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MODERN FEATURES OF A MONETARY POLICY OF THE BRICS COUNTRIES: AN EMPIRICAL ANALYSIS AND MODELING RESULTS OF A MODIFIED TAYLOR RULE

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The article is devoted to modern issues of a monetary policy of the BRICS countries. Currently under the fragile economic situation the role of central banks is increasing; governments search for some new effective methods to stimulate economic growth. One of the key factors of progress is price stability support that is connected with a monetary policy and implementation of an inflation targeting. Nowadays this monetary policy framework has been adopted officially by most of the BRICS countries, but the issues concerning what methods and instruments should be used are still being discussed. The key issue of the discussion is whether it is necessary to set a flexible exchange rate arrangement under the inflation targeting conditions. In this connection, the expediency of a central bank to manage the national currency exchange rate is being discussed as it may conflict with the declared monetary policy. The main task of the present research is to assess the impact of a real effective exchange rate index that is considered to be an element of a monetary policy of the BRICS Central banks on a base interest rate. For this purpose an econometric model based on a modified Taylor's equation has been suggested. This model demonstrates the needs of developing economies of the BRICS countries for both price and exchange rate stability. Panel data analysis together with econometric modeling tools have been used to calculate the empirical part of the study. Regression coefficient assessments have proven the significance of these tools; the econometric modeling results have confirmed that Central banks of the BRICS countries mostly direct their attention to basis tools of the inflation targeting and economic agent expectations when achieving price stability. In the terms of the obtained data we may conclude, that it is necessary to consider an exchange rate when implementing a monetary policy in the BRICS countries. Further we will research 1) monetary policy in each of the BRICS countries in detail and will reveal long-terms connections among indices in the reaction equation of a central bank using co-integration vectors in a vector model of error correction; 2) interference of the policy of the BRICS Central banks and whether they are subject to globalization in the world finance sphere.

Keywords: central bank, monetary policy, inflation targeting, Taylor's equation, base interest rate, real effective exchange rate, the BRICS countries.

СОВРЕМЕННЫЕ ЧЕРТЫ ДЕНЕЖНО-КРЕДИТНОЙ ПОЛИТИКИ СТРАН БРИКС: ЭМПИРИЧЕСКИЙ АНАЛИЗ И РЕЗУЛЬТАТЫ МОДЕЛИРОВАНИЯ МОДИФИЦИРОВАННОГО ПРАВИЛА ТЕЙЛОРА

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Статья посвящена вопросам современной денежно-кредитной политики стран БРИКС. В условиях неустойчивого экономического развития наблюдается повсеместное усиление роли центральных банков, происходит поиск новых эффективных методов стимулирования экономического роста. Одним из ключевых факторов поступательного движения является поддержание ценовой стабильности, что связано с выбором режима денежно-кредитной политики – инфляционного таргетирования. В настоящее время данный режим официально принят большинством стран БРИКС, однако ведутся дискуссии о методах его реализации и наборе используемых инструментов монетарной политики. Основным пунктом дискуссии является необходимость введения режима плавающего валютного курса в рамках таргетирования инфляции, в связи с чем обсуждается целесообразность для Центрального банка управлять обменным курсом национальной валюты, что может противоречить целям объявленной денежно-кредитной политики. Основная исследовательская задача заключается в оценке значимости влияния показателя реального эффективного валютного курса как элемента монетарной политики центральных банков стран БРИКС на реальную процентную ставку в экономике. С этой целью предложена модель, построенная на основе модифицированного уравнения Тейлора, отражающая потребности развивающихся экономик БРИКС в поддержании ценовой стабильности и стабильности внутреннего валютного рынка. Эмпирическая часть работы проведена с помощью инструментария эконометрического моделирования с использованием метода анализа панельных данных. Полученные оценки всех коэффициентов регрессии позволяют сделать вывод об их значимости; результаты эконометрического моделирования свидетельствуют, что в наибольшей степени для достижения целей ценовой стабильности центральные банки стран БРИКС ориентируются на базовые инструменты инфляционного таргетирования и ожидания экономических агентов. На основе полученных оценок сделан вывод о целесообразности учета валютного курса при реализации монетарной политики в странах БРИКС. Перспективными направлениями дальнейших исследований могут стать: детальное изучение денежно-кредитной политики каждой из стран БРИКС и выявление долгосрочных взаимосвязей между индексами в уравнении реакции Центрального банка с помощью построения коинтеграционных векторов в векторной модели исправления ошибки; анализ взаимного влияния политики центральных банков стран БРИКС и их подверженность процессам глобализации в сфере мировых финансов.

Ключевые слова: Центральный банк, денежно-кредитная (монетарная) политика, инфляционное таргетирование, уравнение Тейлора, базовая процентная ставка, реальный эффективный валютный курс, страны БРИКС.

