The Adaptive Markets Hypothesis and the BRIC Share Markets[1]

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Abstract

The efficient market theory is one of the most controversial economic theories of the last half-century. The market efficiency has been topic of various studies, but the results are mixed. Although some of the studies confirmed efficiency of a market, another studies often rejected it. As a result, the adaptive market hypothesis was formulated. It says that the ability of share prices to reflect all the available information changes over time. This paper analyses the development of weak-form market efficiency of BRIC share markets. It shows that although the BRIC share markets are weak-form inefficient in the long-term, there are some shorter time periods of weak-form efficiency that alternate with periods of weak-form inefficiency. It means that technical and fundamental analysis can be used on BRIC share markets to generate returns superior to returns of the market portfolio.

Keywords: *share market, BRIC, market efficiency, adaptive markets hypothesis, variance ratio test*

JEL Classification: G10, G14

Introduction

The Efficient Market Theory is one of the most controversial economic theories of the last half-century. The theory says that on an effective market, the share price always reflects all of the important information (Fama, 1965). It means that the shares always trade at their fair value and it is impossible to outperform the market using technical analysis and market timing. Fama later modified his

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theories saying that the lower the transaction costs and costs of information the more efficient the market (Fama, 1991) and that chance may generate abnormal returns (Fama, 1998).

There are three forms of market efficiency: the weak form, the semi-strong form and the strong form (Roberts, 1967). The weak form of market efficiency assumes that share prices reflect all historically known information. As a result, technical analysis is inefficient, as it is unable to generate higher returns than the market portfolio. The share price movement is random and it is unable to identify any trends. The semi-strong form of market efficiency assumes that share prices reflect all publicly known information and they change instantly, after new information become available. As a result, technical as well as fundamental analysis is inefficient. The strong form of market efficiency claims that the share prices reflect even yet unknown information as well as insider information. According to Haugen (1993), an efficient market reflects all meaningful information and there are no undervalued or overvalued shares on the efficient market.

The Efficient Market Theory later evolved into the Adaptive Markets Hypothesis that assumes that the market efficiency is not static but it evolves in time and there can be found time periods of market efficiency and time periods of market inefficiency.

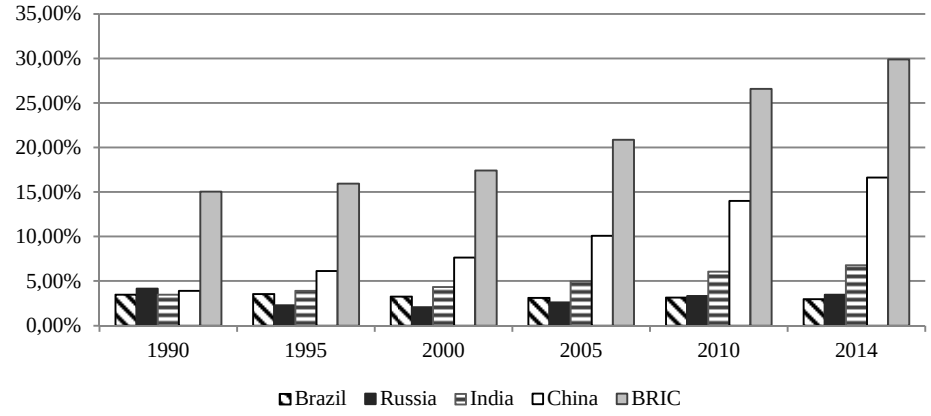
BRIC is a group of the most important emerging market countries. It consists of Brazil, Russia, India and China. The whole economies as well as financial markets of the BRIC countries have a lot of specifics compared to the traditional western countries. The role of the government is very strong and investors have to deal with various regulations.

On the other hand the economic power of BRIC countries has been rapidly growing for the last two decades. As shown by Figure 1, in 1990, the total share of Brazil, Russia, India and China on the global GDP (PPP) was approximately 15% according to data of the World Bank. The share increased to 29.9% by 2014 and the 2015 data will show that it crossed the 30% level. The rapid pace of growth was driven mainly by China and India. Although the Chinese GDP growth rate has declined lately, its economy is still growing by approximately 7% per year. It is expected that the importance of BRIC countries will keep on growing in the foreseeable future.

As the economies of the BRIC countries grow, their share markets evolve and they attract a lot of domestic as well as foreign investors. The BRIC share markets are known for their high level of volatility (Figure 2) which means that they are able to generate significant returns although the investors have to face higher levels of risk.

