International Business Management 9 (5): 868-876, 2015
ISSN: 1993-5250

"Digital Money in World Economy Exemplified by Crypto-Currency Bitcoin: Principle of Functioning and Economical Analysis of Exchange Rate's Formation"

[1]Elena Karasik and [2]Anastasiya Kuzmina
[1]Department of Human Resource Management Institute of Management,
Faculty of Economics and Finances, Kremlevskaya St. 18, 420008 Kazan,
Republic of Tatarstan, Russian Fedration
[2]Kazan (Volga Region), Federal University, Kremlevskaya St. 18, 420008 Kazan,
Republic of Tatarstan, Russian Federation

Abstract: In the view of globalization processes and switch from industrialism to post-industrialism in developed countries, it appears that formation of new economic mechanisms would require creation of new world reserve currency which could be represented by digital currencies that are not exposed to direct control from the side of any country. This study is dedicated to crypto-currency Bitcoin. Originality of this research is represented by revealing correlation between formation of Bitcoin's exchange rate and such factors as number of transactions and number of queries in Wikipedia with the help of econometric methods. In order, we could study formation of currency exchange rate, we performed analysis of stationary state of time series, defined the moment of change in trend's incline that was connected with changing structure, we built VECM Model and impulse response functions. We have also performed Ljung-Box test for the presence of residual autocorrelation. We have revealed correlation between In-transformed number of transactions and prices for Bitcoin for the whole period and during the period before structural changed. Besides, we have touched upon the questions about the role of digital currencies in modern economy and particularly in crypto-currency Bitcoin.

Key words: Econometrics, econometrics of time series, digital currencies crypto-currencies, Bitcoin, impulse response model, VECM, perron criterion

INTRODUCTION

Digital currency is a type of alternative currency that exists solely electronically and doesn't have any physical form. It is not issued by central bank of any country and thus, it actually exists apart from the real economy. Nevertheless, its prices (in other words, exchange rate of this currency) are subject to the changes that influence real currencies. However if exchange rate of real currencies could not be separated from macroeconomic indicators, such as gross domestic product, inflation rates, interest rates, etc. and is formed on the base of supply and demand, there are no bases for digital currencies. As concerns supply of digital currencies, it is wither fixed or grows in accordance with the algorithm (like in case with Bitcoin). Demand for digital currency doesn't appear to depend on macroeconomic development but rather is defined by speculative activity of money market players. Thus, stock market trends become a key factor at formation of digital currency's exchange rate (Ladislav, 2013). In 2012, the volume of digital currencies' market equaled 47.5 billion of USA dollars and by 2017 this index is expected to reach 55.4 billion of dollars (Anonymous, 2013).

Since, the phenomenon of digital currencies is now at the initial state of its development, low level of capitalization and excessive speculative activity are typical for them. It may cause volatility of exchange rate, which prevents spheres of their application from expansion. For example, volatility of crypto-currency Bitcoin is 7 times higher than volatility of gold and 8 times higher than the one of S&P 500 index (Williams, 2013). However, according to experts, this disadvantage may be overcome as far as the currency is developing (Vlasov, 2012). As some researchers believe, crypto-currency Bitcoin may even solve the problem of digital gap, since it provides access to financial services with low transaction costs (Jerry and Andrea, 2013).

Crypto-currencies need to be specifically mentioned. Crypto-currency is a type of digital currency, issue and

Corresponding Author: Elena Karasik, Department of Human Resource Management Institute of Management, Faculty of Economics and Finances, Kremlevskaya St. 18, 420008 Kazan, Republic of Tatarstan, Russian Fedration

discounting of which are based on cryptographic methods. Issue of such currency as well as control over its circulation is performed solely on the base of peering network and system of cryptographic keys while no issuing center is present. Bitcoin is the most widespread currency in the world with capitalization of 8 billion sof USA dollars. It is characterized by decentralized issuance which is controlled by mathematic algorithm, deflationary characteristics, anonymity, low transaction cost as a consequence of absence of intermediaries, open API (application programming interface) (Manakhov, 2014).

Research objectives: Understanding of correlation between formation of Bitcoin exchange rate and other factors.

Hypotheses:

- There is a correlation between the number of transactions, performed through Bitcoin and exchange rate of this currency
- There is a correlation between the number of queries at Wikipedia.org and exchange rate of this currency

MATERIALS AND METHODS

The following software was used for the analysis: MS Excel, program for econometric analysis Gretl, statistical analysis package RATS. Data in the form of time series was taken from web sites http://stats.grok.se for the information taken from Wikipedia and http://www.bitcoincharts.com for Bitcoin information. Analysis of temporary series' stationarity was performed with the help of Dickey-Fuller test. Also, we used Perron criterion (integrated Dickey-Fuller test) for determination of the moment of trend's inclination that is connected with structural changes and also we have performed Johansen Cointegration test. Basing on this data we built VECM Model and performed Ljung Box test for the presence of autocorrelation in remainders. Later, we built the function of impulse responses.