Introduction

Currently the role of central banks in economy is significant and recently it has been increasing. This growth is associated with new effective methods of a government support in national economies that are suffering from a long-term negative impact of economic crises. Countries have started applying different methods to stimulate economic growth after the world financial crisis of 2008–2009. These methods include new tools of a monetary policy that support national producers and increase the national economy competitiveness. It is typical

for both developing and developed countries as well as for the BRICS countries[1] that we study.

The BRICS countries that used to be a formal formation currently work hard to create a political and economic entity that could cope with negative consequences of economic crises as well as with the aggressive economic policy of some developed countries. The first summit of the BRIC countries was in the crisis 2009 in Russia and discussed the issues of economic security of the countries that are the parts of the formation[2]. The success of its activity has been proven by a number of summits that have already been hold: the ninth summit was in Xaimen, China in 2017. Despite the decades of collaboration the BRICS countries have different views on the formation aims[3]. Although there are mostly political relations in the formation but cultural, scientific, economic, financial and other ties are also observed among the countries.

The BRICS countries are similar in the development level and are likely to have common approaches to different parts of an economic activity. The national economies of the BRICS are characterized by emerging financial markets and national financial regulators that role is changing. Recently a monetary policy framework of most countries has changed. At the same time control over a domestic foreign exchange market is a significantly important issue for all countries of the union due to the exiting type of the economy and a place of a country at the world markets.

A monetary policy of the central banks of the BRICS countries, as well as other countries of the world, should support national economy and contribute to an economic growth. Any central bank has its own strategic aims though it should support a sustainable growth, national currency stability and the efficiency of the financial system. Recently these purposes are associated with the achievement of medium-term targets that demonstrate price stability in economy. This stability is expressed with the establishment of a monetary policy framework of an inflation targeting.

Nowadays an inflation targeting has been declared by four countries of the BRICS except China. However, despite the establishment of a monetary aggregate targeting, the People's Bank of China has an official inflation target. This fact proves the importance of price stability for an economic growth.

When an inflation targeting is officially established, a central bank should use the available monetary policy methods more effectively as it is determined by the national economy demands. Ideally this regime suggests to refuse an exchange market control and to pass to a floating exchange rate arrangement. However, the experience of the inflation targeting in developing countries has revealed that a simultaneous use of the two tools of a monetary policy – the correction of a base interest rate and intervention – is more preferable.

In a modern developing economy with the inflation targeting a real interest rate is a key target of a monetary policy, a short-term base nominal interest rate is a key tool used by a central bank and an exchange rate is often a necessary element of a monetary policy that may be a manipulation object to influence other economic factors.

Thus, the main research task is to assess empirically the impact of a real effective exchange rate that is considered to be an element of a monetary policy of the central banks of the BRICS countries, on a real interest rate in economy. In this case we may conclude about the consequences of the central banks to manage an exchange rate.

Discussions concerning the transformation of a current monetary policy and its role in economic development

Russian readers are mostly interested in the continued discussions concerning the transformation of the monetary policy regime in Russia, whether the change to an inflation targeting is reasonable and how it will be realized. The opportunity to abolish the inflation

[1] The BRIC countries (Brazil, Russia, India, China) as an informal formation have been researched since the publications of an expert group of the international bank Goldman Sachs in 2001; South Africa joined the union in 2011 and as a result the formation name changed to "the BRICS countries".

[2] The BRICS Summits. Dossier. Available at: http://tass.ru/info/2098676 (accessed 03.09.2017).

[3] The BRICS Summits: What the leaders of the five countries go to China with. Available at: http://tass.ru/ekonomika/4527922 (accessed 03.09.2017).

targeting in Russia and its transformation to an exchange rate targeting are being discussed by scientists. It is mainly associated with the negative results of the monetary policy transformation in 2013 and with the introduction of a floating exchange rate in Russia [1]. The negative consequences of the monetary policy transformation could have been predicted before, but unfortunately the Central Bank of the Russian Federation ignored them. In fact, only currency speculators being the main economic agents benefited from the rejection of the exchange rate targeting and the uneven increase in an interest rate by the Central Bank of the Russian Federation at the end of 2014 [2].

Though, some scientists protect the modern monetary policy framework describing opportunities, aims and mechanisms of the monetary policy conducted by the Central Bank of the Russian Federation [3]. They explain the currency crises of 2014–2015 by theoretical models of payment balance shocks of a small open economy [4]. Detailed critical analysis of the Central Bank of the Russian Federation activity and the protection of the financial regulator are based on the correct application of particular established procedures of the inflation targeting results by some scientists [5]. Another argument for the inflation targeting is the assertion about the impossibility to provide economic stability in case of a controlled exchange rate [6]. At the same time scientists believe that if the present monetary policy retains under foreign-economic pressure and the crises in the Russian economy, the central bank should counteract unreasonable volatility of the Russian rouble exchange rate [7].

