of returns as usual in a purely parametric framework. This autoregressive evolution of the quantile over time and unknown parameters are then determined by the regression quantile framework introduced by Koenker and Basset (1978). Besides, the autoregressive nature of the CAViaR captures directly in the tails of the distribution some stylized facts in empirical finance, such as autocorrelation in daily returns arising from market microstructure biases and partial price adjustment (Ahn et al., 2002; Boudoukh et al.,

[3] One of the main advantages of VaR cited in literature is its user friendly way to concisely presentquery risk supported by the regulatory authorities.

[4] Recent GARCH approaches have been developed to remove these assumptions, such as E-GARCH, GJR–GARCH, and GARCH models under a Student-t distribution to name a few.

[5] See Section 3.

[6] According to Gouriéroux and Jasiak (2001), volatility cannot be considered as a satisfactory measure of risk when extreme market movements occur.

[7] According to Engle and Manganelli (2004), dynamics of VaRs can vary considerably across risk levels.

[8] Indeed, the forward energy markets can result in both physical delivery and speculative purposes.

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