International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2019, 9(3), 229-243.

Is there a "Reverse Causality" from Nominal Financial Variables to Energy Prices?

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Received: 02 January 2019 **Accepted:** 22 March 2019 **DOI:** https://doi.org/10.32479/ijeep.7526

ABSTRACT

This paper is aimed at examining the association between energy prices and financial variables, but, in contrast to previous works, it explores the possibility of a reverse causality from financial variables towards energy prices from a global perspective considering the world's four largest world economic poles (the United States, China, the European Union, and Japan), as well as the prices of oil (Brent) and Natural Gas. In order to study the interaction between energy prices and relevant nominal variables (stock market returns, interest rates, and exchange rates), a panel vector autoregression analysis is carried out. The empirical finding is that Brent oil and natural gas price fluctuations are positively and highly significantly influenced by lagged interest rates, that is, energy markets are sensitive to monetary policy signals and, most likely, to economic agents' expectations about inflation. Other empirical results also reveal that: (1) Lagged exchange rate fluctuations have a negative and significant effect over the stock market; (2) a positive performance of the stock market has a negative effect on the exchange rate, and: (3) That interest rate markets follow their own dynamics independently of the rest of the model variables.

Keywords: Energy Prices, Stock Market Returns, Interest Rates, Exchange Rates
JEL Classifications: G10, G15, E43, F31

1. INTRODUCTION

In recent years, a large number of empirical studies have addressed the relationship among international oil prices, financial markets and economic variables. Among those studies, one of the most prolific strands of the literature centers on the subject of the influence of oil prices on stock markets performance; for example: Chen et al. (1986), Jones and Kaul (1996), Chiou and Lee (2009), Arouri et al. (2011), Demirer et al. (2015), Abhyankar et al. (2013), Aloui and Aïssa (2016), Aali-Bujari et al. (2018), and other relevant and thoroughly explored research area has to do with the relationship of energy prices and financial and economic variables. For example: On the incidence of oil prices on interest rates and exchange rates (e.g., Bal and Rath, 2015; Selmi et al., 2015; Kim and Jung, 2018; Aali-Bujari, et al., 2017; and Salazar-Núñez and Venegas-Martínez, 2018; 2018b); on macroeconomic variables, both at a domestic and at a global level, (e.g., Hamilton, 1983; Barsky and Killian, 2004; Hamilton, 2009; Ozturk, 2010; Blanchard and Galí, 2010; Chatrath et al., 2012; and Ahmadi et al. 2016); on channels of interaction between oil prices and different economic sectors (e.g., Davis and Haltiwanger, 2001; Brown and Yudel, 2002; Lardic and Mignon, 2008; and Wattanatorn and Kanchanapoom, 2012); on the relationship between oil prices and monetary policy response (e.g., Bernanke et al., 1997; Kilian and Lewis, 2011; and Bodenstein et al. 2013); and, still others, have argued that the behavior of oil prices is not completely exogenous, but that it responds to a variety of stimuli that simultaneously affect the world economy and the energy markets (Barsky and Killian, 2004).

In spite of the above abundant research on the subject, until now very little attention has been paid to explore the possibility of a reverse causality between nominal financial variables and energy prices. This work empirically addresses such relationship by considering a global perspective that includes the world's four largest economies or economic areas (the United States, China, the European Union, and Japan), and the prices of oil (Brent) and Natural Gas. In order to study the interaction between energy prices, and relevant financial variables (stock market returns, interest rates, and exchange rates), this research carries out a panel vector autoregression analysis (PVAR) (Holtz-Eakin et al., 1988; Love and Zicchino, 2006; and Abrigo and Love, 2016).

The main empirical finding is that Brent Oil and Natural Gas price fluctuations are positively and highly significantly influenced by lagged interest rates. That is, energy markets are sensitive to monetary policy signals and, most likely, to economic agents' expectations about inflation.

The obtained empirical results also reveal that: (1) Lagged exchange rate fluctuations have a negative and significant effect over the stock market returns; (2) a positive performance of the stock market has a negative effect on the exchange rate, and; (3) interest rate markets follow their own independent dynamics, that is, they do not respond to the rest of the model variables' influence. Additionally, Brent oil lagged fluctuations have a negative effect on next day's Brent fluctuations, and lagged Natural Gas fluctuations have a positive influence on oil. Finally, Natural Gas prices are negatively influenced by lagged Brent oil prices and positively influenced by their own lagged price changes.

Based on several tests, it is possible to conclude that the influence that energy prices have over the stock market, the exchange rate, and the interest rates of the four largest world economic poles is neither statistically nor economically significant, in agreement with, for example, Chen et al. (1986), Huang et al. (1996), Apergis and Miller (2009), Ghosh and Kanjilal (2016), and Zhang (2017), among others.

Thos paper is organized as follows. The following section presents a brief literature review, classifying several representative studies on the influence of energy prices on financial nominal variables according to their economic context. Section 3 discusses the world economic environment and the evolution of the variables of under study during the sample period (January 5, 2005 through December 30, 2016). Section 4 addresses the methodological issues, the database, the estimation results and their interpretation and discussion. Finally, section 5 concludes and highlights important implications of the empirical findings.

2. A BRIEF LITERATURE REVIEW

An argument initially put forward in the work of Miller and Ratti (2009) postulates that crude oil is an important input for a large variety of industries and, for that reason, its price fluctuations directly affect the cost composition of many productive processes. Natural gas price fluctuations play a similar role, probably on a narrower spectrum of economic activities, but with very similar consequences. Since energy price changes have a direct effect on corporations' cash flows, they should have an incidence on their stock performance in the market. Nonetheless, the interrelationship between the effects of energy prices on economic activity and the stock market performance of publicly traded companies' shares can only be separated conceptually for analytical purposes since they effectively interact all the time. However, only a few studies have captured their real-world complex and complementary interaction. One possible explanation of that analytical bias has to do with the fact that energy prices not only affect the cost structure of productive activities, but also have consequences over inflation and monetary policy, as well as a significant influence on other commodity market prices, each deserving special attention.

The interest of the present study is on the association between energy prices and financial variables but, in contrast to previous studies, it explores the possibility of a reverse causality from financial variables towards energy prices. For that reason, the aims of this literature review are purposely circumscribed to some representative studies that analyze how do energy prices interact with the stock market, the exchange rates and interest rates, and briefly refers to the few studies that suggest the possibility of an influence from nominal variables over energy prices.

2.1. Oil Price and the Stock Market Relationship in the United States

To the present, most published empirical studies on the relationship between oil prices and the stock market have been centered on the United States markets, which is not surprising given the large number of public firms that exist and the abundant availability of detailed statistical and financial information. However, more recently, the interest on how energy prices interact with financial markets has widened to include the most developed and an increasing number of emerging countries.

Among the first studies that incorporate the impact of oil prices on financial assets prices is that of Chen et al. (1986) that finds that a number of macroeconomic and financial factors representing sources of risk for the stock market are significantly priced by the stock market, including spreads between long and short interest rates, inflation (expected and unexpected), industrial production, and the risk premium spread between high- and low-grade bonds. However, they also find that oil price volatility is not independently rewarded in the market.

According to Huang et al. (1996) the prominent role that oil plays in the economy and the politics of industrialized countries justifies the large number of studies that have been devoted to the study of energy and its effects on the macroeconomics. Among the most relevant studies are those on the negative relation between oil price increases and real GNP (as documented by Hamilton, 1983; Mork et al.[1], 1994; and Gilbert and Mork[2], 1986). However, the consequences of energy shocks on financial markets had been scarcely researched.