A lot of publications are devoted to the analysis of an inflation targeting in developing countries. Scientists analyse the experience of both particular countries and a group of countries comparing approaches to this monetary policy framework in developed, developing countries and countries with emerging economies. A list of Russian and foreign publications concerns actual implementation of the approach that involves two tools and two aims by central banks. The researchers conclude that emerging economies, facing with the need to stabilize prices and the exchange rate of national currency simultaneously, can conduct this policy effectively avoiding multi-direction actions [8], as well as benefit during economic crisis [9]. They note that when controlling inflation, the application of two tools of monetary policy – an interest rate and a monetary intervention – may lead to opposite results in some cases [10]. Despite this fact, not all countries that target inflation, especially from the list of countries with emerging economies, abandon a currency intervention. It happens because the control over national currency market and the support of national currency exchange rate are strategically significant elements of a public policy. For example, Indonesia and Turkey set a modified regime of an inflation targeting when they control a pricing level and regulate speculative demand at the currency market [10]. Indonesia and Thailand use a flexible approach to the implementation of the monetary policy framework and their central banks focus at different tools and this focus depends on the needs at a current time period; e.g. they focus at the pricing stability during crisis [11]. On the basis of the world experience of the inflation targeting in developed countries we may conclude that practically all countries that established the monetary policy framework resorted to different tools to regulate the national currency market and it did not contradict the main aims of the regime [12]. We have empirically proven the efficiency of a simultaneous application of the two tools mentioned above when analysing the exporting countries that implement the inflation targeting [13]. We have also included in the analysis the countries with the emerging markets that conduct the regime of controlled flexible currency exchange rate de-facto [14], developing countries that central banks are not able to manage currency exchange rate [15], and countries with financially unstable economies [16].

When analysing the approaches to assess the feasibility of the inflation targeting to stimulate an economic growth it should be noted that this monetary policy framework may be used by both developed and developing countries. Although “precise inflation targeting is considered to result to strong volatility of a currency exchange rate” [17, pp. 71–72], that may negatively affect the economic growth. The sampling of 176 countries has been empirically

assessed using econometric modelling methods. The results of this assessment have proven that the efficiency of the monetary policy at the inflation targeting may be increased by a currency exchange rate management for both developed and developing countries [18]. Different authors when studying the intervention of a central bank in the situation at the currency market have empirically demonstrated that there is so called "a comfort zone" of a currency rate fluctuation and if the zone extends, a central bank may take emergency response measures [19]; and even if an aim to manage an exchange rate is not declared, a central bank will try to smooth its significant fluctuations [20]. Scientists have concluded that the inflation targeting is currently acute but its implementation should not contradict to real economic demands but should gain public confidence in a central bank [21].

It is worth mentioning that currently not enough attention is paid to a comparative analysis of different aspects of the BRICS central banks activity in scientific literature. Though, there is a significant list of publications devoted to challenges of particular countries in macro-economic finances. For example, some articles are devoted to the issues of modelling of Chinese monetary policy results. These articles prove that classical tools of the monetary policy are useful [22], at the same time they highlight that sharp strengthening of a national currency exchange rate may be destructive for the national economic growth [23]. Scientists, who investigate the monetary policy of the Reserve Bank of India, currently discover the advantages of the operating transmission channels. They conclude that the control of bank interest rates is expedient but the control of the currency exchange rate should be weak [24]. After the crises the Central Bank of Brazil confronted with difficulties to support the pricing and currency rate stability [25] that was typical for other countries of Latin America. The monetary policy was changed in 2011 but the inflation targeting retained [26]. Thus, the role of the currency exchange rate to support macro-economic stability is still significant in the region. According to [27] the purpose of the South Africa Reserve Bank since 2008 has been to maintain the price stability. Despite the crises of 2008 the Reserve Bank did not increase the inflation target index and managed to maintain the economic activity successfully. The South Africa maintains the inflation targeting that suggests active application of monetary tools to achieve a real interest rate target. The target is determined by the Taylor's equation. Research of the monetary policy efficiency together with the analysis of the interest rates dynamics and their correspondence to calculated values as it is prescribed by a monetary policy, demonstrates significant independence of the South Africa Reserve Bank [28].

