Efficient Market Hypothesis: Some Evidences from Emerging European Forex Markets

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This study attempts to analyze the presence of weak form efficiency in the forex markets of a set of select European emerging markets namely Bulgaria, Croatia, Czech Republic, Hungary Poland, Romania, Russia, Slovakia and Slovenia using the monthly NEER data ranging from jan-1994 to Dec-2013. We employ a two step comprehensive methodology where in the first place we test for weak form efficiency using a family of individual and joint variance ratio tests. The results show that while the markets of Croatia, Czech Republic and Bulgaria may be weak form efficient at a shorter lag, the other six markets are not informationally efficient. In the next stage, we estimate a measure of relative efficiency to show the extent to which a market is weak-form inefficient. From the results, it is found that the forex markets of Croatia, Czech Republic and Bulgaria are least weak form inefficient compared to others. The findings of the study are of relevance as it shows that even after roughly two decades of free market economic policies, majority of the forex markets in the area remains informationally inefficient.

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1. Introduction

Ever since its inception, efficient market hypothesis (EMH henceforth) put forwarded by Eugene Fama (Fama 1965) has been at the centre stage of the mainstream financial theory. The hypothesis states that past information is fully reflected in the current price of a security. The market is said to be weak-form efficient if the current price of a security fully reflects all its information contained in its past prices. It means that studying the behaviours of historical prices cannot help in earning abnormal returns. The implication of weak-form efficiency is the random walk hypothesis (RWH), which indicates that successive price changes are uncorrelated.

There are many statistical tools available to test EMH, however Variance Ratio tests are considered to be powerful amongst them. Lo and Mackinlay (1988) were the first to construct the first variance ratio test. There were new tests constructed over the time to address the potential shortcomings associated with the test. For example, Richardson and Smith (1991) proposed a joint test with a Wald type statistic. Later, Chow and Denning (1993) modified Lo-MacKinlay's(1988) test to form a simple multiple variance ratio test. Choi (1999) put forward a data-driven automatic Variance Ratio test. Chen and Deo (2006) proposed a test to take care of the small sample distribution problem associated with Variance ratio (VR) statistic.

A forex market being efficient or inefficient of has far fetching implications. In case of inefficiency, it is possible to develop a model that best predicts exchange rate moves, providing opportunities for profitable forex transactions. Furthermore, in an inefficient foreign exchange market, the government/central bank can determine the best way to influence exchange rates, reduce exchange rate volatility and evaluate the consequences of different economic policies. On the other hand, an efficient forex market needs minimal intervention and its participants cannot make abnormal gains from foreign exchange transactions.

Here, this study seeks to analyze the presence of weak form of market efficiency in foreign exchange markets of the following countries: Bulgaria, Croatia, Czech Republic, Hungary Poland, Romania, Russia, Slovakia and Slovenia. They were selected for analysis because for two reasons. First, these countries were part of the former Eastern bloc before the dissolving of the USSR. Further, they had adopted market reforms around the same time. Hence, it would be interesting to see if the forex markets of the above mentioned countries share any common features. In this analysis we are using a family of Variance ratio tests to study the presence of weak form efficiency. Further, we create an efficiency index to see to what extent a market deviates from weak-form market efficiency. As a background to the present study, a review of earlier literature is presented.

LITERATURE REVIEW

A major chunk of the studies related to forex market efficiency were carried out on developed country markets. However, there are a few noteworthy studies that are mentioned below.

Giannellis and Papadopoulos (2006) tests for weak form market efficiency for Poland, Czech Republic and Slovak republic using a Behavioral Equilibrium Exchange Rate (BEER) model, an LSTAR model and unit root testing. They had used monthly bilateral rates of the national currencies against Euro. The study found Poland/Euro market to be efficient while Slovak/Euro market was found to be quasi efficient. Czech / Euro market was found to be inefficient.

A study was performed on the weak-form efficiency for foreign exchange markets in the SAARC countries for the period from 1985 to 2005 by Noman and Ahmed (2008). The methodology used was the variance ratio test of Lo and Mackinlay (1988) and Chow-Denning joint variance ratio test (1993).Their study did not find any sufficient evidence to reject the null hypothesis of a random walk for all the seven currencies and theyconcluded that foreign exchange markets in

South Asian region follow random walk process and, therefore, are weak-form efficient.