1 Mork et al. (1994) extend their conclusions to other countries different from the United States.

2 Gilbert and Mork (1986) analyze the macroeconomic effects of oil supply disruptions.

Huang et al. (1996) study the impact of oil price shocks on the United States stock market from the perspective of the dynamic interactions between oil futures prices traded on the New York Mercantile Exchange and stock prices, using a multivariate VAR model to explore the possibility of lead, lag and feedback effects. The possible linkages between oil prices and stock market are examined at three levels: First, for a wide stock price index, the S&P 500 index; second, for twelve equally weighted stock price indices based on stocks classified according to the first two digits of their SIC codes; and, third, for three individual oil company stock price series (Chevron, Exxon, and Mobil). Their conclusions are that, contrary to the often-cited relevance of oil for economic activity, there is limited evidence that a link exists with the stock market, except for oil companies, for which they report the presence of significant Granger causality from oil futures (something to be expected). Huang et al. (1996) conclude that given the lack of correlation between oil futures and stock markets, the former represent an attractive vehicle for diversifying stock portfolios.

Sadorsky (1999), on the basis of the results of a VAR model with monthly data for the United States, reports that oil prices and oil price volatility combine to affect real stock returns, and that the structural nature of the relationship changed after 1986. As of that moment, the reported evidence shows that oil price changes explain a larger fraction of the error variance in real stock returns than interest rates. This study also reports evidence that oil price volatility shocks have asymmetric effects on the economy. The findings of Ciner (2001) are consistent with those from Sadorsky (1999) regarding the influence of oil shocks on stock returns, and challenge the findings of Huang et al. (1996). In effect, he argues that Huang et al. (1996) conclusions are due to the fact that they only focus on linear dependencies, and tests for linear and nonlinear causality between oil futures and the S&P500 for the 1980s (same data as Huang et al., 1996) and for the 1990s to find that oil price shocks do affect the returns of the S&P500 in a nonlinear fashion. Notably, this study is among the few that finds that there is a feedback relation between the S&P500 index and oil futures prices during the 1990s.

On the other hand, Chiou and Lee (2009) examine the asymmetric effects of oil price changes on stock returns and explore the importance of structural changes in that relationship. Using daily data on the S&P500 and the price of West Texas Intermediate oil from 1992 to 2006, they incorporate expected and unexpected oil price fluctuations into a model of stock returns. These authors also explore the way that oil price volatility can influence the stock market. Based on the results of an Autoregressive Conditional Jump Intensity model with structural changes, they report that high oil price fluctuations have unexpected asymmetric impacts on the S&P500 returns.

Based on the results of a time-varying transition-probability Markov-switching model to characterize bull versus bear markets as a function of oil prices, Chen (2010) explores if higher oil price increases the probability that the stock falls into bear territory. The results of their analysis, which are tested for robustness, suggests that increases in oil prices raise the probability of a bear market emergence. Their work also finds that further increases in oil price also augment the probability that the market remains in a bear mood.

The work of Narayan and Sharma (2011) is exceptional in the sense that instead of studying the relationship between oil prices and the stock market, it explores the relationship between oil price and 560 individual firms listed in the NYSE with the aim to determine whether oil prices affect different sectors of economic activity differently. They use three versions of a GARCH (1,1) model and report that, indeed, oil price fluctuations affect the price of different economic sector stocks differently. These authors also report strong statistical evidence of oil price effects on stock returns with lags for all the firms in the sample which, in a sense, corroborates that there is underreaction to information arrival in the short-run, i.e., "the effect of information is felt after some time" (as in Hong and Stein, 1999), and that the lagged effect is maximized at two lags for six productive sectors including chemicals, electricity, general services, manufacturing, supply, and transport. Another objective proposed in their paper is to examine if the relationship between oil price changes and individual firm stock returns is related with firm size, which they attempt by subdividing their sample in size-quartiles and then calculating the relative frequency with which oil price is found to have a statistically significant positive and negative effects on a firm's stock returns in each quartile. Along with the main findings, the paper reports that, in most cases, small firms stock returns are positively related with oil price, contradicting the initial findings that for the whole sample, in which the relation is negative. Also, as the size of firms increases, for firms in which oil price has a statistically significantly negative relationship, the magnitude of such relationship grows by a factor of three times.

Kang et al. (2015) estimate the impact of oil price shocks on the return and volatility of the United States stock market by constructing, from daily observations, the covariance of return and volatility on a monthly basis. They measure daily volatility as realized volatility, conditional volatility from a stochastic volatility model, and implied-volatility deduced from options prices, and find that positive shocks to aggregate demand are associated with negative effects on the covariance of returns and volatility, while supply disruptions have positive effects on the covariance of returns and volatility. Their study also reports a large and highly statistically significant spillover index between oil price shocks and the covariance of stock returns and volatility.

Narayan and Gupta (2015) study monthly time series of oil prices and the United States stock market for a period of 150 years (from October 1859 to December of 2013). This exceptional characteristic in terms of the length of the observation period makes it the first analysis of its kind. These authors are interested on the relationship between oil price and stock returns, and engage in an analysis based on a time-series predictive regression model originally developed by Westerlund and Narayan (2012) and Westerlund and Narayan (2015). This modeling is capable of accommodating the persistency and endogeneity of oil prices, and any heteroscedasticity present in the regression model. The analysis is conducted both in-sample and out-of-sample and tests whether oil price nonlinearly is capable of predicting stock returns. The main findings of their work are that oil price "is a persistent and endogenous predictor variable," and the hypothesis of no stock return predictability can be rejected. Also, find that while oil prices predict the returns of the United States stock market, that predictability is "non-linear" in the sense that negative oil price changes predict stock returns better than positive changes.

As is clear from the sample of studies reviewed in this section, most of them find that oil shocks have a negative impact on the United States stock markets.

2.2. Regional Studies on the Relationship between Oil Prices and the Stock Market in Developed Countries

Several studies that address the relationship between the dynamics of energy prices dynamics and the performance of stock market have followed either a multinational perspective or a more regional/country focus, widening the available evidence on the interaction between these variables. In what is already considered a classical study on the subject, Jones and Kaul (1996) revise whether the response of international stock markets returns to shocks in oil prices is justified by changes to current and future real cash flows and expected returns. They find that, during the years after the Second World War, the response of the United States and Canadian stock markets to oil shocks may be completely accounted for by cash flow and expected return changes induced by oil shocks. However, that is not the case in the United Kingdom and Japan, where oil price shocks induce a greater response than that attributed to expected changes in cash flows and returns.

In a country level study, Papapetrou (2001) attempts to clarify the dynamic relationship among oil prices, real stock prices, interest rates, real economic activity and employment in Greece by running a multivariate VAR model. The results indicate that oil price changes have an influence on real economic activity and, as a consequence, on employment levels. The empirical evidence suggests that oil price changes affect real economic activity and employment and they are also capable to explain stock price movements.

Park and Ratti (2008) argue that if oil price shocks affect consumer and firm's behavior (as documented in, for example, Hamilton, 1983; Barsky and Killian, 2004; Blanchard and Galí, 2010; and Chatrath et al., 2012), it follows that the effects of oil price shocks should be reflected on the world stock markets. To contrast their hypothesis, they use a multivariate VAR model with linear and non-linear specifications of oil shocks, and study the impact of oil price shocks on the stock returns of the United States and thirteen European stock markets, from 1986 to 2005, to find that there is a significant contemporaneous association (and next-month association) between the two variables. They also insist on the convenience to consider the effect of oil price fluctuations in different national markets in order to identify cross-country effects that may be systematic in nature. Interestingly, they report that in the case of Norway, an oil exporting country, there is a positive statistically significant real stock market return response to oil price advances, consistent with the logic that the country receives larger rents when oil prices increase. By contrast, for many European countries' stock markets, the response to increases in oil price volatility is negative.

Lescaroux and Mignon (2008) investigated the relationship between oil prices and different macroeconomic and financial variables for a large sample of countries that includes oil-importers and oil-exporters. These authors study both short- and long-run relationships by means of Granger-causality tests, and evaluate cross correlations between the cyclical components of the series to detect leads and lags, and to carry out a cointegration analysis. The main findings reported include evidence on the short-run link between oil prices and the stock market, as well as the presence of Granger-causality from oil prices towards other macroeconomic variables in the long-run.