General issues that the central banks of the BRICS countries currently deal with are connected with the practicality of the monetary policy and currency exchange rate establishment. All countries except China target inflation. Moreover, all countries declare a floating exchange rate arrangement, although in fact there are some peculiarities of its functioning in some countries including China. Some authors point out that the countries with emerging markets when adapting to the inflation targeting have to weaken the control over the currency market. That often does not correlate with the current economic tasks [29; 30]. Studying the advantages and threatens of a floating exchange rate arrangement in the case study of Brazil, India, China and South Africa scientists mention that macro-economic conditions should be the main prerequisites of its introduction. These conditions will contribute to the regime efficiency and expediency [31].

Despite the BRICS peculiarities and their particular challenges in real and financial sectors, at stock and currency markets these countries are supporting each other in a monetary sphere. For these purposes new joint financial institutions such as New Development Bank and BRICS Contingent Reserve Arrangement are created. Their aim is to support financial stability of the participants and to prevent negative impact of the monetary policy conducted by the Federal Reserve System and European Central Bank on the economic condition of the BRICS countries [32].

The review of scientific literature devoted to the challenges of a modern monetary policy of the BRICS countries has highlighted the urgency and importance to compare monetary policies of these countries as well as to

further research the impact of the applied tools of a monetary policy on its key targets.

Monetary policy of the BRICS countries

During the latest world financial and economic crisis some countries have changed their monetary policy tools and methods. In our opinion these changes were significant for developed countries. As in these countries an interest rate channel of monetary policy transmission mechanism stopped working so their central banks were forced to involve bank lending and cash flow channels. The same transformation was less significant for the developing countries where tools of macro-prudential regulation were mainly added. The transformation of the monetary policy of developing countries was characterised by the understanding of the importance of an exchange rate channel of a transmission mechanism. Central banks of developing countries now may more effectively use nominal exchange rates as indicators of markets and signs for a real sector of economy. Features of the monetary policy of the BRICS countries are presented in Table 1.

Table 1

Features of the monetary policy of the BRICS countries*

Features	Brazil	Russia	India	China	South Africa
Monetary policy framework	Inflation targeting regime	Inflation targeting regime	Flexible inflation targeting	Targeting regime of monetary aggregates	Inflation targeting regime
Year of acceptance	1999	2014	2011	1996	2000
Inflation target , %	4.5	4	4–6	3.5	4.5
Monetary policy tools	Operations at an open market; long-term and short-term operations of refinancing; short-term interest rates	A key rate and interest rates of a money market, liquidity provision tools; reserve demands; tools of currency rate policy; macro-prudential standards	Basic interest rates; operations at an open market; reserve demands; tools of currency rate policy; macro-prudential standards	Basic interest rates; operations at an open market; reserve demands; Policy of an open window; tools of currency rate policy	Liquidity management tools, currency swaps; interest rates of a money market; benchmark rates; operations at an open market

* Worked out by the authors using data taken from the official sites of the BRICS Central banks: 1) the Central Bank of Brazil. Available at: www.bcb.gov.br (accessed 19.07.2016); 2) the Central Bank of the Russian Federation. Available at: www.cbr.ru (accessed 19.07.2016); 3) the Reserve Bank of India. Available at: www.rbi.org.in (accessed 19.07.2016); 4) the People's Bank of China. Available at: www.cbc.gov.tw (accessed 19.07.2016); 5) the South Africa Reserve Bank. Available at: www.resbank.co.za (accessed 19.07.2016).

Among similarities we have to mention the same level of development of the BRICS countries. The differences among them are the declared aims of a monetary policy and a whole economic policy that is being conducted by these countries. In general the current monetary policy conducted by the BRICS countries is similar to an inflation targeting and officially it is implemented by four out of the five countries. The present regime was introduced by Brazil and South Africa in 1999 and 2000 correspondingly. All the rest BRICS countries declared it not long ago. Currently the monetary policy of India is characterised as a flexible inflation targeting. It introduces corridors to determine a desirable inflation rate. China stands apart in this list. It officially introduced M2 growth rate as an intermediate aim of the monetary policy in 1996. Though, as we have already mentioned China has an inflation target.

The exchange rate policy of the People's Bank of China, as well as the monetary policy in general differs from the policies implemented by other countries of the BRICS. Currently the exchange rate policies conducted by four out of the five investigated countries are characterised by International Monetary Fund as a floating exchange rate arrangement (Table 2). The

central bank of China does not aim to introduce the yuan floating exchange rate controlling the situation at the currency market and supporting the national economy during crisis periods of development.