F i g u r e 1

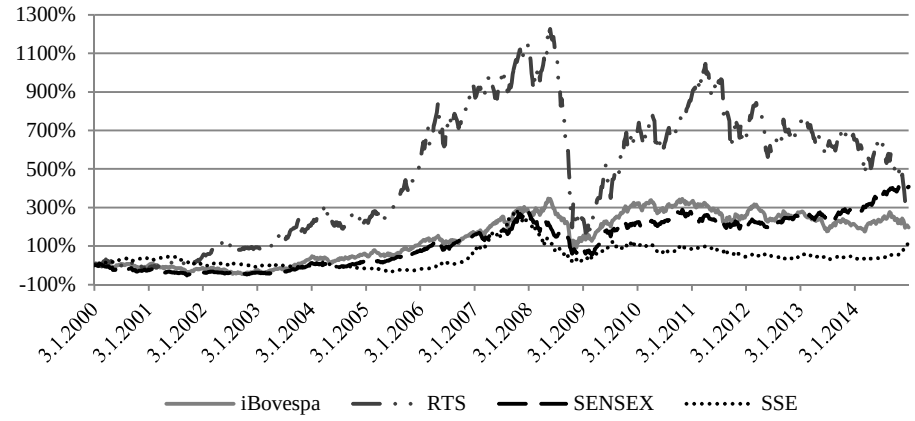
Share of BRIC Countries on the Global GDP (PPP)



Source: Own processing, using data of the World Bank.

F i g u r e 2

Comparison of Major BRIC Share Market Indices Development



Source: Own processing, using data of Yahoo Finance.

The opinions about the market efficiency of share markets in the emerging market countries are mixed. The share markets of the BRIC countries are less developed than the U.S. or western European share markets, but in some aspects, such as market capitalisation or liquidity, they are comparable. It is able to assume that as the BRIC share markets mature, they should become more and more similar to the developed share markets. And if we assume that the adaptive market hypothesis is correct, BRIC share markets should experience alternating periods of weak-form market efficiency and weak-form market inefficiency.

Literature Review

There are a lot of various studies that try to identify whether a particular share market is efficient. Most of them focus on the weak form of market efficiency trying to find out whether the share prices move in accordance with the Random Walk Hypothesis. If the share prices behave according to this hypothesis, they move randomly without any pattern and they can't be predicted, which means that the share market is weak-form efficient. In other words, if a share market is weak-form efficient, the share prices don't follow any pattern that could be used in a trading strategy that would generate abnormal returns. The implication of the weak-form efficiency is the random walk hypothesis, which indicates that successive price changes are random and serially independent (Chan, 2008). In other words, the returns are not autocorrelated.

Most of the research papers conclude that the developed share markets of Western Europe and North America are weak-form efficient although there are some studies that claim the opposite. For example a study by Borges (2010) shows that Portugal, Greek and UK share markets are not weak-form efficient but German and Spanish share markets are weak-form efficient. Alexeev and Tapon (2011) studied the securities traded on Toronto Stock Exchange and they concluded that the weak-form efficiency can't be rejected although there are some sectors that appear to be less effective than others. Kim and Shamsuddin (2008) concluded that Japanese, South Korean and Taiwanese share markets are weak-form efficient. Worthington and Higgs (2009) studied the Australian share market on the time period from 1875 to 2006 and they came up with mixed results. While the serial correlation tests showed weak-form efficiency on the monthly basis they showed weak-form inefficiency on the daily basis. Their runs tests showed that the Australian share market is inefficient and the variance ratio tests confirmed weak-form efficiency on the monthly basis and weak-form inefficiency on the daily basis. Lim (2007) concluded that market efficiency evolves over time and that the US market is the most efficient.

The results from emerging markets are even more controversial. Some of the studies have confirmed weak-form market efficiency of particular markets and some studies have denied it. Liu and Liang (2007) claimed that the Chinese stock market is weak-form efficient but Chen and Jarrett (2011) concluded that it was weak-form inefficient in the pre-crisis era and it started to be weak-form efficient during the financial crisis of 2008. Hajek (2007) studied the central European share markets and he concluded that the Hungarian share market is weak-form efficient while the Czech and Polish share markets behave weak--form inefficiently. On the other hand study of Divis and Teply (2005) shows that the Czech, Polish, Hungarian and even Slovak share markets are weak-form

efficient. Dragota and Tilica (2014) investigated the weak-form market efficiency of share markets in Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia and Ukraine during the financial crisis. They concluded that although for some assets the efficient market hypothesis cannot be rejected there are serious doubts about the share market efficiency of the abovementioned countries.