According to Driesprong et al. (2008), oil price fluctuations represent a reliable predictor of stock market returns, and the evidence reported in their work indicates that significant predictability is found in both developed and emerging markets. Using stock market data from 48 countries, a world stock market index, and prices of different types of oil, they find that stock returns are lower after oil price increases and higher when oil prices fall in the previous month. They report that this predictability is not only statistically significant but also economically significant. Instead of accepting the argument that such results are a consequence of time-varying risk premia, they argue that their evidence is consistent with an underreaction hypothesis "as it appears to take time before information about oil price changes becomes fully reflected in stock market prices," and suggest that their findings can be explained under the "gradual information diffusion hypothesis" of Hong and Stein (1999).

Apergis and Miller (2009) study specific structural shocks that, characterize oil prices fluctuations as endogenous impact stock-market returns in 8 industrialized countries. First, they decompose unexpected real oil-price changes into mutually orthogonal components and classify them as produced by oil-supply shocks, global aggregate-demand shock, and global oil-demand shocks, and then they run VAR and VECM models that includes global oil production, global real economic activity, and real oil prices, to estimate what are the effects of structural shocks on the stock market returns. The reported results in their study suggest that the sample stock market returns are not sensitive enough to oil market shocks. i.e., they are significant but small in magnitude.

Ghorbel et al. (2014) examine behavioral contagion between oil prices, the United States stock market, and stock markets of oil-importing and oil-exporting countries during the oil shock and the Global Financial Crisis of 2008-2009, with a tri-variate BEKK-GARCH model that includes the VIX, oil prices and returns of stock market indices of 22 oil-importing and -exporting countries, adding up the United States. They examine the spillover of volatility between oil market prices and stock market, and find that there exists a volatility spillover of American investor sentiment towards the stock market returns and the oil market returns. The pure contagion effects between the oil market and stock markets are captured by using the Kalman filter, independent of the macroeconomic fundamental factors. By analyzing the dynamic correlation between the forecasting errors of oil price returns and the stock indices returns, these authors find there was a sharp increase in the time-varying correlation coefficients during the oil crisis and the global financial crisis, which represents supporting evidence of the idea that there was a herding-behavior contagion between the oil market and the several stock markets in the sample during the period of analysis. Specifically, the authors consider investor-sentiment and herding-bias to explain the volatility transmission between oil and stock market returns.

An alternative approach that explains oil price shocks effects, considering both world oil production and world oil prices, with the aim to disentangle oil supply from oil demand shocks is suggested by Cunado and Perez de Gracia (2014). They analyze the influence of oil price shocks on the stock returns of twelve European oil-importer countries with VAR and VECM models for the period between 1973 and 2011. Their main findings are that the response observed varies greatly depending on the nature of the oil price change, which confirms that there are statistically significant negative sensitivities among most European stock market returns. Furthermore, they find evidence that European stock market returns are mostly affected by oil supply shocks.

"Finally, Zhang (2017) implements a methodology that was developed in previous work by Diebold and Yilmaz (2009, 2012 and 2014) to analyze the relationship between oil shocks and returns for six major stock markets, and combines it with a rolling windows analysis to find that that the contribution of oil shocks to the world financial system is limited, but can occasionally contribute significantly to stock markets. He also proves that only large shocks matter."

2.3. Oil, Exchange Rates and Interest Rates

A few studies have specifically tackled the relationship between oil prices and exchange rates. That relationship should be more explicit in the case of those countries where oil exports represent a significant component of their foreign trade, or where oil imports can affect the cost of production and distribution of their main industries. It should be noted, however, that the size of the economy and the relative importance of the oil industry, as well as other characteristics of the economy are factors in the determination of how much will exchange rates respond to changes in oil prices. For example, the paper of Huang and Guo (2007) investigates to what extent the oil price shock and other types of macroeconomic innovations affect China's real exchange rate. They estimate a structural VAR model whose results indicate that real oil price shocks have a lesser appreciation effect on the long-term real exchange rate, relative to other trading partners who are also members of the *reminbi* basket peg regime due to China's lower dependence on imported oil. In contrast, the work of Lizardo and Mollick (2010) argues that since oil represents a strategic input "into making virtually everything, including steel, aluminum, plastics, rubber, fabrics, and fertilizers", and given the dependence of the United States economy with respect to oil imports increased towards the end of the first decade of the century, the US dollar may be losing value against other major currencies due to the supply and demand relation for dollars, i.e., as more US dollars are paid out to import a large volume of oil every day, an increase in its price will also enlarge the supply of dollars to the market, pressuring down the exchange rate. In order to test their hypothesis, these authors expand the monetary model of exchange rates, and find that oil prices significantly explain movements in the value of the dollar against major currencies in between the 1970s and 2008, and also confirm that their long-run forecasts are remarkably consistent with an oil-exchange rate relationship. They reveal that an increase in the real price of oil results in a significant depreciation of the US dollar with respect to oil exporting countries' currencies, such as in the cases of Canada, Mexico, and Russia.

On the other hand, Ghosh (2011) studies the relationship between the oil price and the exchange rate in India, by using GARCH and EGARCH models, for the period from July 2007 to November 2008, and reports as the main findings that increasing oil prices produce a depreciation of the Indian currency with respect to the USD because India is an oil-importer, and as oil prices rise, Indian refiners pay more dollars for oil-imports, putting pressure downwards on the Indian currency. The study also concludes that, in contrast to previously published works, oil price shocks have symmetric effect on the exchange rate, and that oil price shocks influence exchange rates volatility in a permanent way.

It is important to point out that Basher et al. (2012) have studied the relation among oil prices, emerging market stock prices and exchange rates. These authors explored the way in which oil prices and emerging market stock prices are related, or how oil prices affect exchange rates. However, the combined dynamic between all three variables had not been extensively dealt with. This paper estimates a structural VAR model that serves as a platform to study the interactions between the three variables, and which serves to perform an impulse-response analysis. The results are in line with previously published stylized facts, like the negative response of emerging market stock prices and dollar exchange rates to oil price increases in the short run.

Aloui and Aïssa (2016) utilize different copulas of the elliptical, Archimedean and quadratic families to model the underlying dependence structure between crude oil prices and the USD exchange rate of five major currencies, Euro, Canadian Dollar, British Pound Sterling, Swiss Franc, and Japanese Yen, during both bearish and bullish market phases, over the 2000-2011 period. They find reliable evidence of a significant and symmetric dependence for almost all the oil price-exchange rate pairs considered. Oil price increases are related with a depreciation of the dollar according to the Student-t copulas results, and the main results are unchanged when considering alternative GARCH-type model specifications.

A fundamental relationship that surprisingly has seldom been mentioned in the literature is the fact that the USD is the currency used to invoice international oil trading most of the time and, for that reason, the dollar appreciation or depreciation caused by changing macroeconomic conditions should influence the dollar price of oil. According to Zhang (2017), since 2002 the dollar price of oil increased when the USD depreciated, suggesting the existence of a co-movement in the long-run. This author uses cointegration analysis to confirm that this is the case, but finds that cointegration does not show unless two structural breaks are controlled for (November 1986 and February 2005).

At a the macroeconomic level, the relationship between exchange rates and interest rates is subject to supply and demand conditions that ensure a simultaneous equilibrium in both markets. While interest rates respond to inflationary pressures, mainly through the monetary policy channel, and exchange rates respond, among other variables, to interest rates. In that sense, the work of Kim and Jung (2018) examine the dependence structure between crude oil prices, exchange rates, and interest rates in the United States by using a MV-GARCH-BEKK model and data for the 1998-2017 period. These authors find that there exists an inverse relationship between interest rates and crude oil prices and that the link between oil prices and exchange rates becomes stronger for oil dependent countries after the global financial crisis of 2006-2008.

