RECENT TOPICS IN TIME SERIES AND FINANCE: Theory and applications in emerging markets

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(Editors)
Chapter 8
Oil prices and stock market returns: a comparison among Brazil, Chile, and Mexico

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Abstract
This paper analyzes the relationship between the dynamics of oil price returns and stock market returns. Specifically, this research examines the interaction between the Brent or the West Texas Intermediate (WTI) returns and the representative stock market indices IBOVESPA, IPSA, and IPC returns, for Brazil, Chile and Mexico, respectively. To do that, an unrestricted Vector Autoregressive (VAR) model and a Structural Equation Model (SEM) are used. Under this framework, the impact of the Brazilian market on the dynamics of other assets and the influence of oil prices on stock markets indices is assessed.

Keywords: oil prices; stock markets; Latin American stock markets.

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1. INTRODUCTION

The economic and financial literature concerning the relationship between the dynamics of oil prices and the stock market is broad. Most studies concentrate on analyzing this link in developed countries, while there is limited empirical evidence on emerging economies for such association. Considering this limitation, this paper aims to determine whether there is any linkage between the dynamics of oil prices and stock markets in the cases of Brazil, Chile, and Mexico by using daily returns from January 2010 to December 2014. The returns for oil prices are those from Brent and West Texas Intermediate (WTI), and returns from stock markets are those from Bovespa Index (IBOVESPA) of the Stock Exchange Sao Paulo and Brazilian Markets and Futures Exchange (BM & FBOVESPA), the IPSA Index for the Santiago Stock Exchange, and the Index of Prices and Quotations (IPC) of the Mexican Stock Exchange (BMV).

The study of the relationship between the dynamics of oil and stock prices is relevant because it highlights that there are interconnected markets worldwide, which helps to explain the patterns of growth or stagnation of the economies because oil is a basic source of energy, used as an input in productive activities, whose prices also reveal the position of countries as net exporters or importers for this commodity.

This chapter is organized as follows: the second section reviews recent literature regarding the association between the dynamics of oil prices and the performance of other assets, the third section shows the econometric methodology used for the analysis, and the main empirical findings, and finally, the fourth section presents some conclusions.

2. THEORETICAL AND EMPIRICAL EVIDENCE

Several authors have examined the linkage between the dynamics of oil prices and the variability of stock markets from different approaches, and focused mainly on developed countries. For instance, Filis, Degiannakis, & Floros (2011) analyzed the time-varying correlation between oil prices (Brent crude oil) and stock market prices for some exporters
or importers of oil (Canada, Mexico, Brazil, USA, Germany and Netherlands). They did not find significant evidence of differences among those countries, but showed that the correlation increases due to demand-side oil price shocks, and not by supply-side oil price shocks. Similarly, Broadstock & Filis (2014) explored the same time-varying correlations, but added specific demand shocks. In all cases, they found evidence of strong correlation, but higher in the US than in China.

Chang, McAleer, & Tansuchat (2013) studied the conditional correlations and volatility spillovers between crude oil returns (from West Texas Intermediate and Brent crude) and stock index returns (FTSE100, NYSE, Dow Jones and S&P500). These authors showed that the conditional correlations for returns across markets are very low, but there is evidence for correlations between series in the same markets.

Park & Ratti (2008) explained that oil price shocks and oil price volatility affect short-term interest rates and stock market returns in the US and most European countries. They showed these results by using an Unrestricted Vector Autoregressive model (VAR) applied to monthly data from 1986 to 2005 and using Brent crude oil prices. Moreover, Basher, Haug & Sadorsky (2012) used a Structural Vector Autoregressive model (SVAR) in order to examine the relationship between oil prices, exchanges rates and emerging markets stock prices (measured by the MSCI Index). These authors found that positive shocks of oil prices depress market stock prices and US exchange rates in the short term. Also, Conrad, Loch, & Rittler (2014) analyzed the association with macroeconomic variables in the US by using a Dynamic Conditional Correlation–Mixed Data Sampling (DCC-MIDAS) econometric model. They found that the movements in long-term oil volatility could be predicted by US macroeconomic activity. Also, they showed that both long-term oil volatility and stock market prices respond to the same macroeconomic information.