As an answer to the often contradictory conclusions about the efficiency of share markets, the Adaptive Markets Hypothesis (AMH) was formulated (Lo, 2004). The hypothesis combines principles of the Efficient Markets Hypothesis and behavioural finance. According to Lo, prices reflect as much information as dictated by the combination of environmental conditions and the number and nature of market participants. As a result, the investment strategies undergo cycles of profitability and losses, as the business conditions and number of competitors change. In other words, the market efficiency is not static but it is evolving and there can be found time periods of higher efficiency and periods of lower efficiency or inefficiency. The AMH is supported by results of various studies. For example Kim, Shamsuddin and Lim (2011) tested the Dow Jones Industrial Average (DJIA) returns from 1900 to 2009 and they presented strong evidence of time--varying return predictability. They also found out that the return predictability has been smaller during economic bubbles than in normal times and that the return predictability is associated with stock market volatility and economic fundamentals. A similar study focused on the DJIA from 1900 to 2013 was realised by Urquhart and McGroarty (2014) who examined the AMH through calendar anomalies. They concluded that all of the four calendar anomalies, they used in their study, support the AMH as their performance varies over time. In another study, Urquhart and McGroarty (2013) investigated the AMH in the U.S., UK and Japan share market using linear autocorrelation, runs and variance ratio tests and they came to conclusion that the AMH is valid for all of the three markets.

Some of the authors investigated the AMH in other than major share markets. For example Zhou and Lee (2013) tested the AMH in a subsector of the U.S. share market, as they focused on the Real Estate Investment Trust (REIT) market efficiency. They concluded that the AMH is valid, as the predictability of REIT market returns is time varying and it is affected by the broader market conditions. Bogdanov and Ivanov (2014) investigated adaptive and relative market efficiency of seven south-eastern and eastern European countries. They came to mixed results as they discovered that the Bulgarian and Serbian share markets are highly predictable, while the levels of predictability of the Croatian and Russian share markets are diminishing. They also concluded that the Turkish share market was highly efficient throughout the investigated time period.

Data and Methodology

This paper analyses the market efficiency of Brazilian, Russian, Indian and Chinese share markets using the Lo-MacKinlay variance ratio test (Lo and MacKinlay, 1988). The variance ratio test was developed by Lo and MacKinlay as a tool for investigation of the random walk hypothesis.

The analysis is based on daily and weekly closing prices provided by Yahoo--Finance. The share markets are represented by major share indices, namely: iBovespa (Brazil), RTS (Russia), Sensex (India) and SSE (China). 15 years long time period (2000 – 2014) is studied. The time period is divided into three 5-sub--periods (2000 – 2004, 2005 – 2009, 2010 – 2014) as well as five 3-sub-periods (2000 – 2002, 2003 – 2005, 2006 – 2008, 2009 – 2011, 2012 – 2014).

Data were logarithmically modified and the Lo-MacKinlay variance ratio test was used to identify whether the share market returns were changing according to the random walk hypothesis. Statistical software Gretl was used to perform the Lo-Mackinlay variance ratio test for the abovementioned share indices and time periods. The results were used to verify the predetermined hypotheses.

The variance ratio test is based on the assumption that if a series of returns behaves in line with the random walk hypothesis, the variance of the q-th-differenced variable is equal to q times the first-differenced variable.

When p_t is index value at time t and q is any positive integer, then formula for variance ratio is as follows:

$$VR(q) = \frac{\frac{1}{q}\mathrm{Var}\left(p_t - p_{t-q}\right)}{\mathrm{Var}\left(p_t - p_{t-1}\right)} \tag{1}$$

If the variance ratio is close to 1, we cannot reject the random walk hypothesis and the share market can be considered weak-form efficient. To evaluate whether the variance ratio deviates from 1 sufficiently to reject the random walk hypothesis, the Z-statistic is calculated. For homoscedastic datasets, Z-statistic is calculated as follows:

$$(q) = \frac{VR(q) - 1}{\left[\frac{2(2q - 1)(q - 1)}{3q(nq)}\right]^{1/2}} \sim N(0, 1) \tag{2}$$

In formula (3), VR is the variance ratio, q is any positive integer and (nq) is the serial number of the penultimate observation.