The relationship between oil prices and interest rates is probably more obvious when considering that oil prices are an element of cost-push inflation in many productive sectors to which monetary policy will immediately react by raising interest rates. With the aid of a structural cointegrated VAR model for the G-7 countries, Cologni and Manera (2008) study the effects of oil price shocks on economic activity and the general price level, as well as the reaction of monetary authorities. In the case of all G-7 countries with the exception of Japan and the U.K., the hypothesis of oil prices influence on domestic inflation is not rejected and, in most countries, there is a temporary effect of oil price shocks on domestic prices. Besides, impulse-response analysis reveals monetary policy reaction to inflationary pressures are different from one country to another. These authors also report the results of a simulation exercise to estimate the impact of the 1990 oil price shock and suggest that "a significant part of the effects of the oil price shock is due to the monetary policy reaction…"

Ioannidis and Ka (2018) study the way oil price shocks impact the entire yield curve of the United States, Canada, Norway and South Korea by using a structural VAR model. These authors report that the term structure incorporates oil shocks differs depending on what drives them, as well as the degree of dependence of the country on oil. According to the reported results, shocks of oil prices originated by demand raise interest rates among oil importers, but not among oil exporters. In all studied countries, demand originated shocks result in an increase of the yield curve slope. By contrast, oil supply originated shocks result in brief negative responses of the United States and Canada yield curve slopes, which are also associated with an accommodating monetary policy.

Another example of a research that aims to contribute to the understanding of the relationship between oil price changes and interest rates is that of Sotoudeh and Worthington (2015). In it, the authors test for the presence of nonlinear causality between the two variables in the context of net oil-consuming and net oil-producing countries by using the Hiemstra and Jones' (1994) nonlinear parametric model and the Mackey and Glass' (1977) parametric model. The findings are that while there is no evidence that direct effects of oil price changes are present on interest rates in net oil-consuming countries, those effects are nonlinear and asymmetric among oil-producing countries.

Previous studies on the relationship assume that the direction of the impact runs from oil price to interest rates. However, only a few studies have addressed the inverse relationship. "One first example is the work of Akram (2009) that revises the fluctuations of different commodity prices (crude oil, food, metals and industrial raw materials) and investigates whether declines in real interest rates favor higher commodity prices, since price increases may be associated to reductions in interest rates and, as a consequence, to the dollar parity vis à vis other currencies." With several structural VAR models estimated on quarterly data over the period 1990-Q1-2007Q4, Akram's findings are that commodity prices, including oil prices, rise when real interest rates decrease in the United States. Also, this author reports that real interest rate fluctuations explain in a good measure the forecast error variance in commodity prices, and commodity prices tend to overshoot in response to interest rate changes. The conclusions of this work suggest that lower interest rates in the United States lead to a weaker dollar, which explains why commodity prices tend to rise in response.

Another perspective on the nature of the relationship between interest rates and oil prices is presented in the work of Arora and Tanner (2013). In it, the authors show that oil prices fall when there are unexpected increases in either United States' interest rates or other major industrial countries' interest rates. The underlying reasoning is that the opportunity cost of oil extraction and storage is represented by the real interest rate. In that sense, when interest rates are low, production is low and storage increases; the opposite is expected when real interest rates increase, creating the conditions of an inverse relation between oil price and interest rates. According to the paper results, oil price falls when the ex-post short-term real interest rates increase, and the response of oil price to ex-ante real interest rate changes depends on the inclusion of certain periods of observation. However, oil price is at all times responsive to short-term real interest rates (at least, during the observation period, from January 1975 through May 2012), and oil prices become more sensitive to long-term interest rates through time.

2.4. Natural Gas and the Stock Market in Different Economic Regions

The relative abundance of studies focused on the relationship between the price of energy commodities and financial markets is much greater in the case of oil than in the case of any other combination of alternatives (e.g., oil and interest rates or exchange rates; natural gas and the stock market, interest rates or exchange rates, etc.). However, some works that study the relationship between natural gas prices and financial variables deserve a brief mention in this section.

For example, Acaravci et al. (2012) investigate what is the nature of the long-run relationship between natural gas prices and the stock market using Johansen and Juselius' (1990) diagnostic test to identify the presence of cointegration among the variables, and then proceed to develop a vector error correction model with which they measure Granger causality for the EU-15 member countries between 1990 and 2008. The reported empirical findings include the existence of a long-term equilibrium between natural gas prices, industrial production, and stock prices in Austria, Denmark, Finland, Germany and Luxembourg, but not in the other ten EU-15 countries. Granger causality analysis results also suggest that the increases in natural gas prices affect industrial production growth, which, in turn, affects stock market returns.

Another study regarding the interaction between energy and the stock markets in the USA is that of Gatfaoui (2015). After controlling for structural breaks, characterizing dependencies, and using a multivariate copula to assess the joint dependence structure among natural gas, crude oil, and stock markets, the author documents the changing nature of the relationship over time. In particular, the author focuses on the identification of changes of sign in correlations and the possibility of dependence among extreme price changes.

One last reference on the relationship between natural gas prices and the stock markets is the work of Ahmed (2017). The author proposes the analysis of the dynamic mean and variance of natural gas and the stock market in Qatar. By using a modified cross-correlation test, controlling for structural breaks in conditional variances, and removing regional as well as international factors, this author finds mean and volatility spillover effects from natural gas prices to Quatar's stock market.

2.5. Studies on the Influence of Stock Markets on Energy Prices

The influence of nominal financial variables (exchange rates, interest rates, stock exchange returns) on energy (oil, natural gas) prices has been scantly explored. Just a few works pay attention to the influence of financial variables on energy prices; however, they have recognized that there is evidence that financial variables can influence energy prices. For example, Akram (2009) and Arora and Tanner (2013) report the influence of interest rates on oil prices and other commodities. Also, Ghorbel et al. (2014) find that there exists a volatility spillover of American investor sentiment towards the stock market returns and the oil market returns. Other works that report an influence from financial variables onto energy prices include that of Kilian and Park (2009) that questions the validity of the studies that attribute the impact of oil prices on the macroeconomics as if they were exogenous, omitting the possibility of reverse causality from macro aggregates to oil prices.