Table 2

Transformation of the exchange rate regime in the BRICS countries

Characteristics	Brazil	Russia	India	China	South Africa
Exchange rate arrangement in 2007	Floating exchange rate	Controlled floating exchange rate	Controlled floating exchange rate	Crawl-like arrangement to the US dollar	Floating exchange rate
When the changes occurred	No	2014	2011	2008, 2010	No
Current status of the exchange rate market	Weakening of the national currency	Sharp weakening of exchange rate, volatility	Weakening of the national currency	Strengthening of the national currency	Weakening of the national currency
Features of currency wars	Weakening of the national currency	Episodes in 2016	No	Slight weakening of the national currency in 2015 then further weakening in 2016	No
Current exchange rate arrangement	Floating	Floating	Floating	The regime with an opportunity to adjust the exchange rate	Floating

* Worked out by the authors using data taken from the official sites of the BRICS Central banks: 1) Central Bank of Brazil. Available at: www.bcb.gov.br (accessed 19.07.2016); 2) Central Bank of the Russian Federation. Available at: www.cbr.ru (accessed 19.07.2016); 3) Reserve Bank of India. Available at: www.rbi.org.in (accessed 19.07.2016); 4) People's Bank of China. Available at: www.cbc.gov.tw (accessed 19.07.2016); 5) South Africa Reserve Bank. Available at: www.resbank.co.za (accessed 19.07.2016).

One of the features of the current monetary policy is an opportunity to affect the national currency exchange rate in order to support national producers during an inflation targeting. It is called a currency war policy or a competitive devaluation policy. This phenomenon is broadly discussed in scientific literature now. This policy is sometimes used by central banks of both developed and developing countries. It should be noted that the countries have different opportunities for manipulation; and according to the studies the effect duration [33] and such forms of possible profit as the increase of trade and financial flows may also differ [34].

As we can see from Table 2, not all of the above considered countries have resorted to the competitive devaluation. China is more often condemned in this regard. The economy of Brazil was also affected by the currency wars introduced by the USA. And this fact was announced by a Minister of Finance in 2010 [35]. Due to a weak national economy and limited recourses to affect the exchange rate, Russia was mostly subjected to a currency crisis during the above mentioned period. Though separate episodes of the competitive devaluation were observed in 2016[4]. All the BRICS countries, except China, have introduced a floating exchange rate arrangement but it is not absolute as foreign exchange market interventions are possible in case of an urgent support of the national currency.

According to the comparative analysis of the BRICS monetary policies and the introduced exchange rate arrangements the assumptions about the importance to use monetary policy tools by the Central banks to

[4] This can be confirmed by the dynamics of liquidity provision and absorption by the Central bank of Russia in July 2016 (Central Bank of the Russian Federation. Available at: www.cbr.ru (accessed 19.07.2016) in response to the statement by V.V. Putin about a high cost of the rouble (Putin charged to strengthen the rouble. Available at: http://www.finanz.ru/novosti/valyuty/putin-poruchil-razobratsya-s-ukrepleniem-rublya-1001311827 (accessed 19.07.2016). It caused the weakening of the rouble during a sort period.

achieve the pricing and national currency stability has been made.

Central bank monetary policy equation

Current monetary policy of the BRICS countries is actually based on the use of base interest rates as a key tool and on the situation at the domestic foreign exchange market. In this regard we have suggested and empirically verified a model that considers modern features of the monetary policies implemented by the BRICS countries. The model demonstrates the following interrelations: it is mainly based on the Taylor's equation that connects the monetary policy inflation target, a balanced real interest rate and the deviation of GDP from the sustainable condition (GDP gaps[5]).

When extending the description of a monetary policy, Taylor [36] highlighted the importance to include a nominal exchange rate change in the "equation of a state reaction". He insisted that changes in the exchange rate influence a country economy with two main channels: an export component and import goods prices. Besides, an exchange rate affects the capital market in a country.

In the present research we use a modified Taylor equation that is based on Laurence M. Ball rule. This rule considers a real exchange rate and its changes. According to the Ball's rule of a monetary policy [37] a nominal short-term interest rate is connected with such indices as an inflation deviation from an optimal level, a GDP gap, and, what is more significant, a real effective exchange rate change. This rate considers the situation in countries that are trade partners of a state.

An index of a real effective exchange rate was considered to be a foreign exchange market condition factor. A real exchange rate demonstrates a structure of trade partners of a state, nominal correlations between a national currency exchange rate and an exchange rate of its trade partners. It also reflects price levels in these countries. This fact estimates the contribution of the above mentioned components in general. According to many scientists the index does not only demonstrate a price competitive ability but a labour productivity level in the economy as well [38]. Besides, according to the Bank for International Settlements publications this index is used by some countries as a calculation component for a monetary and finance economy index. And it is also used to calculate measures of external shocks impact and intermediate aims of a monetary policy. The index of a real effective exchange rate was used by some authors as an indicator of international competitive ability [38; 39; 40].