For heteroskedastic datasets, Z-statistic is calculated as follows:

$$Z^*(q) = \frac{VR(q) - 1}{\left[\sum_{j=1}^{q-1}\left[\frac{2(q-j)}{q}\right]^2 \delta(j)\right]^{1/2}} \sim N(0, 1) \tag{3}$$

where

$$\delta(j) = \frac{\sum_{t=j+1}^{nq}(S_t - S_{t-1} - \mu)^2 (S_{t-j} - S_{t-j-1} - \mu)^2}{\left[\sum_{k=1}^{nq}(S_t - S_{t-1} - \mu)^2\right]^2} \tag{4}$$

If $Z(q)$ or $Z^*(q)$ ϵ (–1,96; 1,96) the null hypothesis that the time series follows a random walk cannot be rejected at the 5% significance level.

In this paper, the variance ratio tests were performed for q = (2; 4; 8; 16). The share market can be considered to be weak-form efficient, if the two-tailed p-value is higher than 0.05 for every q. If there is a strong trend where growing q is accompanied by decreasing p-values (in this paper it was the analysis of the daily data from the Chinese share market), there is a high probability that the random walk process is disrupted (an additional analysis with q = 32 was performed with Chinese daily data in order to re-evaluate the original results).

The aim of this paper is to evaluate 4 hypotheses regarding BRIC share markets:

H1: Although the BRIC share markets are weak-form inefficient in the long--term, there are time periods of weak-form market efficiency.

H2: The time periods of weak-form market efficiency of individual BRIC markets coincide.

H3: The time periods of weak-form efficiency and weak-form inefficiency of BRIC share markets coincide with periods of weak-form efficiency and weak--form inefficiency of the U.S. share market represented by Dow Jones Industrial Average.

H4: As the BRIC markets develop, the periods of weak-form market efficiency grow stronger.

Hypothesis H1 assumes that the BRIC markets are inefficient in the long--term (2000 – 2014), but in accordance with the Adaptive markets hypothesis, there are some shorter time periods when the share market returns follow the random walk. It means that although the BRIC share markets were not weak--form efficient during the whole 2000 – 2014 time period, there should be some weak-form efficient 5-year and 3-year time periods.

Hypothesis H2 assumes that the time periods of market efficiency coincide. In other words, when there is one of the BRIC share markets efficient over a particular time period, the rest of the BRIC share markets are efficient as well, due to the similar nature of these markets (the level of state interventions, flows of international capital, structure of economies), and similar risk perception (especially the foreign investors are more sensitive to various political risks related to the BRIC countries).

Hypothesis H3 assumes that the time periods of market efficiency of the BRIC share markets and the U.S. share market coincide. Although BRIC share markets have a lot of specifics, they are a part of the global financial markets. Due to the liberalisation and globalisation that took place over the last two decades, the BRIC share markets are affected by the same major economic events that affect the developed share markets, the U.S. share market included. Both China and India have huge economies and they are important producers of consumer goods.

Russia is a major producer and exporter of oil, natural gas, iron ore and steel, copper, aluminium, fertilizers, cereals, etc. Brazil is a major producer and exporter of iron ore, oil, soybeans, corn, coffee, sugar, poultry meat, etc. The BRIC countries and their share markets are closely connected to the global economy, which could be seen also during the global financial crisis of 2008. Therefore, it is possible to expect that the weak-form market efficiency of BRIC share markets is impacted by the global factors that have strong impact also on the U.S. share market.

Hypothesis H4 assumes that the market efficiency of BRIC countries improves over time. In other words, the time periods of weak-form market efficiency should show more and more convincing statistical results in favour of not rejecting the null hypothesis that the share markets follow random walk.

The approach applied in this paper can be summed up into following steps:

1. Selection of major share indices representing the BRIC share markets.
2. Definition of time periods to be investigated.
3. Formulation of hypotheses.
4. Preparation of data (daily and weekly closing prices provided by Yahoo Finance), logarithmical adjustment of data.
5. Investigation of the weak-form efficiency of individual BRIC share markets during the pre-defined time periods, using the Lo-MacKinlay variance ratio test (tests performed using statistical software Gretl).
6. Investigation of the weak-form efficiency of the U.S. share market represented by Dow Jones Industrial Average, in order to verify hypothesis H3.
7. Evaluation of hypotheses and formulation of conclusions.

Results

Tables 1 – 4 show results of Lo-MacKinlay variance ratio tests for daily as well as for weekly closing prices of the benchmark share indices (iBovespa, RTS, SSE, SENSEX) that are able to represent the whole share markets of individual BRIC countries (Brazil, Russia, India, China).

Table 1 shows results of the variance ratio test for the Brazilian share index iBovespa. Although the share market wasn't weak-form efficient over the long time period (2000 – 2014), the results show that there were several sub-periods where the random walk hypothesis cannot be rejected. The Brazilian share market is supposed to be weak-form efficient over these time periods. We can also see that the results are consistent whether using daily or weekly data. The only exception is the 2005 – 2009 time period that was weak-form inefficient based on the daily data but weak-form efficient based on the weekly data.