RESULTS AND DISCUSSION

In order, we could analyze formation of Bitcoin exchange rate to USA dollar, we selected the following two factors: the number of transactions, performed in that currency and the number of queries at Wikipedia.org. Let us, substantiate the choice of variables for the analysis.

As we have already mentioned, Bitcoin exchange rate as a rate of any other digital currency doesn't seem to be dependent on fundamental indicators, since it is not related to macroeconomic condition of any country (as in the case with the exchange rate of national currency) or any financial indicators of any company (as in case with company's share prices). In this case, the main factor at rate's formation may be presented by stock climate. Indicator of investors' interest may be represented by the number of queries at web-sites, including Wikipedia as an informational resource. Since, the latter one is the fifth website in the list of the most visited sites in the internet, we selected its data for the analysis.

In regard to the number of transactions, it is logical to assume that it correlates with exchange rate. Besides if we speak about Bitcoin, we should mention the following peculiarities: first of all, its volatility is rather high; second, abrupt jumps and price slumps may be attributed to increased or decreased attention on the part of mass media. In its turn, attention of mass media may be focused on crypto-currency in connection with news, like the news about sensitivity of network protocol, hacking of organizations that are in charge for exchange of Bitcoin into other currencies, detection of fraudulent activity, which is performed in Bitcoin (for example, Silk Road Website that traded illegal goods, accepted Bitcoin payments) or official statements of public authority regarding legitimacy of using Bitcoin.

Time series from BTC/USD exchange rate log was subject to analysis as well as time series from log of number of transactions. Variables were assigned with the following names: BTC/USD rate stood for "rate", number of transactions stood for "transactions", number of queries stood for "queries" and dummy variable stood for "dummy".

Sample size equaled 1323; data was received daily, starting from 17.08.2013-24.04.2014. First of all, time series of BTC/USD exchange rate was checked on the presence of unit root with the help of Dickey-Fuller test. P-value appeared to be >0.05, thus, hypothesis H_0 regarding the presence of unit root was not discarded and that means that range is non-stationary one. The same result is obtained for its log. Having performed similar operation with "transactions" variable, we see that this time series is not stationary nor do the range of its logarithms. However in case with "queries" variable, we may conclude that the range is stationary (Fig. 1).

Let us now consider the graph of variance of BTC/USD exchange rate. If we consider the range from the first order difference for "rate" variable (Fig. 2), we may see structural changes which probably took place at the end of 2013.

Consequently, using RATS package, we have performed Phillips-Perron test. Perron procedure summarizes the procedure of Dickey-Fuller test in

