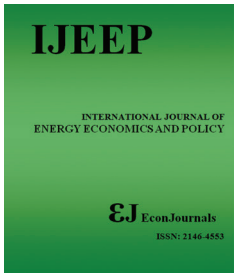

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Volatility Spillover Effect between Stock and Exchange Rate in Oil Exporting Countries

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ABSTRACT

This paper proposes the volatility spillover effect between stock and foreign exchange markets in both directions in oil exporting countries - Russia and Brazil. The data sample consists of daily observations. The method is based on FIGARCH model of the long memory. For emerging markets, volatility spillover is observed mainly in one direction: from the currency market to stock market. Calculations show that long memory is present in the dynamics of volatility, when models take into account structural breaks and frictions. We develop a model to predict the impact of oil prices on stock market indices for Russia, Brazil. The volatility spillover effect is observed in one direction: from the exchange rate to stock market. Calculations show that long memory is present in the dynamics of volatility, when models take into account structural breaks and frictions. This paper focuses on new method for forecasting of volatility (taking into account the structural breaks) on the base of FIGARCH model. The financial markets became more integrated after the World Economic Crisis of 2008–2009. The paper shows that volatility can be predicted using the FIGARCH model if the structural breaks are incorporated in the model. The paper should be of interest to readers in the areas of economic forecasting on the base of long memory models.

Keywords: Efficient Market Hypothesis, Stock Indexes, Exchange Rates, FIGARCH Model, Structural Breaks
JEL Classifications: C51, C58, F31, G12, G15

1. INTRODUCTION

Financial markets became more integrated after the world economic crisis of 2008–2009, which is described in the works of Kim et al. (2013), Babecky et al. (2013), Zivkov et al. (2015), Bong-Han et al. (2015). On the back of liberalization there are tendencies of increasing the volume of the stock and foreign exchange transactions in emerging markets.

Economic theory suggests two main channels that explain the relationship between stock and foreign exchange markets: The traditional trade balance channel and the market portfolio channel.

In the first case, the exchange rate affects the trade balance of the domestic and foreign goods. Further, the growth of real output affects a current and future cash flows of domestic companies, especially export-oriented ones. And the positive correlation between the two assets occurs.

On the other hand, the portfolio balance channel depends on the demand and supply of financial assets. The increased demand for shares causes the demand for domestic currency, which ultimately leads to its appreciation. If the exchange rate changes are caused of any external breaks, the investors decide to buy or sell any assets. There is a direct relationship between two variables.

The majority of empirical studies on the relationship between currency and stock dynamics focused on developed markets. For example, Kanas (2000) have found significant positive impact of stock market on changes in the exchange rate of all countries, except Germany.

These countries benefited from the global investor sentiment to robust economic growth, inflation decrease and economic liberalization, as argued by Lee and Kim (1993) and Josifidis et al. (2009). In turn, this has influenced the balance of supply and demand on the national currency.

It was actually the reason of the correlation between stock indexes and exchange rate dynamics, as indicated by Kanas (2000). Global investors and portfolio managers are trying to understand the relationship between the two groups of financial assets—foreign currency and stock indexes, which also included a currency risk.

2. LITERATURE REVIEW

Most empirical research shows the link between stock and foreign exchange markets, the relationship between these markets is often unstable.

Any changes in prices of stock indexes, caused by fluctuations in the exchange rate, turn the optimal investment strategy. Moreover, the principle of mean reversion (mean reversion) is applicable to long-term time interval and may lead to errors in the timing of the transaction. Chaudhuri and Wu (2003) argued that structural breaks can cause incorrect conclusions about the efficiency of the stock market. Jung and Maderitsch (2014) find evidence that the volatility can dramatically change, if structural jumps are not reflected in the forecast model.

Mikhaylov (2014; 2018) outlines the macroeconomic trends of supply and demand in the oil market and the characteristics of the modeling in the conditions of unstable economic situation in Russia.