T a b l e 1

Variance Ratio Test Results for iBovespa

			$q = 2$	$q = 4$	$q = 8$	$q = 16$
Daily data	(2000 – 2014)	two-tailed p-value	0.644820	0.256640	0.022688	0.049605
	(2000 – 2004)	two-tailed p-value	0.060662	0.368810	0.896350	0.875990
	(2005 – 2009)	two-tailed p-value	0.494660	0.032147	0.004937	0.024093
	(2010 – 2014)	two-tailed p-value	0.492220	0.769470	0.507440	0.364000
	(2000 – 2002)	two-tailed p-value	0.091669	0.355270	0.918240	0.773550
	(2003 – 2005)	two-tailed p-value	0.334990	0.789300	0.404320	0.861860
	(2006 – 2008)	two-tailed p-value	0.710460	0.098884	0.025117	0.081338
	(2009 – 2011)	two-tailed p-value	0.123400	0.168710	0.205150	0.208090
	(2012 – 2014)	two-tailed p-value	0.380110	0.689340	0.843190	0.617380
Weekly data	(2000 – 2014)	two-tailed p-value	0.009749	0.326460	0.940540	0.878080
	(2000 – 2004)	two-tailed p-value	0.062118	0.570680	0.778360	0.888560
	(2005 – 2009)	two-tailed p-value	0.130570	0.589750	0.792120	0.523980
	(2010 – 2014)	two-tailed p-value	0.682950	0.730240	0.607220	0.531100
	(2000 – 2002)	two-tailed p-value	0.074269	0.321430	0.731930	0.413790
	(2003 – 2005)	two-tailed p-value	0.397500	0.815920	0.974560	0.886470
	(2006 – 2008)	two-tailed p-value	0.002516	0.589490	0.815570	0.581590
	(2009 – 2011)	two-tailed p-value	0.951840	0.793590	0.596900	0.783420
	(2012 – 2014)	two-tailed p-value	0.798380	0.983320	0.786970	0.859100

Note: Time periods where the null hypothesis cannot be rejected (i.e. the share index returns follow the random walk) are highlighted.

Source: Own processing.

The results of variance ratio test for the Russian share index RTS (Table 2) show that the Russian share market in general is less efficient compared to the Brazilian share market, based on the daily data. Although both of the markets were weak-form inefficient over the 2000 – 2014 time period, the Brazilian share market had 6 weak-form efficient sub-periods while the Russian share market experienced only 3 weak-form efficient sub-periods.

T a b l e 2

Variance Ratio Test Results for RTS

			$q = 2$	$q = 4$	$q = 8$	$q = 16$
Daily data	(2000 – 2014)	two-tailed p-value	0.000000	0.000077	0.003818	0.039603
	(2000 – 2004)	two-tailed p-value	0.114950	0.389460	0.412250	0.657510
	(2005 – 2009)	two-tailed p-value	0.000051	0.000884	0.008609	0.058141
	(2010 – 2014)	two-tailed p-value	0.000164	0.011162	0.228620	0.221730
	(2000 – 2002)	two-tailed p-value	0.441930	0.687460	0.843380	0.933690
	(2003 – 2005)	two-tailed p-value	0.002593	0.091956	0.029708	0.052093
	(2006 – 2008)	two-tailed p-value	0.003223	0.030057	0.105760	0.406040
	(2009 – 2011)	two-tailed p-value	0.000209	0.000398	0.045959	0.197270
	(2012 – 2014)	two-tailed p-value	0.087036	0.528950	0.751380	0.578340
Weekly data	(2000 – 2014)	two-tailed p-value	0.123130	0.094622	0.025342	0.006404
	(2000 – 2004)	two-tailed p-value	0.793240	0.847070	0.889520	0.641360
	(2005 – 2009)	two-tailed p-value	0.093874	0.120760	0.002553	0.000011
	(2010 – 2014)	two-tailed p-value	0.662610	0.249580	0.770790	0.974480
	(2000 – 2002)	two-tailed p-value	0.470870	0.807310	0.894160	0.975780
	(2003 – 2005)	two-tailed p-value	0.010627	0.123040	0.399380	0.978940
	(2006 – 2008)	two-tailed p-value	0.063909	0.227830	0.010056	0.000864
	(2009 – 2011)	two-tailed p-value	0.421510	0.806390	0.861750	0.765690
	(2012 – 2014)	two-tailed p-value	0.177810	0.112920	0.496930	0.845330

Note: Time periods where the null hypothesis cannot be rejected (i.e. the share index returns follow the random walk) are highlighted.