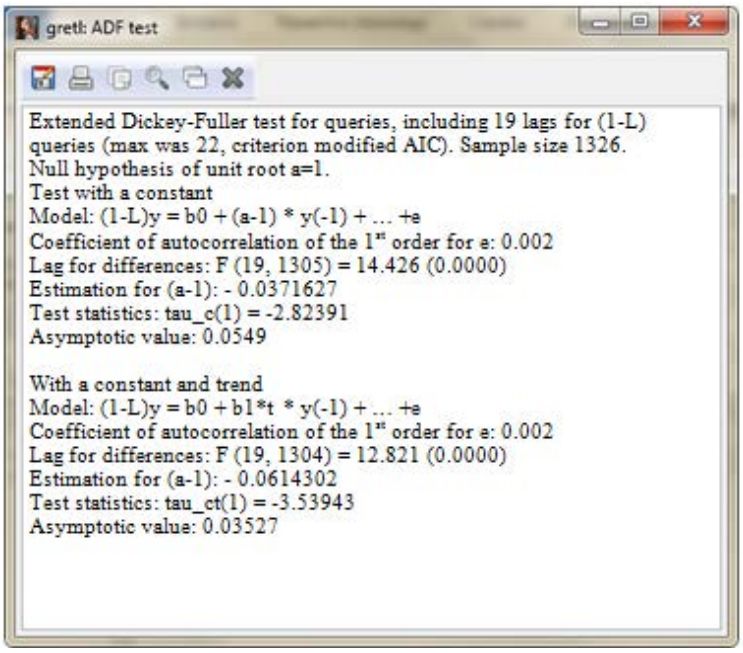


Fig. 1: Test for the presence of unit root for variable queries

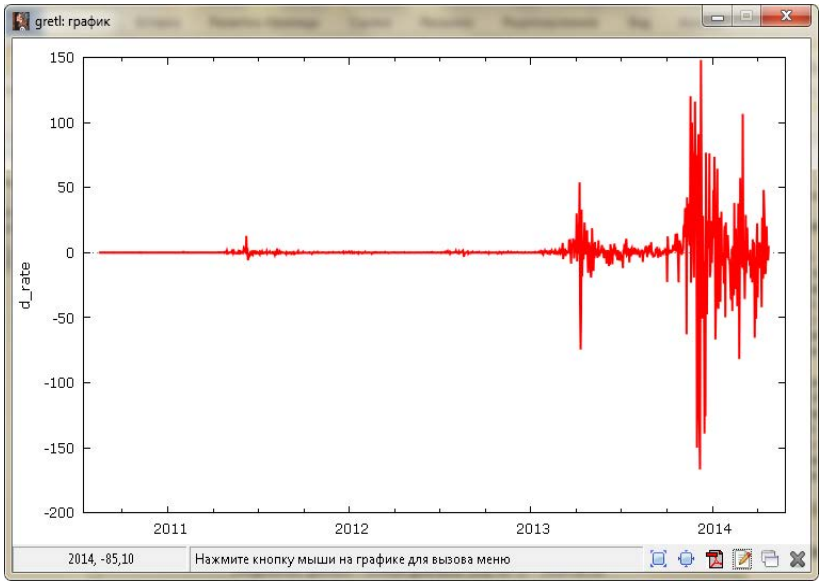
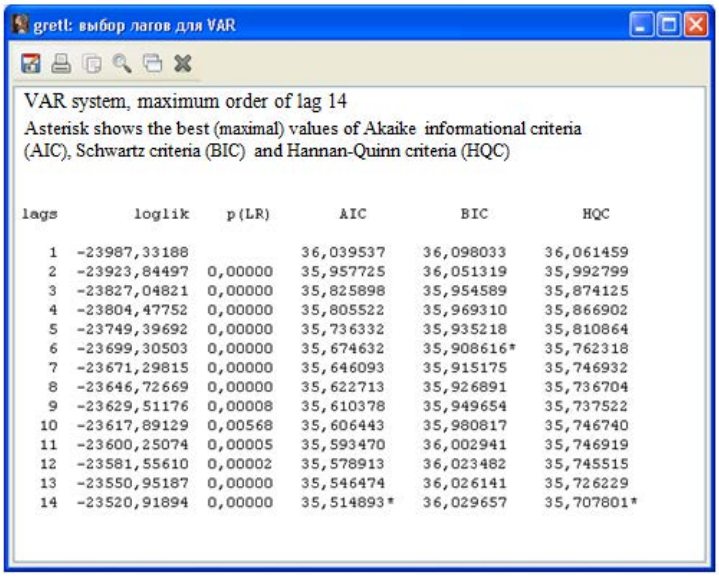


Fig. 2: Time series chart of first-order difference rate (calculated on the base of source)

situation when within monitoring period there are structural changes in some moment of time or in the form of level's change or in the form of trend's inclination or in the form of combination of these two changes (Nosko, 2002). Besides, structural changes may occur suddenly (model with additive emission). The test shown that $t<0.05$ which indicates the presence of unit root; moreover, we were able to identify the moment of time where structural changes took place (on the 10th of December, 2013). It may be explained by Senate hearings regarding Bitcoin which took place on 9.12.2013 as well as limitations, introduced by PR China and general increased attention, focused in crypto-currency. Phillips-Perron test also defined structural change as sudden alteration of trend's inclination (model with additive emission).



lags	loglik	p(LR)	AIC	BIC	HQC
1	-23987,33188		36,039537	36,098033	36,061459
2	-23923,84497	0,00000	35,957725	36,051319	35,992799
3	-23827,04821	0,00000	35,825898	35,954589	35,874125
4	-23804,47752	0,00000	35,805522	35,969310	35,866902
5	-23749,39692	0,00000	35,736332	35,935218	35,810864
6	-23699,30503	0,00000	35,674632	35,908616*	35,762318
7	-23671,29815	0,00000	35,646093	35,915175	35,746932
8	-23646,72669	0,00000	35,622713	35,926891	35,736704
9	-23629,51176	0,00008	35,610378	35,949654	35,737522
10	-23617,89129	0,00568	35,606443	35,980817	35,746740
11	-23600,25074	0,00005	35,593470	36,002941	35,746919
12	-23581,55610	0,00002	35,578913	36,023482	35,745515
13	-23550,95187	0,00000	35,546474	36,026141	35,726229
14	-23520,91894	0,00000	35,514893*	36,029657	35,707801*

Fig. 3: Determination of lag order for the model throughout

Bering obtained data in mind, let us introduce dummy variable which equals 0 at all the values up to 9.12.2013 inclusive and which equals 1 at all the values that go after that. Now let us check the presence of cointegration between all time series with the help of Johansen test. For this, we need to select the sequence of lags according to Schwartz information criterion. The best (i.e., the least) value of the criterion was observed at the lag in 6 (Fig. 3).