3. ANALYSIS OF THE FINANCIAL VARIABLES AND GAS AND OIL PRICES

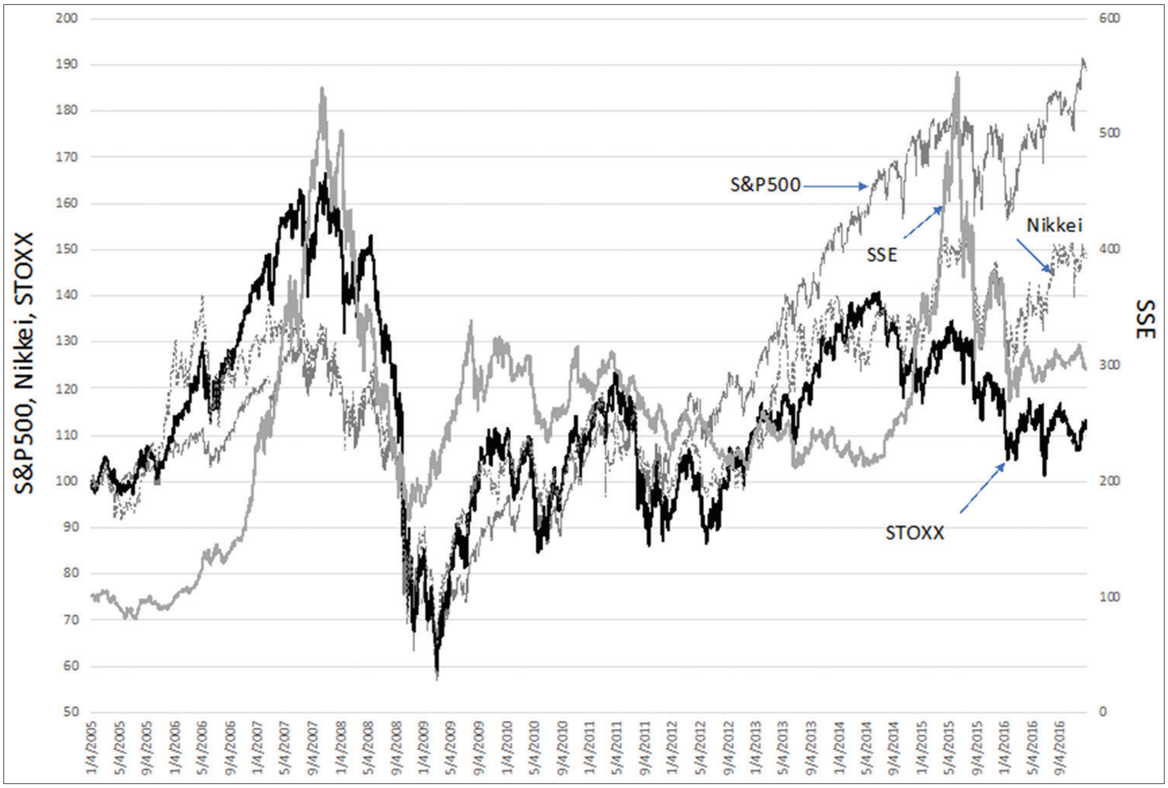
The 1st years of the XXIst century were plagued by unexpected global economic and geopolitical events that generated an intense turbulence in the world's markets. After the dot.com burst in 2000, the United States economy was ready to slow-down. The terrorist attack to the World Trade Center catalyzed what came to be a relatively mild recession, and 2 years later, in 2003, the world was precipitated into a new war, in Iraq. By 2007 the subprime mortgages segment of the United States financial markets went into tail-spin fall and, by the 1st months of 2008, financial markets around the world were in absolute chaos. Associated with the financial crisis, the United States and other major economic powers fell in a deep recession and, when they were experiencing the first recovery signs, a new financial crisis was detonated by the sovereign debt crisis in Greece, Ireland, Portugal and Spain (from 2009 to 2012). Only then did a very gradual recovery of the world economy take place from the depths of the 2008-2009 crisis.

The evolution of the stock markets of the main economic regions reacted to the aforementioned events, as observed in Figure 1. The four major stock market indices are converted to a common base with value equal to 100 on January 4, 2005, to allow a visual comparison of their relative evolution during the period of analysis. Figure 1 shows that the United States, the Eurozone and Japan's stock markets follow similar paths, responding to the world's economic and geopolitical conditions, and that China's main index, the Shanghai Stock Exchange (SSE) index, recorded two dramatic roller-coaster like ups and downs, the first one reflecting the enthusiasm for the impressive economic growth and the rapid modernization of the country during the 1st years of the century, followed by the drastic deacceleration due to the financial crisis, and the second one probably associated to the liberalization of the exchange rate and other important market oriented institutional changes in that country. It must be emphasized that the SSE transformed index is represented on the right axis of Figure 1 due to the disproportionate magnitude of its range (reaching 554 points during June 2015).

Figure 2 represents the evolution of trade-weighted exchange rates of the world's four largest economic areas, converted to a common index, with base on January 2005=100. The index for the USD was relatively stable throughout the period, while the renminbi appreciated consistently, at times experiencing strong technical adjustments. Notice that after reaching a 50% appreciation level, it ended with a 30% appreciation in the observation period. After an initial appreciation between 2005 and 2008, the euro depreciated consistently, and by the end of the period it had lost almost 24% of its initial value. In the meantime, the yen appreciated almost 25% between 2005 and 2012, but during the latter part of the observation period depreciated consistently and ended the period around 10% below its initial level.

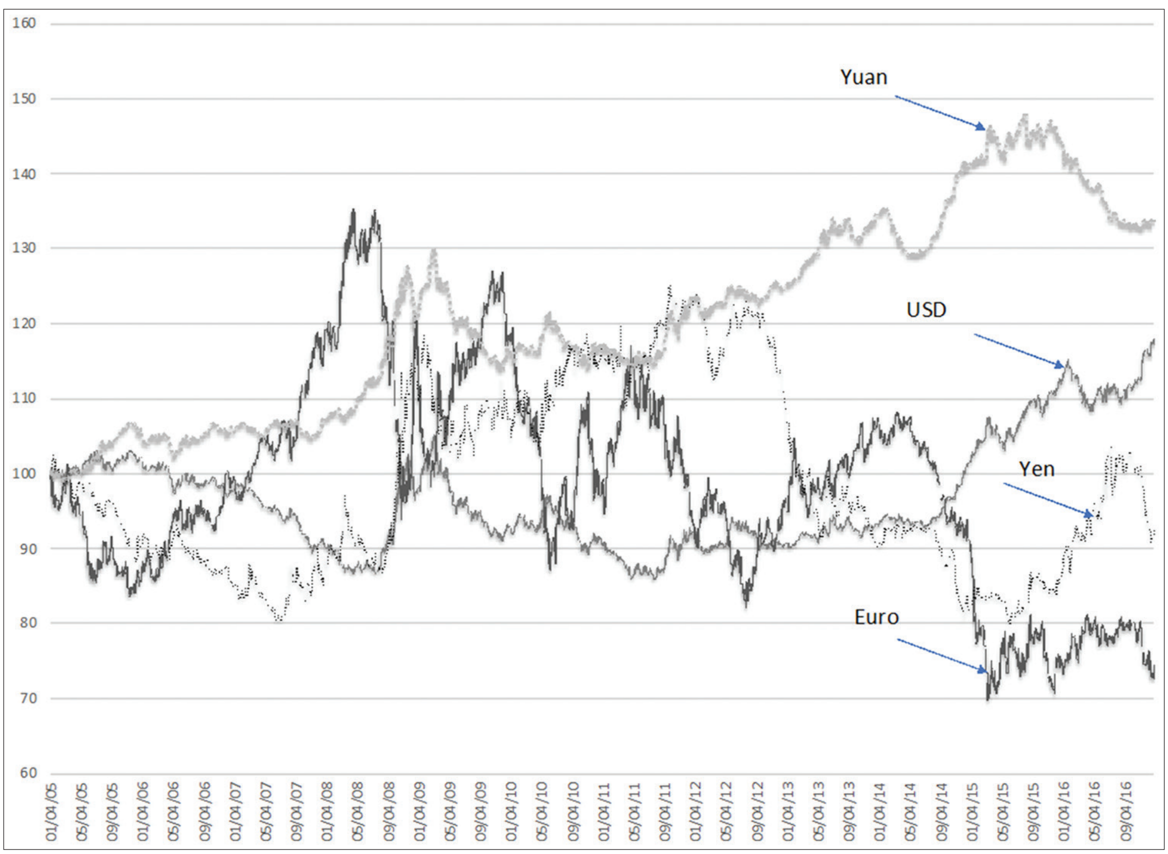
Energy prices often have sustained increases during relatively long periods and the demand elasticity for energy is highly rigid. Those two characteristics differentiate energy prices from other commodities (Kilian, 2008). But the idea that exogenous energy price shocks are the main cause of economic recessions is probably an oversimplified description of the problem. While a number of works present significant evidence about the relation between oil price and economic activity is not a statistical coincidence (Hamilton, 1983; and Blanchard and Galí, 2010), others theorize there may be an indirect link via monetary policy. For example, Bernanke et al. (1997) examine the role of monetary policy when responding to oil shocks, which they authors consider to be exogenous, and test whether the response of the Fed by raising interest rates to control potential inflationary pressures with anticipation becomes the main cause of downturns, but find no concluding evidence. These authors suggest the possibility

Figure 1: Indices of the four largest stock markets in the world (January 2005=100)



Source: Bloomberg

Figure 2: Trade-weighted exchange rates for the USD, the Euro, the Yen and the Renminbi (January 2005=100)



Source: Bloomberg

of "obtaining credible measurements of monetary policy's contribution to business cycles" is rather challenging. What cannot be denied is that the Fed's (and other Central Banks') policy decisions are mainly justified by macroeconomic conditions, as its main task is to maintain price stability and full employment, and that in order to execute its policy decisions, it makes use of the discount rate (the Fed Funds rate in the case of the United States, i.e., the reference interest rate for commercial banks, which is also a benchmark for new debt issues and many other contractual arrangements). In that sense, one would expect interest rates to respond to oil price shocks, although there are also many other macroeconomic variables that guide the decisions of central banks.