Methods to calculate the index of a real effective exchange rate may be different. The main differences are observed when calculating the following parameters: used currencies and their amount; a principle to determine weight of currencies in a currency basket in comparison with a national currency weight; a size of a currency basket; a base period for a currency weight determination; trade flows determination; the choice of a deflator for the index [38]. From the view point of Bank for International Settlements the index of a real effective exchange rate increases if a national currency strengthens and in this case economy looses its importance at the international scene; i.e. the index growth is the evidence of an international competitive ability decrease due to export that relatively rises in price.

In our opinion the present indicator for the BRICS countries may not be unambiguously interpreted as an index that explains the growth or increase of an international competitiveness level. We strongly believe that its change mainly demonstrates either a national currency exchange rate instability due to crisis (e.g. in Brazil, Russia and South Africa) or it is connected to a conducted exchange rate policy (e.g. China). The analysis of the index of a real effective exchange rate may be added by investigations of international financial and trade flows [34], and by the impact of national currency depreciation on the economy growth rate [41]. In this connection

[5] In Russian scientific literature two terms to determine the deviation of GDP from the sustainable condition are used: GDP gaps and GDP breaks. We stick to the first one.

S. Moiseev, I. Pantina highlight that this index plays an important informative function in a monetary policy implementation [42].

We think that the index of a real effective exchange rate may be considered to be an indicator of a monetary policy trend that influences a country position at the international arena. We suggest determining the importance of the index empirically during the application of monetary policy methods by central banks of the BRICS countries.

To calculate GDP gaps we used the HP filter, Hodrick–Prescott filter [43]. The method is described in the equation (1). The variable τ_t is the value of a non-cyclic GDP at a t period, and c_t is a stationary cyclic component that is considered to be a GDP deviation from its stable state. At the same time τ_t may contain a deterministic or stochastic trend without being a stationary quantity.

The main point of a filter is to find such τ_t values that provide the minimum of remainders according to the optimisation task presented in the work by Hodrick and Prescott [43]:

$$min[\sum_{t=1}^{T}(y_t-\tau_t)^2 + \lambda \sum_{t=2}^{T-1}\{(\tau_{t+1}-\tau_t) - -(\tau_t-\tau_{t-1})\}^2], \quad (1)$$

where λ is a fixed parameter[6]. When the trend component that provides a minimum of functions is calculated, we calculate the gaps with a cyclic component c_t .

And finally we have applied a modification called Orphanides rule to calculate GDP deviations. According to this rule the deviation of GDP from its sustainable development is substituted to the difference between an actual growth of GDP and its trend [44]. Time effects and effects of countries have been taken into account in the model. Using the model we relied on researches by A.R. Ghosh, J.D. Ostry, M. Chamon [45] who analysed a monetary policy of countries with emerging economy.

The model is:

$$i_{j,t} - \pi *_{j,t} = \beta_0 + \beta_1(i_{j,t-1} - \pi *_{j,t-1}) + + \beta_2 \Delta ln(REER_{j,t}) + \beta_3 YGAP_{j,t-1} + \beta_4 \pi_t^e + + \sum_j^n D_j + \sum_t^T D_t + \varepsilon_{j,t}\,, \quad (2)$$

$$y_t = \tau_t + c_t\,, \quad (3)$$

where j – a BRICS country, j = 1,…5; t – quantity of periods, t = 1, …85 (by the quarters starting since 01.01.1994 to 01.01.2015); i – a nominal interest rate; $\pi *_{j,t}$ – a target inflation index; π_t^e – an anticipated inflation; $REER$ – a real effective exchange rate index; $i_{j,t-1} - \pi *_{j,t-1}$ – a lag variable, that reflects the fact of monetary policy tools adjustment; $YGAP_{j,t-1}$ – a lag during one quarter of GDP deviation from the trend; D_j – an individual fixed effect of a country; D_t – a time fixed effect; $\varepsilon_{j,t}$ – standard errors; y_t – GDP; τ_t – a GDP trend; c_t – a stationary cyclic component that is considered to be a GDP deviation from its stable state.

According to the rules of a monetary policy central banks seek for affecting a real interest rate and establish a particular inflation target. For this purpose Central banks use a base interest rate as a tool considering a price growth target indicator. Finally the use of the monetary policy tool will result to the change of the real interest rate. This change is suggested to happen in the next period due to a quick response.

There are a lot of methods to estimate an expected inflation level in scientific literature on economics [46]. We suggest that according to a Rational Expectations Theory consumers will expect an inflation level in the next period to be the same one [47].

A nominal exchange rate policy and other parameters of external economic ties such as a structure of trade partners and their inflation level also influence the investigated index. The growth of a real effective exchange rate index demonstrates the change of national economy competitiveness level; in case of its decrease a national currency weakens and as a result it will lead to potential profits of national companies that produce goods for export. The index may also affect general results of a current monetary policy.

[6] In the present research this parameter is 1600, and that corresponds to recommendations by Hodrick and Prescott [44] for quarterly data.