Obtained result is presented on Fig. 4. We can see than at r = 1, p>5%, thus, hypothesis H_0 regarding cointegration range that equals 1 is not discarded that is there is a cointegration between all abovementioned factors and its range equals 1. Accordingly, we move to building of VECM Vector Model of correction of errors. This is generalized model of vector auto regression. In case, cointegration system I(1) of y_{1t}, … , y_{Nt} ranges may be represented in the form of VAR with rank A(1) = r, then there exists corresponding presentation of VAR in ECM form (Nosko, 2002).

Let us build 2 models: the first in which the number of queries influences rate's log and log of number of transactions and the second model in which logarithm of transactions influences log of rate which in its turn, influences the number of queries.

Correspondingly, let's arrange variables according to the degree of increasing of endogeneity. Moreover, lag of dummy variable will be noted as = 1.

Let us check the presence of autocorrelation in both models via Ljung-Box test (Fig. 5). For both cases p>5%, thus, hypothesis H_0 regarding the presence of autocorrelation is not discarded. That means that autocorrelation is absent.

Now, basing on the model of vector correction of mistakes, we may build functions of impulse responses. In all cases, the level of significance that = 90% will be used. Conclusion about significance of impulse response's function at each lag is made depending on whether zero level is included into confidence interval.

Using the same scheme, let us analyse the period up tostructural changes (from 17.08.2010-09.12.2013). Sample size equals 1205 values (Fig. 6 and 7).

According to Schwarz criterion sequence of lags would = 6. As a result of Johansen test at r = 1, p>5%, thus, hypothesis H_0 regarding cointegration range that equals 1 is not discarded; it means that cointegration between all abovementioned factors is present and its range equals 1. Let us build VECM Model in which the number of queries influences rate's logarithm and it it its turn, influences logarithm of the number of transactions. Ljung-Box test for the presence of autocorrelation (Model 1 and 2, respectively) for the period before structural changes shows that for both cases p>5%, thus, hypothesis H_0 regaridng absence of autocorrelation is not discarded.

Let, us build functions of impulse response (Fig. 8 and 9). Now let us anlyze the data for the period from 10.12.2013 till 24.04.2014. According to Schwartz criterion lag order equals 1.

As a result of performance of Johansen test at r = 2, p>5%, thus, hypothesis H_0 regarding cointegration range that eqials 2 is not discarded which means that there is cointegration between all abovementioned factors and its range equals 2. Figure 10 and 11 illustrate impulse responses for this model.