Chang & Yu (2013) fitted a MS-ARJI-GJR-GARCH-X model in order to explain the effect of oil price shocks on stock market returns. They added some characteristics generally ignored, like structural changes, jump behavior, and asymmetric volatility risk. Other interesting linkages are described by Sadorsky (2014), who models volatilities and conditional correlations among market stock prices and the prices of other commodities such as copper, oil, and wheat. This author proved that correlations between assets are higher after 2008, and that oil is
the cheapest hedge for emerging market stock prices. Aloui & Jammazi (2009) also studied linkages between oil price shocks and stock markets, and employed a two-regime Markov-switching EGARCH model for UK, France and Japan stock markets from 1989 to 2007. These authors showed that common recessions fit with the low mean and high variance regime, also the probabilities of transition between regimes depend on the increase in the net oil price, and that rises in oil price significantly impact both the volatility of stock returns and the probability of transition across regimes.

Arouri (2011) studied the short-term impacts of oil prices on stock returns by sectors in Europe from 1998 to 2010. This author employed a multifactor asset pricing model and found different effects in sectors, i.e., the oil price increases negatively affect the returns in the areas of financial services, food and beverage, health care, personal and household goods, technology, and telecommunications, but positively in the cases of oil & gas, basic materials, and consumer services. Also, Ratti & Vespignani (2013) examined the interrelations among liquidity, global oil production, real oil prices, and the real global aggregate demand in the BRICK. The authors employed a Structural Vector Error Correction model and found that China and India drive the liquidity effects in oil prices and oil production. Moreover, (it is considered the position of countries as importer or exporter of oil) to explain why the liquidity of Brazil and Russia increases with oil prices, but for China and India the liquidity decreases.

Ma, Wei, Huang, & Zhao (2013) analyzed the cross-correlation between WTI and the stock markets of the BRICK (Brazil, Russia, India, and China). They found that the multi-fractality strength between WTI and the Chinese market is stronger than others, and the cross-correlations are more strongly multifractal for the short term. Also, by using unconditional and conditional copula methods, Zhu, Li, & Li (2014) examined the dependence between oil prices and stock markets for ten countries of the Asia-Pacific region from 2000 to 2012.

Although overall dependence is weak, the relationship established between pre-crisis and post-crisis scenarios is interesting. Using a similar methodological approach, Nguyen & Bhatti (2012) studied the dependence structures and tail dependence between oil price changes and stock market indices. This analysis is done by Plots and Copula methods. Their work employed the tail dependence to deter-
mine whether the two variables move together in the same or opposite directions; particularly it was found that a decrease in oil price is accompanied by a decrease in Vietnam’s stock market, but there is no such relationship in the Chinese market.

Lake & Katrakilidis (2009) analyzed the interactions among oil prices in the London commodities market, its volatility, and the main stock market indices in Europe and their futures return indices (i.e., the FTSE-ASE for Greece, the Dow Jones for US, the FTSE 100 for UK, and the DAX for German market) during the period 1999-2007. These authors used a Structural Equation Model (SEM), and concluded that the Greek and the US markets are the ones that are affected by oil prices.

3. DATA AND EMPIRICAL RESULTS

For the empirical analysis, daily data from January 2010 to December 2014 is used. The prices of Brent and wti crude, and the indices of ibovespa, ipsa, and ipc for the Brazilian, Chilean and Mexican stock markets, respectively, are considered. First, a descriptive study of the properties of the time series is carried out. Figure 1 shows the dynamics of the series (in levels) and their returns. The similarity in the dynamics of stock indices, especially in periods of high volatility can be seen, and also a higher volatility in Brent prices compared to wti prices is observed.
The Augmented Dickey Fuller (ADF) test is performed to prove the stationarity of the returns series. In all cases, the null hypothesis of non-stationarity is rejected, since the reduced value of the ADF test compared with the critical values of MacKinnon. The VAR model to be estimated is