Mikosch and Starica (2004), Hillebrand (2005), Kramer and Azamo (2007) argued that the level of volatility persistence can be accounted by using the autoregressive model for long memory (IGARCH).

This article proposes that the effect of volatility spillovers between national stock indexes and exchange rate takes place in both directions. As a currency market breaks can cause a change of currency rate and the currency shock is reflected in the stock market.

We use the fractal method by Sanso et al. (2004) to detect structural changes in the market volatility. The analysis was focused on the markets of Oil exporting countries, namely Russia, China, Brazil and India at the period from March 2009 until March 2017.

Any countries apply the floating exchange rate regime in this period (India and Brazil). China is going to go to the free currency regime. But Russia abolished the exchange rate band and established the inflation targeting regime since the beginning of 2015.

The main hypothesis is that the volatility spillover effect on financial emerging markets is foreseeable. In addition, it is not clear whether there is a constant long memory including the structural breaks in stock and currency market volatility.

The presence of long memory in the volatility analysis plays an important role, because it implies that recent market trends can be used to predict future asset prices. In addition, the structural changes tend to increase the variance of the long persistence of volatility. Previously Kasman et al. (2009) found a long memory in eight Eastern European stock markets. At the time, Wang and Moore (2009) suggested the presence of this factor on the five stock markets in Central Europe.

There are no papers purposed the constancy of the long memory FIGARCH methodology for the oil exporting countries taking into account the impact of structural breaks.

Kim and Kim (2011) investigated the American market and the results showed that the high rate of the exchange against the U.S. dollar affects the volatility of national index, but reduces the volatility of the U.S. stock market.

Jayasinghe and Tsui (2008) have identified the relationship between stock and exchange rate in Japan. The authors argued that there is a spillover effect between the volatility of stock prices in six industries of Japan. In these sectors the volatility of equities increases more than the volatility of the exchange rate.

Grobys (2015) have also examined the volatility of exchange rates of three main U.S. trading partners (Canada, EU and Japan) and the American stock market. These data suggest that the volatility spillover effect is higher in the times of structural breaks.

Previously Andreu et al. (2013) investigated the relationship between stock and FX markets for twelve emerging markets and found that there is a significant positive impact in both directions in all selected countries, except Colombia.

Results of the study of Kasman et al. (2011) are great: Interest rates and currency fluctuations are the main determinants of the asset price volatility. Abrupt changes caused by volatility breaks between equity and currency markets, have a short term effect. So long term investors should not place about this.

Using weekly data, Walid et al. (2011) investigated the volatility of the exchange rate in four developing countries. They found that the volatility of the stock indexes depends on the mean and variance of the exchange rates.

Zhao (2010) showed that for the Chinese market there is also a correlation in the volatility dynamics of the exchange rates and volatility of prices of Chinese equities in the period from 2001 to 2009.

3. METHODS

The presence of structural market shifts is a common problem in forecasting the daily price of financial assets. The stock indexes of Oil exporting countries have been the subject of several shocks after the global financial crisis of 2008. The paper hypothesis is that there have been many structural breaks during this period. Structural changes can lead to long-term increase in the volatility level. In order to identify structural breaks, we used modified method of iterations for cumulative sums of squares (ICSS algorithm) from the research of Inclan and Tiao (1994).

The ICSS algorithm assumes that the unconditional variance of a time series is constant over time until the price shock. After the

shock the variance of the financial asset price gradually returns to its previous average value. This process can be repeated over time, producing discontinuities in the dispersion. Assuming the number of time series (τ_t) with mean zero and variance $\left(\sigma_t^2\right)$, you can use the following formula in accordance with Sanso et al. (2004):

$$AIT=\sup_k|T^{-0.5}G_k \quad (1)$$

$$Gk=\lambda-0.5\cdot[C_k-(k/T)C_T], \text{where } C_k=\sum_{t=1}^{k}\tau_t^2 \quad (2)$$

$$\lambda=\gamma_0+2\sum_{l=1}^{m}[1-l(m+1)^{-1}]\gamma_l \quad (3)$$

$$\gamma_l=T^{-1}\sum_{t=1+1}^{T}\tau_t^2-\sigma^2)(\tau_{t-1}^2-\sigma^2), \text{where } \sigma^2=T^{-1}C_T \quad (4)$$

Where, T - moment of time; k = 1,…,T; C_t - sum of squared deviations from the mean. According to Newey and West (1994) we set lag truncation (m) equal to $0.75T^{1/3}$.