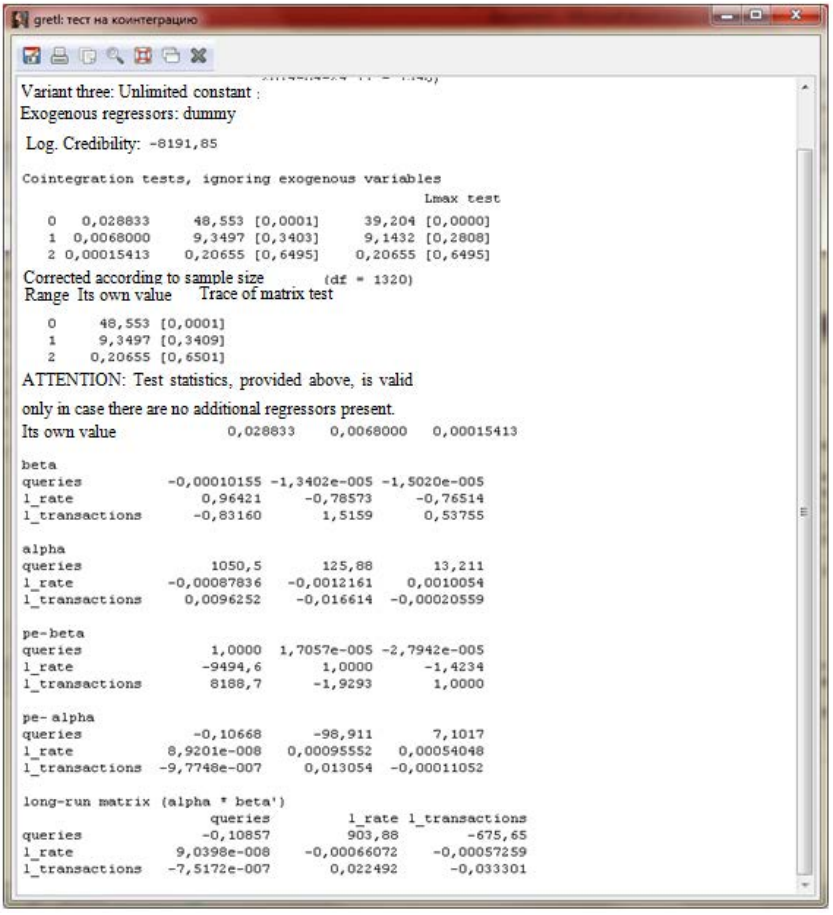


Fig. 4: Obtained results

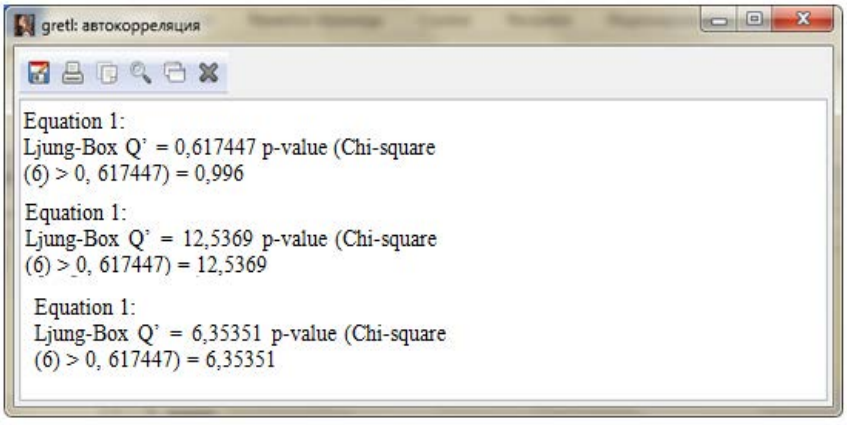


Fig. 5: Ljung-Box test for the presence of autocorrelation (Model 1 and 2, respectively)

Summary: Finally, we'd like to mention growing popularity of crypto-currencies (in particular, Bitcoin) which is evidenced by growing number of companies and web shops that accept Bitcoin as well as growing number of automatic teller machines and bureaus de change. At the same time, we should emphasize that analysis and especially forecasting of exchange rate are very difficult to perform because of high volatility and speculative character of crypto-values.

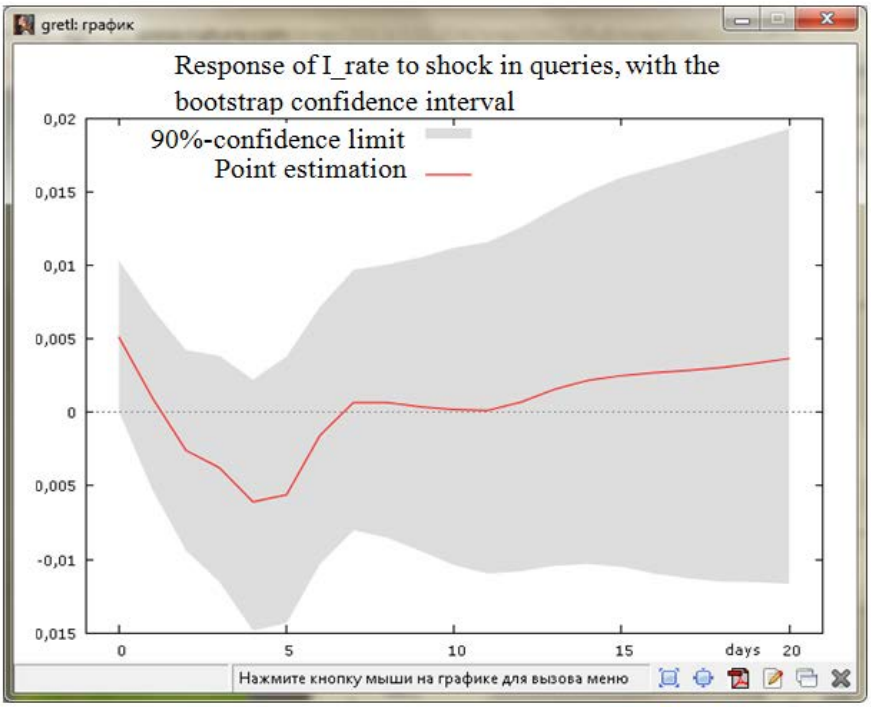


Fig. 6: Function of impulse response of in-transformed prices at Bitcoin and queries at Wikipedia. Response of change of Bitcoin's price log to the change of number of queries is statistically insignificant