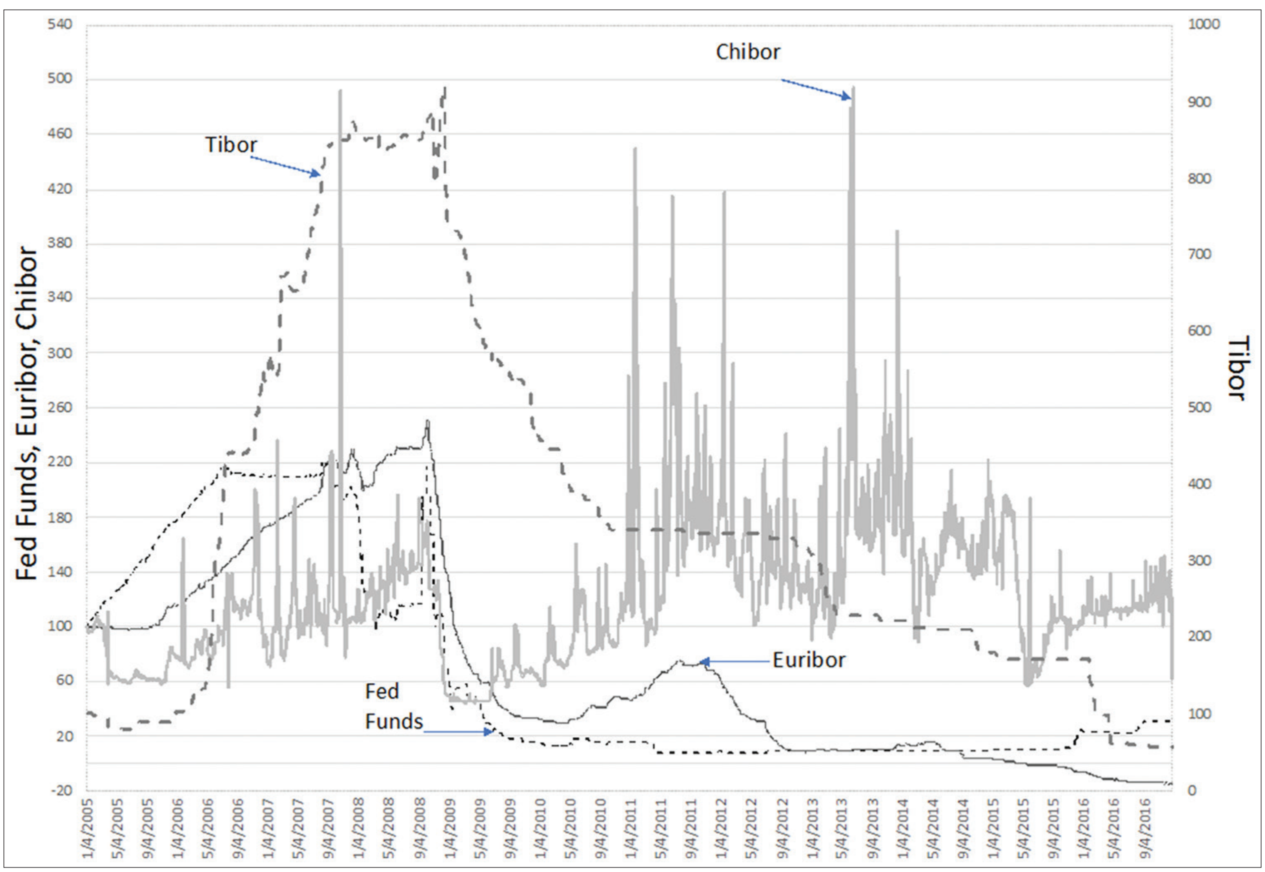
The dynamics of the interest rates in the four economic poles studied in this work is shown in Figure 3 after converting the original series to an index with base January 4, 2005 =100. This conversion, again, is made with the intention to make different interest rate levels relative changes strictly comparable in time. The atypical increase of the Tokyo Interbank Offer Rate (Tibor) index, reaching a value of 908 in December 2008 (and rapidly descending afterwards in response to the world's economy recession) is explained by the very low level (close to 0%) it had at the beginning of the period, and to avoid the distortion effect such a large value would have on the rest of the indices, it is represented with reference to the right axis of Figure 1.

The evolution of Japan and China's interbank interest rates follows very different patterns during the observation period. However, the United States' Fed Funds rate and the Euribor for the Eurozone, maintain certain parallelism. The Chibor rates, represented along with the Fed Funds rate and the Euribor rate on the left axis of Figure 3 recorded two clearly identifiable periods of high volatility, the first between January 2006 and December 2008, and the second from January 2011 through December 2013.

Recent studies on the long-term relationship between natural gas and crude oil prices have recognized they are cointegrated (e.g., Brigida, 2014; Ramberg and Parsons, 2012). However, the prices of oil and gas have followed very different paths and some authors even argue that there is a permanent rupture caused by fundamental transformation in each market. Ramberg and Parsons (2012) find that cointegration needs to be tempered with the additional consideration of the fact that there is a large amount of "unexplained volatility" in natural gas prices at short horizons, and that the cointegrating relationship does not appear to be stable through time. Finally, Brigida (2014) models the cointegrating relationship incorporating structural breaks in the relative pricing relationship by means of a first order Markov switching process.

When looking at the prices of oil and natural gas during the period of study, it is clear that both prices follow a very similar path along most of the 12 years of observation, but they show a significant decoupling towards the last quarter of 2008 to converge again towards the end of 2014. While the price of each commodity is expressed in different units of measurement (oil price is expressed

Figure 3: Interbank interest rates for the four largest economic areas in the world (January 2005=100)



Source: Bloomberg

Figure 4: International price of natural gas and brent oil (January 2005=100)

Source: Bloomberg

in per barrel terms, and natural gas is expressed in per mmBtu terms), the close parallelism observed in Figure 4 is emphasized by the representation of an index whose base is January 4, 2005, for both energy commodities.

4. ECONOMETRIC ANALYSIS, EMPIRICAL RESULTS, AND DISCUSSION

The estimation of a PVAR model identifies the direction and intensity of the reciprocal influence between energy markets and nominal variables of the four largest and most developed economic areas in the world. There is evidence of an influence from the energy markets towards the sample stock market indices, but not the other way around. However, the influence of interest rates on the determination of both oil prices and natural gas prices is highly statistically significant.

The database used in the PVAR analysis consists of four financial variables and two energy prices, with daily observations for the period that goes from January 5, 2005 to December 30, 2016. The financial variables include the stock market indices of the United States (S&P500), China (SSE Composite), the European Union (Stoxx Europe 600), and Japan (Nikkei 225); the interbank interest rates for each country/region, and the corresponding trade-weighted exchange rates of the four main currencies (the US Dollar, the Euro, the Yuan and the Yen). All the data was obtained from a Bloomberg terminal.

The stock market indices correspond to the largest and more liquid markets in each major country/region. The interbank interest rates represent each country/region' cost of borrowing incurred in short-term loans among local banks, and the exchange rates are proxied with trade weighted indices. A detailed description of the selected variables is presented in Table 1.

As mentioned before, the effect that energy prices have on stock markets performance (and other economic and financial nominal variables) has been extensively documented and frequently verified (e.g., Abhyankar et al., 2013; and Aloui and Aïssa, 2016), and the influence of oil price fluctuations on other financial variables, as exchange rates and interest rates response to oil prices changes, has also been frequently studied (e.g., Ferraro et al., 2015; and Kim and Jung, 2018). However, after an extensive review of related works, it was confirmed that the study of the potential influence of financial variables (stock market returns, exchange rate and interest rate fluctuations) on energy prices has been only scantly mentioned in the literature, and that is the main contribution of the present research.