\[ X_t = A_0 + \sum_{i=1}^{p} A_i X_{t-i} + u_t, \]  

where \( X_t = [X_{t1}, \ldots, X_{kt}] \) is a column vector of endogenous variables, i.e., IBOVESPA, IPSA, IPC and WTI or BRENT indices. Here, \( A_0 \) is a vector of constant terms, \( A_i \) is a matrix of unknown coefficients, and \( u_t \) is a column vector of errors. The results of the VAR Granger causality are
shown in Table 1. The test suggests that the variables IPSA and BRENT are not exogenous, and also in most cases the test fails to reject the null hypothesis of excluding the variables from the explanation of dependent variables. We only reject the null hypothesis of excluding IBOVESPA from IPSA, IBOVESPA from BRENT, and WTI from IBOVESPA. These results are relevant because they indicate that only the Brazilian market is the largest link with other markets.

Table 1
Granger Causality / Block Exogeneity Wald Tests

<table>
<thead>
<tr>
<th>Dependent variable: IPC</th>
<th>Excluded</th>
<th>Chi-sq</th>
<th>df</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPSA</td>
<td>3.614527</td>
<td>2</td>
<td>0.1641</td>
<td></td>
</tr>
<tr>
<td>IBOVESPA</td>
<td>0.957355</td>
<td>2</td>
<td>0.6196</td>
<td></td>
</tr>
<tr>
<td>BRENT</td>
<td>1.233187</td>
<td>2</td>
<td>0.5398</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>7.134248</td>
<td>6</td>
<td>0.3086</td>
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</table>

<table>
<thead>
<tr>
<th>Dependent variable: IPSA</th>
<th>Excluded</th>
<th>Chi-sq</th>
<th>df</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPC</td>
<td>2.762598</td>
<td>2</td>
<td>0.2513</td>
<td></td>
</tr>
<tr>
<td>IBOVESPA</td>
<td>8.851503</td>
<td>2</td>
<td>0.0120</td>
<td></td>
</tr>
<tr>
<td>BRENT</td>
<td>0.541454</td>
<td>2</td>
<td>0.7628</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>21.24440</td>
<td>6</td>
<td>0.0017</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent variable: IBOVESPA</th>
<th>Excluded</th>
<th>Chi-sq</th>
<th>df</th>
<th>Prob.</th>
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<tr>
<td>IPC</td>
<td>0.001391</td>
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<td>0.9993</td>
<td></td>
</tr>
<tr>
<td>IPSA</td>
<td>3.101478</td>
<td>2</td>
<td>0.2121</td>
<td></td>
</tr>
<tr>
<td>BRENT</td>
<td>4.541162</td>
<td>2</td>
<td>0.1033</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>8.134334</td>
<td>6</td>
<td>0.2284</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Dependent variable: BRENT</th>
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<th>Chi-sq</th>
<th>df</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPC</td>
<td>2.202488</td>
<td>2</td>
<td>0.3325</td>
<td></td>
</tr>
<tr>
<td>IPSA</td>
<td>0.075580</td>
<td>2</td>
<td>0.9629</td>
<td></td>
</tr>
<tr>
<td>IBOVESPA</td>
<td>7.409180</td>
<td>2</td>
<td>0.0246</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>21.88096</td>
<td>6</td>
<td>0.0013</td>
<td></td>
</tr>
</tbody>
</table>

Source: authors’ own elaboration.
In order to determine the length of the lags, Akaike and Schwarz information criteria are considered. Also, the roots of polynomial characteristic are analyzed and we found that the system is stable and steady. Also, the short-term effects can be observed by the impulse-response functions (Figures 2 and 3). In these graphs, particularly, it is shown the higher effects in IBOVESPA due to innovations in Brent and WTI, although the effects only last for 3 or 4 periods.