Using this modified algorithm, we recognize multiple structural breaks in conditional variances using dummy variables. Each dummy variable corresponds to the price shock in the market.

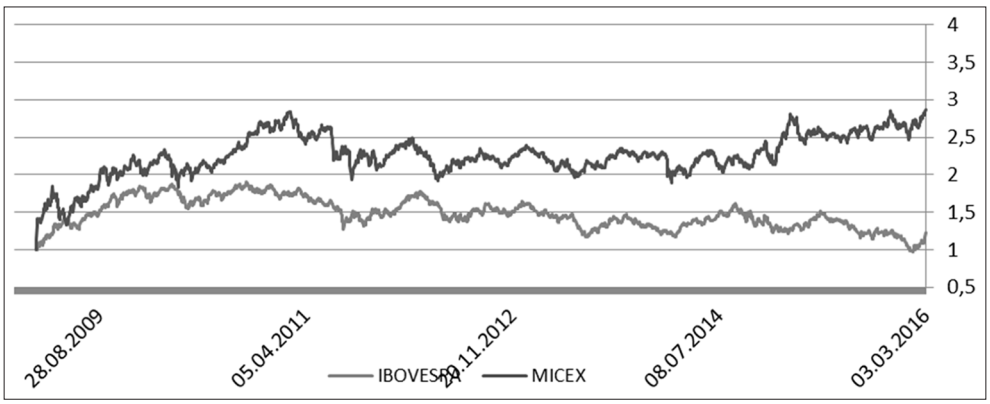
The concept of long memory is associated with a high level of consistency of the time series volatility, which contradicts the efficient market hypothesis. Thus, we assume the presence of long memory in the stock index and currency volatility and we use the FIGARCH model proposed by Baillie et al. (1996), and utilized in the article Zivkov et al. (2015) on the example of Eastern European markets (parameter φ characterizes the volatility spillover effect between stock and foreign exchange markets).

$$\sigma_{(r),t}^2=\omega+\beta(L)\sigma_{(r),t}^2+(1-\beta(L)-\alpha(L)(1-L)^d)\varepsilon(L)-\alpha\xi_t^2+\sum_{j=0}^{k}\omega_j DUM_j \quad (5)$$

Where, $(1-L)^d$ - fractal operator for IGARCH; $[1-\beta(L)-\alpha(L)]$ and $[1-\beta(L)]$ - single roots in GARCH (p,q); DUM - dummy variable; ω, α, β - parameters in GARCH model; d - fractal parameter from 0 to 1, showing the stability of dispersion shocks, r(i,t) – national index (currency rate) changes, P(i,t) - closing price of national index or currency rate (m) at the moment of time (t), and ε_t and ξ_t - identically distributed random error in the relationship between the stock index and the exchange rate. In order to understand the form of the distribution we will use Student's t-test.