Source: Own processing.

The Indian share market represented by share index SENSEX didn't prove to be weak-form efficient over the 15-year or over the 5-year time periods.

T a b l e 3

Variance Ratio Test Results for SENSEX

			$q = 2$	$q = 4$	$q = 8$	$q = 16$
Daily data	(2000 – 2014)	two-tailed p-value	0.000009	0.021143	0.432580	0.206750
	(2000 – 2004)	two-tailed p-value	0.017335	0.164470	0.188340	0.205840
	(2005 – 2009)	two-tailed p-value	0.005302	0.193400	0.853560	0.561620
	(2010 – 2014)	two-tailed p-value	0.018035	0.124750	0.389700	0.616050
	(2000 – 2002)	two-tailed p-value	0.056153	0.136090	0.275650	0.453660
	(2003 – 2005)	two-tailed p-value	0.035001	0.705920	0.422090	0.349910
	(2006 – 2008)	two-tailed p-value	0.041054	0.308980	0.878480	0.718410
	(2009 – 2011)	two-tailed p-value	0.073384	0.357020	0.927030	0.558240
	(2012 – 2014)	two-tailed p-value	0.074454	0.499890	0.790440	0.909090
Weekly data	(2000 – 2014)	two-tailed p-value	0.272770	0.015020	0.046221	0.046377
	(2000 – 2004)	two-tailed p-value	0.149910	0.119150	0.312830	0.157300
	(2005 – 2009)	two-tailed p-value	0.951580	0.084598	0.032259	0.030765
	(2010 – 2014)	two-tailed p-value	0.487260	0.480390	0.542750	0.336930
	(2000 – 2002)	two-tailed p-value	0.650420	0.862150	0.454560	0.368620
	(2003 – 2005)	two-tailed p-value	0.028791	0.013842	0.019966	0.009757
	(2006 – 2008)	two-tailed p-value	0.822080	0.091349	0.032381	0.177620
	(2009 – 2011)	two-tailed p-value	0.812200	0.490420	0.530780	0.275290
	(2012 – 2014)	two-tailed p-value	0.164230	0.456500	0.391630	0.528010

Note: Time periods where the null hypothesis cannot be rejected (i.e. the share index returns follow the random walk) are highlighted.

Source: Own processing.

On the other hand the random walk hypothesis cannot be rejected for the 2000 – 2002, 2009 – 2011 and 2012 – 2014 time periods, based on the daily data. The weekly data have provided results consistent with the Russian share market. In other words, the time periods of weak-form market efficiency coincided.

The most surprising are the results of the Chinese share index SSE. Based on the daily data, the random walk hypothesis couldn't be rejected for any single time period. But it is important to note that there is a clear trend where growing *q* leads to decreasing p-values. It is able to expect that expanding the test by a higher *q* would lead to rejection of the random walk hypothesis. For example *q* of 32 would lead to rejection of the null hypothesis for the 2000 – 2014, 2005 – 2009 and 2006 – 2008 time periods. More interestingly, the analysis of the weekly data indicates that the Chinese share market had lower number of time periods of weak-form market efficiency than the Brazilian, Russian and Indian share markets.

T a b l e 4

Variance Ratio Test Results for SSE

			***q* = 2**	***q* = 4**	***q* = 8**	***q* = 16**
Daily data	(2000 – 2014)	two-tailed p-value	0.653670	0.595440	0.220880	0.058857
	(2000 – 2004)	two-tailed p-value	0.457200	0.818480	0.754320	0.780310
	(2005 – 2009)	two-tailed p-value	0.908600	0.746690	0.229120	0.116150
	(2010 – 2014)	two-tailed p-value	0.894780	0.675110	0.550930	0.099913
	(2000 – 2002)	two-tailed p-value	0.387550	0.840420	0.797100	0.907730
	(2003 – 2005)	two-tailed p-value	0.946300	0.817780	0.632390	0.888840
	(2006 – 2008)	two-tailed p-value	0.923140	0.921220	0.210280	0.109260
	(2009 – 2011)	two-tailed p-value	0.863120	0.553290	0.522880	0.340370
	(2012 – 2014)	two-tailed p-value	0.593840	0.463530	0.491370	0.137690
Weekly data	(2000 – 2014)	two-tailed p-value	0.110550	0.005923	0.002364	0.000013
	(2000 – 2004)	two-tailed p-value	0.740940	0.677960	0.556550	0.492770
	(2005 – 2009)	two-tailed p-value	0.195660	0.029775	0.005447	0.000010
	(2010 – 2014)	two-tailed p-value	0.450730	0.021373	0.174300	0.526030
	(2000 – 2002)	two-tailed p-value	0.604920	0.652290	0.465010	0.613420
	(2003 – 2005)	two-tailed p-value	0.496110	0.968970	0.834450	0.492260
	(2006 – 2008)	two-tailed p-value	0.174650	0.019890	0.002703	0.000000
	(2009 – 2011)	two-tailed p-value	0.734980	0.297320	0.430170	0.414270
	(2012 – 2014)	two-tailed p-value	0.327920	0.046706	0.164400	0.291890