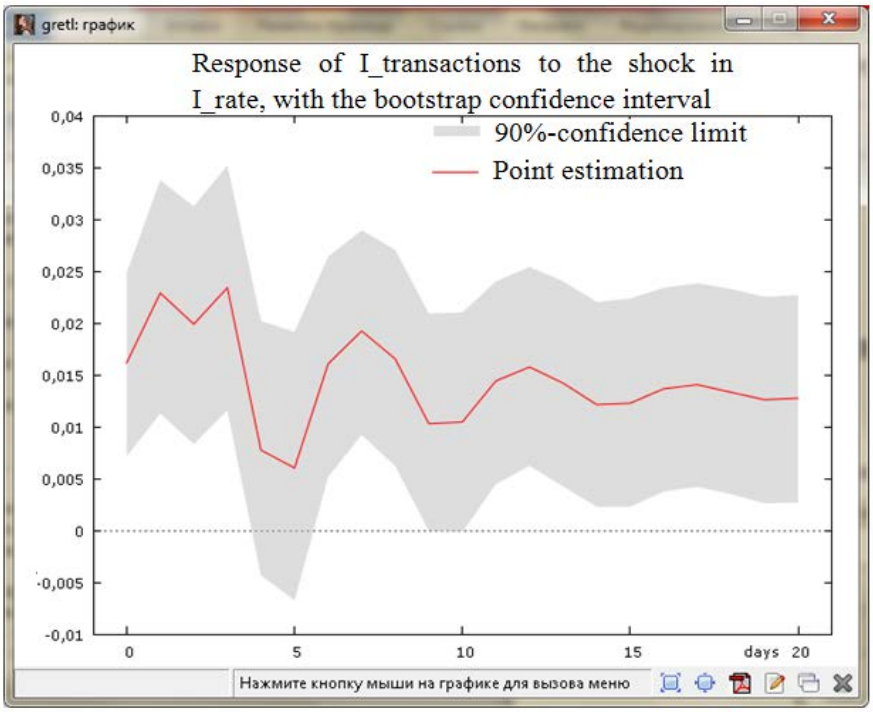


Fig. 7: Function of impulse response of in-transformed number of transactions and prices at Bitcoin. Response reaches 2.25% in the long-term period it equaled 1.25% from the initial value, moreover, lags that correspond to 4 and 5 response function is not significant

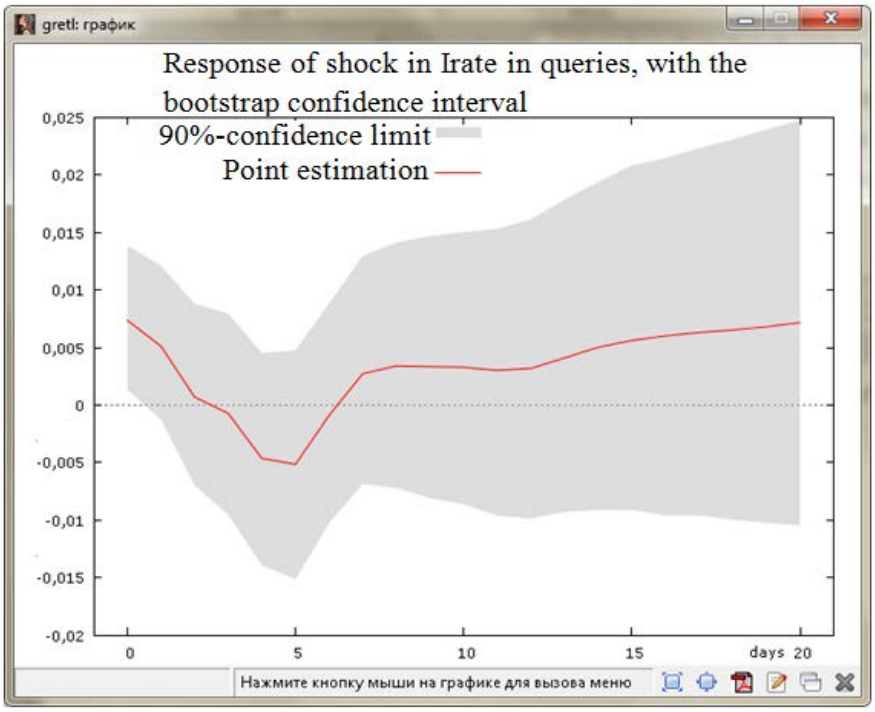


Fig. 8: Function of impulse response of in-transformed number of transactions and prices at Bitcoin and queries at Wikipedia (data for the period before structural changes). Effect is statistically insignificant