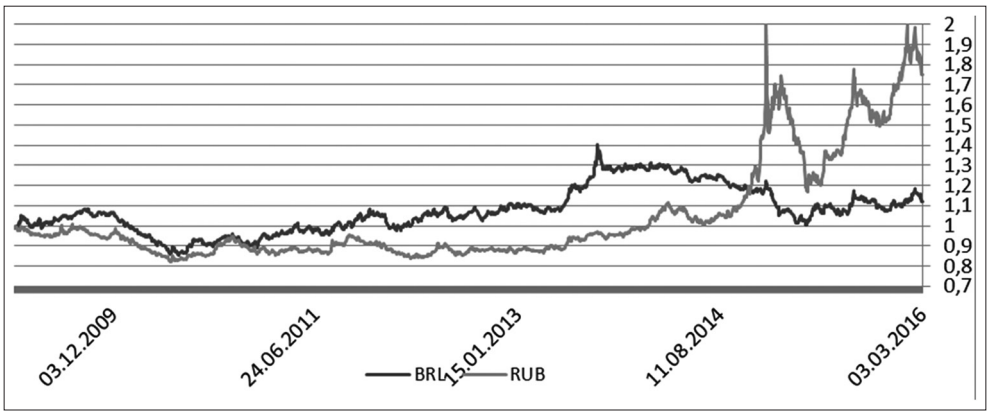
The data set includes the daily dynamics of stock markets and national currencies of the four countries with developing markets: Brazil (IBOVESPA), India (BSE 500), Russia (MICEX), China (SHA) and relevant exchange rate to comparison Euro (Figures 1 and 2). In addition, we used time series of NASDAQ 100 and EURUSD like benchmarks. Based on the research Chkili

Figure 1: Stock indexes of oil exporting countries



Source: Bloomberg

Figure 2: National currencies of oil exporting countries in relation to the euro



Source: Bloomberg

et al. (2012), Grobys (2015) and Jayasinghe and Tsui (2008), Mikhaylov (2012) we chose daily data series.

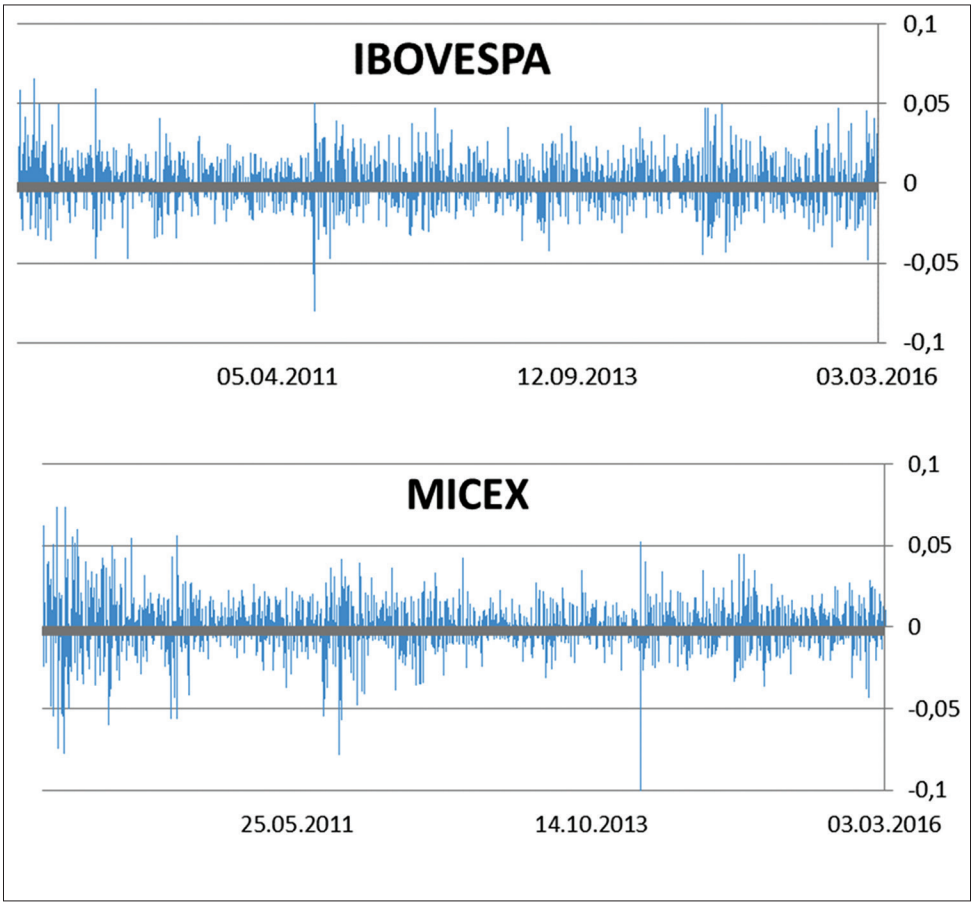
We believe that after the global financial crisis in 2008 there is a fundamentally new nature of the links between stock indexes (Figure 3) and currencies in oil exporting countries, therefore the data cover the range from 3 March, 2009 to 3 March, 2017 for stock markets and national currencies. We used national exchange rates against the Euro (Figure 4). In case of unavailability of some data (caused by national holidays and non-working days in stock markets) dates are synchronized.