Statistical databases of International Monetary Fund, Federal Reserve Bank of St. Louis, official date of the BRICS central banks and other sources of national public statistics were used for our research[7].

Statistical data that were used to calculate the suggested model and to analyse the obtained results then include the indices of a real effective exchange rate, consumer prices indices, interest rates, GDP and the inflation targeting level during 20 years starting since 1996 to 2015. The index of factual level of consumer prices was used in calculations for the period when an inflation targeting level had not been used. Totally 85 observations for each indicator have been made, quarterly data have been used in the calculations.

Assessement of an exchange rate significance in the BRICS monetary policy

To assess GDP gaps of the BRICS countries periodograms of GDP deviation from its sustainable condition have been made. The assessments we obtained are preliminary items that were used further in the suggested model to analyse its results. The dynamics of the gradual percentage deviation of GDP from the trend differs for the BRICS countries. Brazil, India and South Africa are characterised by an irreducible trend with some growth at the end of a period, for China this indicator is mostly unstable in comparison with other countries, though there are some features of growth as well. Russia is characterised by a downward trend.

The results of panel data assessment are presented in Table 3. Values of regression coefficients for three models are presented in the Table columns. Model 1 demonstrates the importance of a lag value of a "desirable" level of a real interest rate and the relevance of a nominal rate deviation from the inflation target value. The bigger the gap between a nominal interest rate and a desirable inflation level was in the previous quarter, the stricter a central bank policy concerning a nominal rate will be in the period. Model 2 considers two indicators: the indicated demonstrated by Model 1 and the GDP deviation from the trend calculated with the HP filter. The assessment results demonstrate that the GDP deviation from the trend in the previous quarter that is 1% higher than the potential level will increase a real interest rate by 0.204% in the quarter.

Table 3

Panel data assessment for the BRICS countries

Regressors	Model 1	Model 2	Model 3
Lag values of an interest rate deviation from a target inflation	0.835*** [0.000]	0.817*** [0.000]	0.821*** [0.000]
GDP deviation from its sustainable condition	-	0.204** [0.035]	0.160* [0.057]
Real effective exchange rate	-	-	–0.169* [0.070]
Expected inflation	-	-	0.811*** [0.000]
Individual fixed effect of a country	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes
Observation quantity	399	399	399
Number of countries	5	5	5
R^2	31.17	34.81	35.09

***, **, * – relevance at 1%, 5% and 10% levels respectively; Significance levels are indicated in brackets (p-values)

All regressors demonstrated their importance when variables with their maximum number of variables (Model 3) were added. The opportunity to apply the Taylor's equation for the sampling countries has been proven by the relevance of the deviation from the GDP trend, of a real exchange rate and interest rates of the previous period in Model 3. This model demonstrates the monetary policy rules that were suggested for developed countries two decades ago. The model competence proves that the factors under considerations that determine a modern monetary policy target

[7] International Monetary Fund. Available at: www.imf.org (accessed 19.07.2016); Federal Reserve Bank of St. Louis https://fred.stlouisfed.org (accessed 19.07.2016); Central Bank of Brazil www.bcb.gov.br (accessed 19.07.2016); Central Bank of the Russian Federation www.cbr.ru (accessed 19.07.2016); Reserve Bank of India www.rbi.org.in (accessed 19.07.2016); People's Bank of China www.cbc.gov.tw (accessed 19.07.2016); South Africa Reserve Bank www.resbank.co.za (accessed 19.07.2016).

for developing countries are acute for the BRICS countries as well.

Autocorrelation and heteroscedasticity in the final model were verified by the corresponding tests. The Brousch–Pagan test that we made to verify the dependence between cross-section data groups proved the hypothesis about the absence of autocorrelation [48]; chi-square statistics is 35.17 (p-value is 0.24). This hypothesis was also tested by Lagrange Multiplier (p-value is 0.71). Heteroscedasticity test also did not allow to reject the null hypothesis about its absence (p-value is 0.61). According to Hansen test specification a model with fixed individual effects turned to be the most appropriate [49].

The real effective exchange rate index under consideration is relevant and this fact proves that its change affects the Central bank policy of the BRICS countries. When the real effective exchange rate index decreases by 1% (that may indicate the international competitiveness growth) in comparison to the previous period, a real interest rate grows by 0.17%. This indicator is higher than that demonstrated in the researches for other countries with emerging markets. In these studies a real interest rate increases by 0.04% in average for 15 countries included in the sample [45].

An expected inflation index is relevant for the real effective exchange rate at a one-percent level and it points out that the Central banks of the BRICS countries consider the expectations of economic agents when making decisions. When an expected inflation increases by 1%, a real interest rate rises 0.811% in the BRICS countries. The growth of a real interest rate leads to a money supply increase and as a result prevents from an expected inflation growth. It agrees with an inflation targeting policy.