Note: Time periods where the null hypothesis cannot be rejected (i.e. the share index returns follow the random walk) are highlighted.

Source: Own processing.

Discussion

As the results show, although the BRIC share markets were not weak-form efficient in the long-term, there were some shorter time periods where weak--form efficiency can be observed. It means that hypothesis H1 (Although the

BRIC share markets are weak-form inefficient in the long-term, there are time periods of weak-form market efficiency) can be accepted. These results are in accordance with the adaptive markets hypothesis (Lo, 2004). The market conditions change and the ability of share prices to reflect all of the available information changes as well.

Hypothesis H2 (The time periods of weak-form market efficiency of individual BRIC share markets coincide) is rejected for daily data results, although there are some signs of coincidence in the weekly data results (Table 5). The analysis of daily data says that all of the markets were simultaneously weak-form efficient only during the 2000 – 2002 and 2012 – 2014 time periods, however the analysis of weekly data shows that all of the markets were simultaneously weak-form efficient during the 2000 – 2004, 2000 – 2002 and 2009 – 2011 time periods. All of them were simultaneously weak-form inefficient during the 2006 – 2008 and 2000 – 2014 periods and all of them, except of Brazil, were simultaneously weak-form inefficient during the 2005 – 2009 time period. Brazil has shown a notable stability of its weak-form efficiency based on the weekly data.

T a b l e 5

Rejection and Non-rejection of the Random Walk Hypothesis

Daily data					
Time period	**iBovespa**	**RTS**	**SENSEX**	**SSE**	**DJIA**
2000 – 2014	r. w. rejected	r. w. rejected	r. w. rejected	r. w. not rejected	r. w. rejected
2000 – 2004	r. w. not rejected	r. w. not rejected	r. w. rejected	r. w. not rejected	r. w. not rejected
2005 – 2009	r. w. rejected	r. w. rejected	r. w. rejected	r. w. not rejected	r. w. rejected
2010 – 2014	r. w. not rejected	r. w. rejected	r. w. rejected	r. w. not rejected	r. w. rejected
2000 – 2002	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected
2003 – 2005	r. w. not rejected	r. w. rejected	r. w. rejected	r. w. not rejected	r. w. rejected
2006 – 2008	r. w. rejected	r. w. rejected	r. w. rejected	r. w. not rejected	r. w. rejected
2009 – 2011	r. w. not rejected	r. w. rejected	r. w. not rejected	r. w. not rejected	r. w. rejected
2012 – 2014	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected
Weekly data					
Time period	**iBovespa**	**RTS**	**SENSEX**	**SSE**	**DJIA**
2000 – 2014	r. w. rejected	r. w. rejected	r. w. rejected	r. w. rejected	r. w. not rejected
2000 – 2004	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected
2005 – 2009	r. w. not rejected	r. w. rejected	r. w. rejected	r. w. rejected	r. w. not rejected
2010 – 2014	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. rejected	r. w. rejected
2000 – 2002	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected
2003 – 2005	r. w. not rejected	r. w. rejected	r. w. rejected	r. w. not rejected	r. w. not rejected
2006 – 2008	r. w. rejected	r. w. rejected	r. w. rejected	r. w. rejected	r. w. not rejected
2009 – 2011	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. not rejected
2012 – 2014	r. w. not rejected	r. w. not rejected	r. w. not rejected	r. w. rejected	r. w. not rejected

Source: Own processing.

Table 5 also shows that hypothesis H3 (The time periods of weak-form efficiency and weak-form inefficiency of BRIC share markets coincide with periods of weak-form efficiency and weak-form inefficiency of the U.S. share market

represented by DJIA) can't be fully accepted. On the daily basis, we can see that there is a strong coincidence between the weak-form efficient and inefficient time periods on the Russian, Indian and the U.S. share markets. On the weekly basis, the U.S. share market was weak-form efficient during all of the studied time periods, except of the 2010 – 2014 time period. Similar results were recorded only by the Brazilian share market.