The PVAR estimated with generalized method of moments (PVAR-GMM) used in this work to examine the interactions of the main financial variables of the world's four largest economic areas, China, the European Union, Japan and the United States, and the price of the two most important energy commodities, oil and natural gas, is estimated following the programming solution developed of Abrigo and Love (2015). The PVAR estimates

Table 1: Description of the variables used in the analysis

Assigned ticker	Bloomberg ticker	Concept	Detailed description
Wti	USCRWTIC Index	Barrel of oil	Bloomberg West Texas Intermediate Cushing Crude Oil Spot Price (WTI)
Brent	EUCRBRDT Index	Barrel of oil	Bloomberg European Dated Brent Forties Oseberg Ekofisk Price (BFOE)
Natgas	NG1 COMB Comdty	Natural Gas	Bloomberg Average Price of Natural Gas
Snp	SPX Index	Stock Mkt	S&P 500 Index
Stoxx	SXXP Index	Stock Mkt	STOXX Europe 600 Price Index EUR
Nikkei	NKY Index	Stock Mkt	Nikkei 225
Sse	SHCOMP Index	Stock Mkt	Shanghai Stock Exchange Composite Index
Usd	USTWBROA Index	Exch. Rate	FED's US Trade Weighted Broad Dollar (Jan 1997=100)
Eur	CEEREU Index	Exch. Rate	Calculated Effective Exchange Rate EURO (1990=100)
Jpy	ATWIJPY Index	Exch. Rate	Westpac nominal effective exchange rate trade Weighted Japanese Yen (Dec 1994=100)
Chy	ATWICNY Index	Exch. Rate	Westpac Nominal Effective Exchange Rate Trade Weighted Chinese Yuan (Dec 1994=100)
Fed	GFED03M Index	Int.Rate	ICAP Capital Markets Domestic Fed Funds 3 months
Euribor	EUR003M Index	Int.Rate	Euribor 3 months ACT/360
Tibor	TI0003M Index	Int.Rate	Japan Bankers Association TIBOR fixing rate 3 months
Chibor	IBO03M Index	Int.Rate	China CHIBOR 3 months

Source: Bloomberg

the direction and intensity of the reciprocal influence between prices and the main financial variables of. Its main focus is the detection and measurement of the short-term influence of changes in financial variables over energy prices. The original variables (Table 1) are transformed into their first differences because of the dynamic nature of the analysis, aimed to identify and quantify the intensity of the response of a given variable when the other variables in the system fluctuate; first order differentiation is also useful to solve the problem of non-stationarity that is present in several of the variables in the original series in levels.

According to Andrews and Lu (2001), a consistent model and moment selection criteria for GMM can be based on the J test statistic for testing over-identifying restrictions, and "include bonus terms that reward the use of more moment conditions for a given number of parameters and the use of less parameters for a given number of moment conditions." In effect, in the context of PVAR, the identification of the optimal number of lags can be based on the Bayesian (BIC), Hanan-Quinn (QIC) and Akaike (AIC) information criteria adapted to the multivariate modeling requirements, and reported here as MBIC, MAIC and MQIC, in Table 2, where the minimum values of the three criteria suggest that a first-order PVAR model must be selected.

The PVAR system estimation considering the nominal financial variables (stock market returns, interest rate fluctuations and exchange rate fluctuations) and energy prices (Brent oil price and the Natural Gas price changes) are reported in Table 3.

The first equation corresponding to the stock market returns as dependent variable, presents a negative and highly significant coefficient corresponding to the exchange rate and suggests that currency depreciation exercises a strong negative influence on the stock market. The second equation, with the exchange rate as dependent variable, it shows that the stock market's returns coefficient is highly significantly and negatively related to the lagged stock market returns coefficient, which suggests that a positive performance of the stock market has a negative effect on

Table 2: Panel vector auto regression lag order selection criteria

Lag	Coefficient detection	MBIC	MAIC	MQIC
1	0.6723	−441.7492	−54.2792	−199.6869
2	0.6972	−290.2568	−31.9435	−128.8820
3	0.1683	−148.5636	−19.4070	−67.8762

Source: Stata output, elaborated by the authors.

the exchange rate, i.e., results in an appreciation of the currency. The third equation, for interest rates fluctuations, shows no evidence of significant influence from the rest of the variables in the system. This may be interpreted as interest rate markets following their own dynamics or, in any case, not responding to the rest of the model's variables influence (it may well be the case that interest rates only respond to central banks' monetary policy decisions and market expectations regarding inflation).

The fourth and the fifth equations of the model correspond to Brent oil price and natural gas price changes as dependent variables, and show evidence of a lagged interest rate's fluctuations positive association with both. That is, lagged increases in interest rates are positively related to Brent oil and natural gas price increases. This is an interesting finding because it suggests that energy markets are sensitive to monetary policy signals (and, probably, market agents' expectations about inflation). A possible interpretation of this is that as central banks raise their reference rates, and all other interest rates in the money and capital markets follow suit with the intention to reduce the incentives for new investment projects and inhibiting consumption (mainly of large price-tag goods), then the market interprets that signal as a gauge of economic activity and, indirectly, of the intensity of prevailing demand.

Brent oil lagged fluctuations also have a negative relation with their own next day's fluctuations, with a moderate statistical significance, just below 10%; and, lagged Natural Gas fluctuations have a positive influence, with a moderate statistical significance at 8%. In the first case, own lagged fluctuations negative relationship suggests that Brent oil prices tend to react to 1 day's upwards

Table 3: Panel vector auto regression estimation

Variables	Coefficient	Standard error	z	P>|z|	(95% confidence interval)	
Stockmkt						
Stockmkt L1	−0.04216	0.03612	−1.17	0.243	−0.11296	0.02864
Xchgrate L1	−0.20742	0.07713	−2.69	0.007	−0.35860	−0.05625
Intrate L1	0.00902	0.00724	1.25	0.213	−0.00517	0.02321
Brent L1	0.03217	0.02058	1.56	0.118	−0.00817	0.07251
Natgas L1	0.00650	0.00897	0.72	0.469	−0.01108	0.02407
Xchgrate						
Stockmkt L1	−0.02463	0.01236	−1.99	0.046	−0.04886	−0.00041
Xchgrate L1	−0.02678	0.03811	−0.7	0.482	−0.10148	0.04791
Intrate L1	0.00209	0.00168	1.24	0.214	−0.00121	0.00538
Brent L1	−0.00415	0.00861	−0.48	0.630	−0.02102	0.01273
Natgas L1	0.00444	0.00453	0.98	0.327	−0.00444	0.01333
Intrate						
Stockmkt L1	−0.14330	0.11937	−1.2	0.230	−0.37727	0.09067
Xchgrate L1	−0.03523	0.22935	−0.15	0.878	−0.48474	0.41429
Intrate L1	−0.12131	0.16909	−0.72	0.473	−0.45273	0.21010
Brent L1	0.02289	0.06197	0.37	0.712	−0.09857	0.14435
Natgas L1	0.00824	0.02669	0.31	0.757	−0.04407	0.06056
Brent						
Stockmkt L1	0.03751	0.03966	0.95	0.344	−0.04022	0.11524
Xchgrate L1	−0.10954	0.09501	−1.15	0.249	−0.29576	0.07668
Intrate L1	0.01804	0.00567	3.18	0.001	0.00693	0.02915
Brent L1	−0.05263	0.03153	−1.67	0.095	−0.11442	0.00916
Natgas L1	0.02447	0.01396	1.75	0.080	−0.00289	0.05183
NatGas						
Stockmkt L1	0.03622	0.05518	0.66	0.512	−0.07193	0.14437
Xchgrate L1	−0.02143	0.12533	−0.17	0.864	−0.26708	0.22421
Intrate L1	0.03840	0.01159	3.31	0.001	0.01568	0.06111
Brent L1	−0.09621	0.03426	−2.81	0.005	−0.16335	−0.02906
Natgas L1	0.03655	0.02239	1.63	0.103	−0.00734	0.08043