The monetary policy of the BRICS countries responds to the deviation of GDP from its sustainable development (the index was calculated with the HP-filter). This conclusion is realistic as during a GDP growth central banks keep a check on it only in case there is an "economic overheating" (according to calculations GDP growth is higher than its sustainable development trajectory). If an increased GDP level is lower than its sustainable development trajectory, a monetary policy will target to its support and stimulation with an interest rate as the main tool of an inflation targeting monetary policy. In the equation of central bank reactions that we verified we noticed that if GDP deviates 1% from its sustainable development, a real interest rate increases by 0.16% in the BRICS countries.

According to Model 3 verifications there is an inverse relationship between a real interest rate dynamics and a real effective exchange rate. In fact, the interference is observed between these indicators. A central bank may manipulate a nominal exchange rate to increase the competitiveness of national producers, however, a real interest rate growth in economy may strengthen the national currency. Using the model coefficients estimations we have done, we may argue that the inverse impact of the indices under consideration prevails in the BRICS countries.

In general, the model that we have empirically verified for the BRICS countries proves that the previous central bank activity that uses a base interest rate as a monetary tool mostly affects the aggregate results of the monetary policy. A real interest rate mostly depends on this particular indicator in the previous period. This fact stresses the importance of consistent actions of a regulator when conducting a monetary policy. An expected inflation is the next most important value. A positive GDP deviation from its potential leads to a real interest rate growth.

Finally, conducting a monetary policy the Central banks of the BRICS countries may change a real interest rate in the result of both a base interest rate and a nominal exchange rate control. The growth of a base interest rate, as well as the decrease of the real effective exchange rate index, leads to the rise of the indices under consideration. The index of a real effective exchange rate also indicates the growth of international competitiveness of the national economy. Despite the fact that the central banks of the countries under consideration mostly follow the inflation

control policy they also consider a real exchange rate when making decisions as this rate is considered to be a competitiveness factor at the global markets.

Conclusion

The BRICS countries that used to be an informal formation nowadays are considered to become a perspective union that successfully meets political and economic challenges. The countries under consideration have similar economic development levels and are characterised by developing financial markets and identical processes in macroeconomic finances. The role of central banks of the BRICS countries is currently increasing in their national economies. All the above mentioned countries aim at a price stability that is considered to be a factor of economic growth. Four countries except China have officially introduced an inflation targeting to achieve the price stability. However despite the priority of the inflation control none of the above mentioned countries refuses the national currency exchange rate control de-facto.

To prove these processes empirically the model called the equation of central banks reactions has been verified in the present research. The model reflects the key concepts of a modern monetary policy. It develops the ideas to simulate the use of the monetary policy tools that were suggested by 1) Taylor – his rule connects an inflation target, balanced inflation rate and the deviation of GDP from its sustainable condition; 2) Ball, who considered a real exchange rate and its change in the verification of monetary policy results; 3) Orphanides who introduced the calculation rules of GDP gaps as a real value deviation from the trend. The ideas of the above mentioned scientists have been used in the research as well as the method of GDP gap calculation with the HP-filter.

On the empirical data analysis basis we may conclude that the rules of a monetary policy used in developed countries are acute and may be applied in the BRICS countries too. Base interest rates remain to be a relative tool of a monetary policy in the BRICS countries in the process of transformation of a monetary policy framework and exchange rate arrangement. The index of a real effective exchange rate being an international competitiveness indicator influences the real interest rate. The importance of this index is more significant for the BRICS countries than for countries with emerging markets. The central banks of the BRICS countries when implementing a monetary policy to support a price stability pay their attention to the inflation expectations of economic agents, GPD growth rate and the fluctuation of a national currency exchange rate.

On empirical calculation basis with a panel data analysis we have verified the presence of country (individual) effects. It proves the idea that the BRICS countries are highly heterogeneous and it is impossible to conduct a unified monetary policy with a single purpose for the whole union. In this regard our further study will be devoted to 1) a detailed analysis of a monetary policy of each country included in the BRICS and an identification of long-term relations among the indices in the equation of central bank reactions with the construction of cointegration vectors in the vector model of error correction; 2) an analysis of interference of the central banks of the BRICS countries and their susceptibility to the globalisation processes in the global finance field[8].

[8] These data have been prepared by the authors and have been included in the report made at the International conference of Higher School of Economics in St. Petersburg and are currently being published: Bekareva S., Meltenisova E., Kravchenko N. The central banks of the BRICS countries in the new global financial system. The International BRICS Global Business & Innovation Conference. 2017. September 14–16. St. Petersburg, Russia.

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