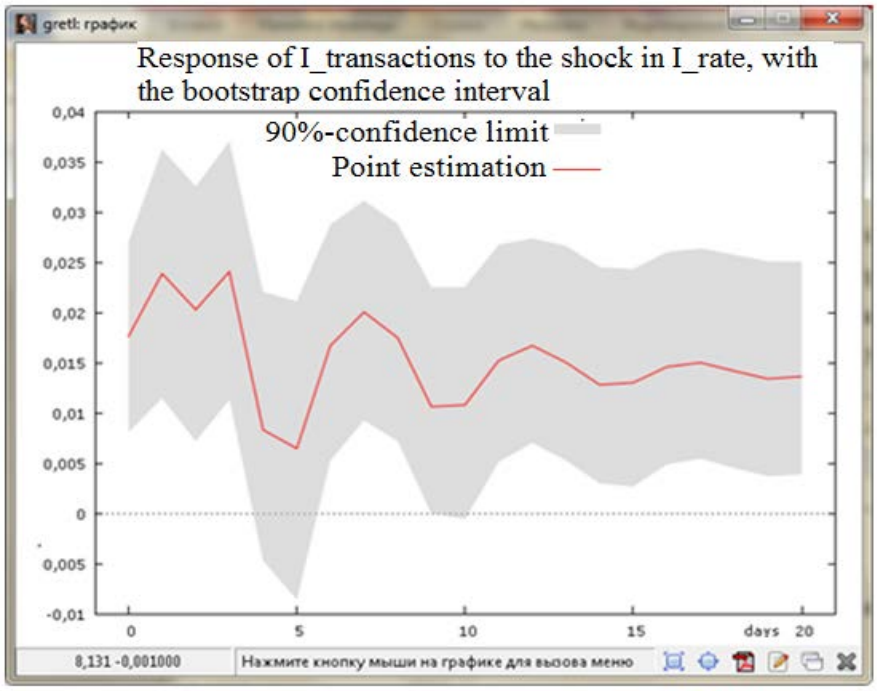


Fig. 9: Function of impulse response of in-transformed number of transactions and prices at Bitcoin and the number of transactions in currency (data for the period before structural changes). Similar to the case with the data for the whole studied period, response reaches 2.25% in long-term period it equaled about 1.25% of the initial value and at lags that equaled 4, 5 and 10, response function was insignificant

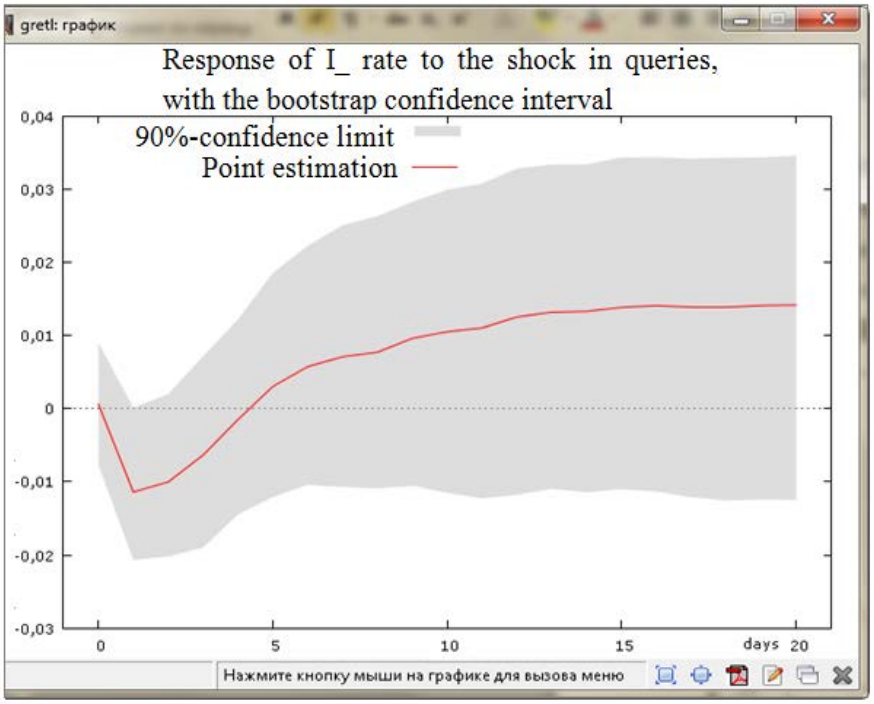


Fig. 10: Function of impulse response of in-transformed prices at Bitcoin and number of queries (data for the period before structural changes). Effect is statistically insignificant