However it is important to note that there are also time periods when all or nearly all of the BRIC share markets behaved the same way as the U.S. market did. Based on the daily data, all of the markets were weak-form efficient during the 2000 – 2002 and 2012 – 2014 periods. Based on the weekly data, all of the markets were weak-form efficient during the 2000 – 2004, 2000 – 2002 and 2009 – 2011 periods. It is able to conclude that BRIC share markets as well as the U.S. share market behave according to the Adaptive Markets Hypothesis, although the number and order of weak-form efficient time periods varies country by country and it seems to be significantly impacted by country-related factors.

Tables 1 – 4 indicate that hypothesis H4 (As the BRIC markets develop, the periods of weak-form market efficiency grow stronger) cannot be accepted. Although the results are mixed, there is no clear evidence of growing p-values. The Brazilian market presented the most compelling results against the rejection of the null hypothesis during the 2012 – 2014 period based on daily as well as weekly data. In Russia it was time period 2000 – 2002 in both cases. In India, the highest p-values were obtained during time periods 2012 – 2014 and 2000 – 2002 and in China it was time period 2003 – 2005 for daily data and weekly data respectively.

The results of this paper are inconsistent with findings of some of the other authors. For example Capobianco, Cister and Maceio (2002) studied the Brazilian share market over the 1968 – 2001 time period and they concluded that it is weak-form efficient. On the other hand results presented in this paper show that it is not weak-form efficient in the long-term, although it is weak-form efficient over the shorter time periods.

Abrosimova, Dissanaike and Linowski (2002) tested the weak-form market efficiency of the Russian share index RTS over the 1995 – 2000 time period. They concluded that it was inefficient at first but it started to show some signs of efficiency during the later parts of the time period. The results of Abrosimova, Dissanaike and Linowski are in accordance with results presented in this paper, as the analysis shows that the weak-form market efficiency of the Russian share market really changes over time. Moreover our results show that the Russian share market was weak-form efficient in the early 2000's (2000 – 2002), based on the daily as well as on the weekly data.

Harper and Jin (2012) analysed the daily data from the Indian share market over the 1997 – 2011 time period. They found out that the Indian share market wasn't weak-form efficient over the analysed time period. This is in accordance with our results that show that based on the daily data, the Indian share market was weak-form inefficient during the 2000 – 2014, 2000 – 2004, 2005 – 2009, 2010 – 2014, 2003 – 2005 and 2006 – 2008 time periods.

Liu and Liang (2007) concluded that the Shanghai stock market is weak-form efficient. Like in the case of Brazil, the results presented in this paper show that it isn't weak-form efficient in the long-term, but its effectiveness is changing and there are time periods of weak-form efficiency and weak-form inefficiency, which is in accordance with the adaptive markets hypothesis.

Kim, Shamsuddin and Lim (2011), found out that the return predictability has been smaller during economic bubbles. But it would mean that the share markets should follow the random walk during economic bubbles. However no one of the BRIC share markets was weak-form efficient during the 2006 – 2008 or 2005 – 2009 time periods, except of the Chinese share market on daily basis.

Conclusion

The results of the variance ratio test show that the BRIC share markets behave in accordance with the adaptive markets hypothesis. Although they are not weak-form efficient in the long-term (2000 – 2014), it is possible to identify some shorter time periods of weak-form efficiency that alternate with time periods of weak-form inefficiency. This conclusion was confirmed by the analysis of daily as well as weekly data of closing values of four major share indices: iBovespa (Brazil), RTS (Russia), SENSEX (India), SSE (China).

It is also possible to conclude that the time periods of weak-form efficiency and weak-form inefficiency of individual share markets tend to coincide during some time periods but there is no clear pattern. The analysis also doesn't show any evidence that would suggest that the level of weak-form market efficiency of BRIC share markets is improving over time. Quite the contrary, most of the statistical results that are strongly against rejection of the null hypothesis that the market returns follow a random walk were related to the 2000 – 2002 time period. The exception is the Brazilian share market that showed best results during the 2012 – 2014 period.

All of the BRIC share markets behave according to the Adaptive Markets Hypothesis which means that they experience time periods of weak-form market efficiency that alternate with time periods of weak-form market inefficiency. This information is important for investors as it proves that technical and fundamental analysis can be used to generate returns superior to returns of the market portfolio.

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