The low value of the Jarque-Bera test statistic for all indexes and currencies means asymmetric reactions and abnormal behavior (Table 1). The Ljung-Box test shows the serial dependence of volatility of all assets, except the stock index of Brazil and the Chinese Yuan. This indicates that the FIGARCH model may be suitable for conditional variance processes.

The Dickey-Fuller and KPSS tests utilized by Kwiatkowski et al. (1992) are used to assess the stationarity of the processes. The KPSS test indicates that all series are stationary and therefore suitable for further examination.

As a rule, the sudden changes in asset prices are the result of various domestic and international events, which lead to untypical behavior of different investors. To identify them we apply the ICSS algorithm. This algorithm is suitable to detect structural breaks. It was tested by many researchers, such as Kumar and Maheswaran (2013), Mensi et al. (2014) and Kang et al. (2011).

Figure 3: Stock market day changes in oil exporting countries



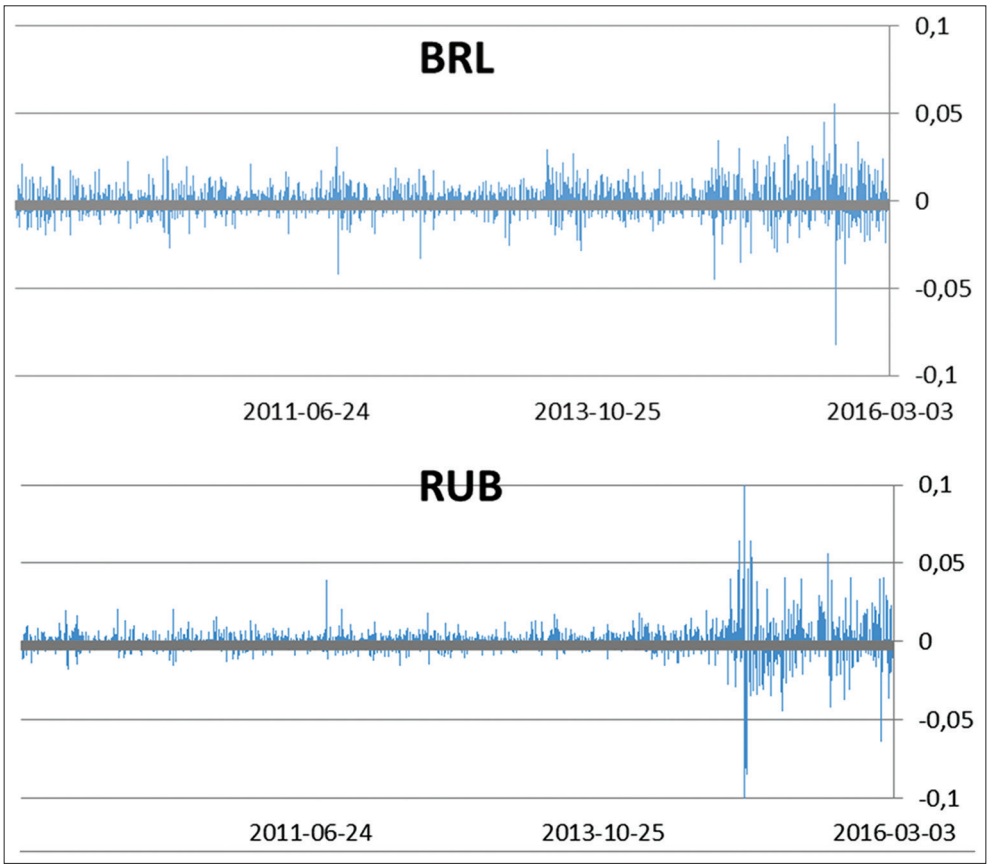
Source: Author's calculation

Table 1: Descriptive statistics and stationarity tests

Parameter	Index				Currency			
	BSE 500	IBOVESPA	MICEX	SHA	INR	BRL	RUB	CNY
Mean±SD	0.076±1.218	0.023±1.488	0.057±1.559	0.028±1.565	0.008±0.649	0.022±0.933	0.037±1.115	−0.009±0.611
Skewness	1.227	0.115	−0.281	−0.708	0.081	−0.174	4.047	0.040
Kurtosis	19.143	1.416	4.019	4.320	3.332	5.677	101.002	2.569
Jarque-bera test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ljung-box test	0.165	0.641	0.363	0.041	0.130	0.000	0.000	0.880
Deckey-Fuller test	−10.96	−12.42	−11.92	−11.97	−12.32	−11.83	−10.74	−11.72
KPSS test	0.58	0.35	0.17	0.11	0.09	0.67	0.58	0.11

Source: Author's calculation

Figure 4: Exchange rate volatility in oil exporting countries in relation to the euro



Source: Author's calculation

4. RESULTS

The volatility of most assets began to grow rapidly from 2014. Uncertainty level in asset markets increased by a combination of conditions (Figures 3 and 4), such as:

1. Escalation of the conflicts in Ukraine, Syria, Libya.
2. Economic crises in emerging markets caused by the USD strengthening.
3. FED's monetary policy became more uncertain in 2014.

In addition, the volatility dynamics of the Russian ruble and, accordingly, the MICEX stock index was affected by an isolation of Russia globally as result of the political and economic sanctions.