**Figure 2**
Impulse –response functions considering Brent

Source: authors’ own elaboration.
Based on the above results, the following linear Structural Equations Model (SEM) specification is examined by the maximum likelihood method (ML)

$$x_i = \alpha_i + \beta_i X + \epsilon x_i,$$

where $x_i$ are the endogenous variables, i.i.d with mean vector $\mu$ and variance-covariance matrix $\Sigma$. $X$ is a latent exogenous variable (in our case, BRENT or WTI). The two versions of this single-factor measure-

Source: authors own elaboration
ment model intended to prove that the dynamics of oil prices (Brent or WTI) determine the endogenous variables IBOVESPA, IPSA, and IPC. The results are shown in Table 2.

Table 2
Coefficients estimated for the Structural Equation Models

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>Variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBOVESPAâ‡¤-Brent</td>
<td>1</td>
<td>IBOVESPAâ‡¤-WTI</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Cons -0.0002628</td>
<td></td>
<td>Cons -0.000262</td>
</tr>
<tr>
<td></td>
<td>0.529224</td>
<td></td>
<td>0.529224</td>
</tr>
<tr>
<td>IPSAâ‡¤-Brent</td>
<td>Cons 0.0000481</td>
<td>IPSAâ‡¤-WTI</td>
<td>Cons 0.0000481</td>
</tr>
<tr>
<td></td>
<td>0.678265</td>
<td></td>
<td>0.678265</td>
</tr>
<tr>
<td>IPCâ‡¤-Brent</td>
<td>Cons 0.0002125</td>
<td>IPCâ‡¤-WTI</td>
<td>Cons 0.0002125</td>
</tr>
</tbody>
</table>

Source: own elaboration.

It was shown, through empirical evidence, that both Brent and WTI have direct effects (equal to the total effects) on stock markets. It is important to observe the similarity of the effects of the Brent and WTI on the stock returns; in addition, the method employed was the Quasi-maximum likelihood (QML) instead ML, but results are also very similar. The tests used for the goodness of fit were, first, verifying the null hypothesis considering the $\chi^2$ test. The test examined if the fitted covariance matrix and mean vector of the sample known are equal to the covariance matrix and vector in the estimated population. The Root Mean Squared Error of Approximation (RAMSEA), the Comparative Fit Index (CFI), the Tucker-Lewis Index, and the Coefficient of Determination (CD), which was close to unity, were also tested.

4. CONCLUSIONS

This paper examined the relationship between oil price dynamics and stock market returns. Although the financial and economic literature about this linkage is broad, the analysis in the cases of Latin American countries is still limited.

This investigation showed the different impact of Brent prices and WTI prices on the stock markets returns. Specifically, it was found that
the Brazilian market (IBOVESPA) is more sensitive to variations in oil prices. For the econometric analysis, the paper used two methods—an Unrestricted Vector Autoregressive Model (VAR) and a Structural Equation Model (SEM). The first was employed to study the global dynamics and linkages between the assets considered, but using SEM to determine the unidirectional effects of oil prices on each stock market.

REFERENCES


Six years have passed since the publication of the first book “Métodos No Lineales en Series Económicas y/o Financieras” in Spanish, and two years since the appearance of the second book entitled “Nonlinear Time Series and Finance” published in English. These two books were created to contribute with novel investigations pushing the frontier of the knowledge of diverse economic and financial matters of great importance.

Now, this third book, entitled “Recent Topics in Time Series and Finance: Theory and Applications in Emerging Markets” attempts to continue providing the most recent advances in nonlinear time series and its applications in finance and economics. It is a desire from editors of this book that this become a reference for students and researchers in financial analysis and economic theory.

This series of books is aimed at increasing theoretical knowledge and empirical applications in non-linear time series and at the same time becoming a reference for practitioners, professionals and researchers. Particularly, this third book analyzes several stylizing facts in emerging markets that, in some cases, contrast with the behavior of developed markets.