Source: Stata output, elaborated by the authors

Table 4: Granger causality tests

Equation/excluded	Chi square	df	Prob >Chi square
Stockmkt			
Xchgrate	7.232	1	0.007
Intrate	1.552	1	0.213
Brent	2.443	1	0.118
NatGas	0.525	1	0.469
ALL	13.163	4	0.011
Xchgrate			
Stockmkt	3.974	1	0.046
Intrate	1.544	1	0.214
Brent	0.232	1	0.630
NatGas	0.96	1	0.327
ALL	8.197	4	0.085
Intrate			
Stockmkt	1.441	1	0.230
Xchgrate	0.024	1	0.878
Brent	0.136	1	0.712
Natgas	0.095	1	0.757
ALL	1.879	4	0.758
Brent			
Stockmkt	0.895	1	0.344
Xchgrate	1.329	1	0.249
Intrate	10.126	1	0.001
NatGas	3.072	1	0.080
ALL	14.686	4	0.005
NatGas			
Stockmkt	0.431	1	0.512
Xchgrate	0.029	1	0.864
Intrate	10.977	1	0.001
Brent	7.887	1	0.005
ALL	19.259	4	0.001

Source: Stata output, elaborated by the authors

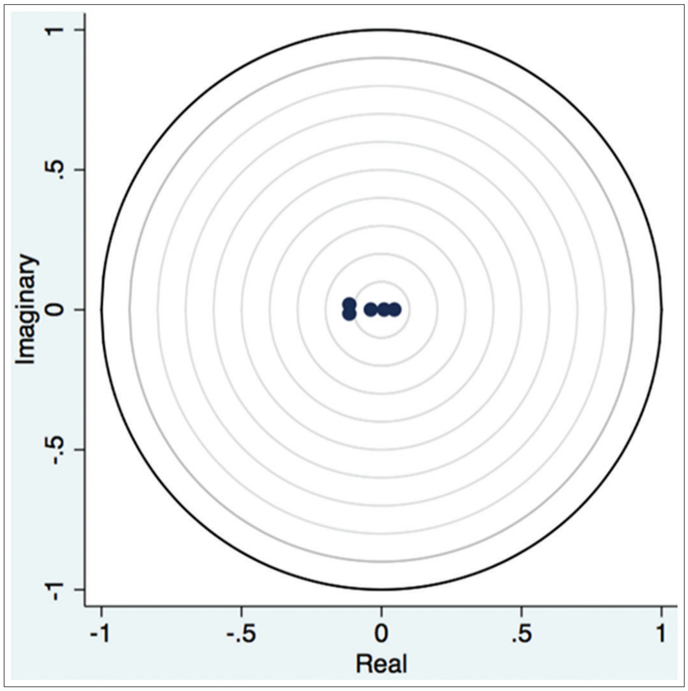
movement, with a following day's downwards movement, in some sort of short-term mean reversion. In the second case, rising natural gas prices impact the Brent oil market as the initial movement reflects an increasing demand for energy, and expectations of the market are bullish regarding economic activity.

In the last equation, with natural gas price fluctuations as a dependent variable, besides interest rates changes positive significant relation, Table 3 also reports a significantly negative influence of lagged Brent oil prices, probably meaning that oil prices can affect economic activity and reduce energy demand; and lagged natural gas prices positively influence that same variable, but with a significance level that is marginally >10%. A Granger causality analysis corroborates the results of the PVAR analysis, as shown in Table 4.

Table 3 results suggest that the exchange rate fluctuations Granger-cause stock market fluctuations, and the stock market fluctuations Granger-cause exchange rate fluctuations. Interest rates seem to have rather independent evolution, as they are not Granger caused by any other variable. However, in the case of the Brent oil price changes, the evidence suggests they are Granger-caused by interest rates and natural gas changes; and natural gas changes are Granger-caused by Brent oil price and Interest Rate changes. All relationships in the causality analysis are consistent with the results reported in Table 2.

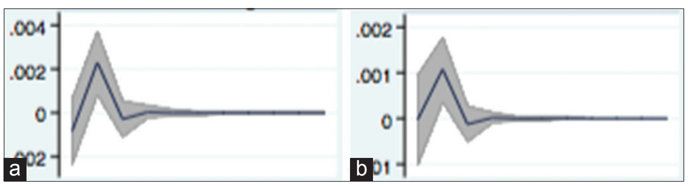
Before proceeding to an Impulse-Response analysis, the stability conditions of the PVAR model are verified by looking at the

Figure 5: Roots of the companion matrix



Source: Stata output, elaborated by the authors

Figure 6: Impulse-response results for interest rate changes on energy prices. (a) Interest rate: Natural gas, (b) Interest rate: Brent oil price



Source: Stata output, elaborated by the authors

calculated modulus of eigenvalues, which are, in all cases, less than one, as can be observed on the complex unit circle (Figure 1) confirming that the model is adequate to describe the stochastic process (Lutkepohl, 2005; Abrigo and Love, 2015) (Figure 5).

While the PVAR-GMM and Granger causality results suggest that there is an important role of interest rate changes on Brent oil and natural gas price changes, a forecast error variance decomposition (FEVD) based on Cholesky's decomposition of the residual covariance matrix of the PVAR model suggests that the relationship only holds in the very short-run. In both cases, after 10 days, a shock to interest rates has less than a one percent explanatory capacity on those two variable variances. By contrast, their own shocks explain as much as 94.7% in the case of Brent oil price changes, and 96.1% in the case of natural gas changes. The orthogonalized impulse-response of the PVAR summarizes the model findings and makes the Granger Causality findings compatible with the FEVD evidence. What one can observe from the representation of interest rates' impact on energy price changes is that.[3] In effect, interest rates have a clear, though small, impact on natural gas price changes, but that impact is rapidly assimilated.

3 Figure 2 only includes interest rates changes impact on energy prices due to space limitations.

That evidence reinforces the conclusion that while daily changes in interest rates seem to have significant influence on the evolution of the next-day price in both energy commodities, the effect is short-lived (Figure 6).

5. CONCLUSIONS

The PVAR model used to analyze the interrelationships among nominal financial variables and energy prices worldwide reveals several different findings: (1) Lagged exchange rate fluctuations have a negatively significant effect over the stock market; (2) a positive performance of the stock market has a negative effect on the exchange rate, i.e., results in an appreciation of the currency; and (3) interest rate markets follow their own dynamics or, in any case, do not respond to the rest of the model's variables influence. Probably the most interesting finding is that Brent oil and natural gas price changes are positively and highly significantly influenced by lagged interest rates' fluctuations, that is, energy markets are sensitive to monetary policy signals (and, probably, market agents' expectations about inflation). Additionally, Brent oil lagged fluctuations have a negative effect on next day's Brent fluctuations, and lagged natural gas fluctuations have a positive influence on oil. Finally, natural gas prices are negatively influenced by lagged Brent oil prices and positively influenced by their own lagged price changes.

It is true that, while the economic importance of each of the four stock market indices in our sample is not comparable by far with other stock markets in the developed and emerging world, there are significant differences in capitalization value and liquidity between the United States market and the rest, while in our analysis its influence is included in the same terms as China, the Eurozone, and Japan's indices. Also, the importance of the interbank interest rates in the United States is more economically significant than is the case of the other three economic areas. Finally, the volatility of the Shanghai composite index is, evidently, much greater than that corresponding to the other three sampled indices, something that may probably be due to its relatively recent creation as well as the fast pace of changes that are taking place in China's economy and financial markets. While these considerations may have weighted in the precision of our reported results, the size of the sample and the highly significant empirical outcomes that are found validate all of the above results.

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