The results show that the directional volatility spillover effect from the exchange rate to the stock market is typical for Russia. Investors in Russian stock market are very alert and react to the bad news about the exchange rate. This effect is observed also for the financial markets of India and Brazil (the Chinese market is not susceptible to this effect et all). Investors in emerging markets remember that the profit from the stock market may be reduced or lost quite because of the sharp devaluation of the national currency.

Investors in the U.S. stock market, by contrast, are not worried about the exchange rate of the US dollar: Volatility spillover effect φ [5] is not crucial. The indicator φ has different values for stock markets and Forex, which confirms the presence of the bilateral volatility spillover effect during the structural shifts in the market.

The proposal for the presence of long memory volatility in the presence of structural shifts proved for all the investigated BRICS markets. Since the fractal parameter d is a relatively low in our model, this means that the volatility is not stable and predictable opposite the postulates of the equilibrium market hypothesis.

The volatility spillover effect from the currency market to the stock market is much stronger for all the analyzed markets (except Chinese market, where the flow in the opposite direction dominated).

5. CONCLUSION

We analyzed the features of the bidirectional volatility spillover effect between the stock and foreign exchange markets for four emerging markets. Modified integrated control system (AIT) is utilized to detect major structural breaks.

The results indicate that bidirectional spillover effect existed in the period 2009–2017 years. It was significantly stronger than it was been before the Late–2000s Financial Crisis. This effect turned out to be the most visible in the Russian stock market, because investors in Russian stocks are the most careful and react sharply to bad news background and changes in the exchange rate.

In addition, the paper shows that volatility can be predicted using the FIGARCH model if the structural breaks are incorporated in the model. Structural breaks only distort the skewness in the FIGARCH model.

The results of this research could be useful for institutional and individual investors, as they can get advantages from knowing the model long memory (if the structural breaks are incorporated in the model) for forecasting the volatility in the emerging markets.

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