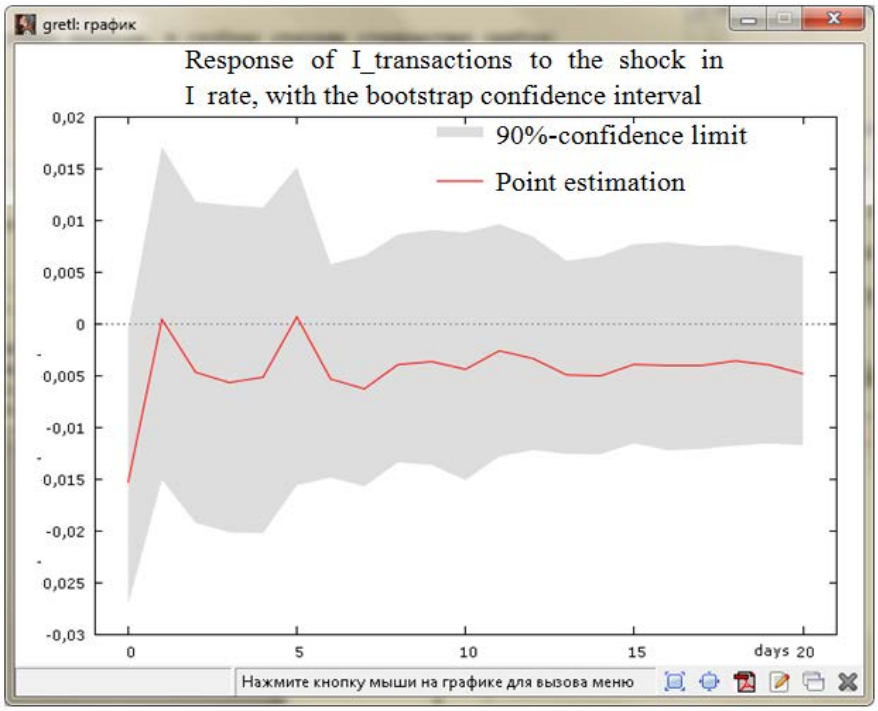


Fig. 11: Function of impulse response of in-transformed number of prices at Bitcoin and number of transactions in currency (data for the period after structural changes). Response function is statistically insignificant

CONCLUSION

Thus, within this work the following important conclusions have been made. Dickey-Fuller test shows that time series of prices for Bitcoin and the number of transactions in Bitcoin as well as logarithmically transformed ranges of these indices are no stationary one while the range from the number of queries in Wikipedia is stationary one.

In December, 2013 structural changes took place which conditioned shift of the logarithm of Bitcoin rate. Thus, three samples are subject to analysis: data for the period from 17.08.2010 till 24.04.2014 from 17.08.2010 till 09.12.2013 (period of structural changes) and from 10.12.2013 till 24.04.2013 (period after structural changes).

Lag that equaled 6 was selected for all three samples according to Schwartz information criterion. As Johansen test has shown, there is cointegration connection between Bitcoin rate, number of transactions in Bitcoin and number of queries related to Bitcoin.

For the data for the whole period before structural changes as well as for the data for the whole period cointegration range equaled 1 while for the data for the period after structural changes cointegration range equaled 2.

For all three samples, we have built model of vector correction of errors and functions of impulse responses, basing on it. Function of impulse response appeared to be statistically significant only for logarithmically transformed number of transactions and prices for Bitcoin for the whole period before structural changes. Response of variable of logarithm of number of transactions to shock of logarithm of Bitcoin rate reaches 2.25% in long-term period it was about 1.25% of the initial value while at lags that equaled 4 and 5 (and for the period of structural changes at lags that equaled 4, 5 and 10) function of response was insignificant.

ACKNOWLEDGEMENT

The research is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

REFERENCES

Ladislav, K., 2013. BitCoin meets Google Trends and Wikipedia: Quantifying the relationship between phenomena of the Internet Era. Scientific Reports 3. 2013/12/04/.

Anonymous, 2013. Yankee Group Analytical Report. “Redefining Virtual Currency”.

Williams, T.M., 2013. “Beware of Bitcoin”. Cognoscenti blog. 90.9 WBUR Boston’s NPR news station 5, December 2013.

Vlasov, A.V., 2012. Electronic money and evolutionary theory of moneys’ origin. Science and education: Economics. Entrepreneurship, Law and Management, No. 12, pp: 13-23.

Jerry, B. and C. Andrea, 2013. Bitcoin: A Primer for Policymakers. Aug 19, 2013.

Manakhov, V.A., 2014. Peer electronic payment system BITCOIN. Innovations in science. No. 29. pp: 218-224.

Nosko, V.P., 2002. Econometrics; Introduction into regression analysis of time series.