Tabak and Lima (2003) analyzed the random walk hypothesis on emerging markets exchange rates by employing Lo and Mackinlay (1989) variance ratio test on data with daily and weekly frequency using a bootstrap technique, which is robust to heteroskedasticity. They examined some Asian and Latin American countries and Russia. Empirical evidence supports the random walk hypothesis on both daily and weekly frequencies for the recent period.

Asad(2009) investigated the random walk and efficiency hypothesis for 12 Asia-Pacific foreign exchange markets using individual as well as panel unit root tests, variance ratio test of Lo and Mackinlay (1988) and the non-parametric-based variance ratio test of Wright (2000). The study used bothdaily and weekly spot exchange rate data from January 1998 to July 2007.The results of the unit root tests and the variance-ratio tests do not differ much when using daily data were used but differ significantly when using weekly data. With daily data, both types of unit root tests identify non-stationarity for all the series and two variance-ratio tests provide the evidence to support random walk hypothesis forthe majority of the exchange rates tested. With weekly data, panel unit root tests identified non-stationarity in the exchange rates and, the unit root tests on a single series basis identified unit root component for the 10 foreign exchange markets. However, the variance-ratio tests rejected the martingale null hypothesis for the majority of the exchange rates when using weekly data.

Sasikumar(2011) analyzed the validity of weak form efficient market hypothesis in Indian foreign exchange market using 3 individual(Lo and Mackinlay, Wright, Choi) as well as 3 joint variance ratio(Chow-Denning, Chen-Deo and Wald) tests. All tests conclusively rejected the hypothesis of weak-form market efficiency.

Ibrahim et al(2011) test for the weak form of market efficiency for the OECD countries using the Augmented Dickey-Fuller(ADF) and

Phillip-Peron(PP)tests. The results indicate that the exchange rates studied follow random walks. The study used bilateral exchange rates to carry out the analysis.

From the literature review, it is evident that there is a serious dearth of studies as far as the eastern European forex markets are considered. Hence, our study becomes relevant on this front.

3. DATA AND METHODOLOGY

Monthly NEER (nominal effective exchange rate) data for all the nine countries ranging from Jan-1994 to Dec-2013 were collected from BIS(Bank of International Settlements) website and log returns were calculated for the analytical purpose. We consider NEER compared to bilateral rates as NEER being a weighted average, could possibly hold more information about the markets as opposed to bilateral rates. The following paragraphs gives description about the methodology employed.

Variance ratio tests works on the basic assumption that if a series is following then, variance at the n the lag should be equal to n times the variance at one lag ie V (1) = n V(n), or $\frac{vn}{nvn} = 1$. Based on this property, a variance ratio test was first formulated by Lo &Mackinlay (1988).

The tests could be classified into two categories i.e. individual variance ratio tests and joint variance ratio tests. In individual variance ratio tests, we test for EMH using different lags while in joint variance ratio tests, a vector of lags are employed. Here we use 2 individual as well as 2 joint variance ratio tests. Detailed description is given in the following paragraphs.

3.1.INDIVIDUAL VARIANCE RATIO TESTS

3.1.1.Lo and Mackinlay (1988,1989) Variance Ratio test

The RWH for a time series X_t can be explained by the following equation:

$X_t = \mu + X_{t-1} + \varepsilon_t$ .... (1)

μ is an arbitrary drift parameter and ε_t is the random disturbance term.

The underlying assumption is that the disturbance terms ε_t are independently and identically distributed normal variables with variance σ_o^2. This is the assumption according to the traditional RWH. Thus, the null hypothesis

H0: ε_t ~i.i.d. $N(0, \sigma_o^2)$ ....(2)

According to the null hypothesis that the variance ratio should be unity for all levels of aggregation, it can be described as follows;

$$VR(q) = \frac{1}{q}\frac{\sigma_q^2(q)}{\sigma_1^2(q)} = 1 \quad \text{.................. (3)}$$

The test statistic that is developed by Lo and Mackinlay for the variance ratio is as follows;

$$Z_1(q) = \sqrt{nq}\overline{M}_r(q)(2(2q-1)(q-1)/3q)^{-1/2} \overset{a}{\approx} N(0,1) \quad \text{..................(4)}$$

Where the variance ratio is,

$$\overline{M}_r(q) \equiv \frac{\overline{\sigma}_c^2(q)}{\overline{\sigma}_a^2} - 1 \quad \text{................(5)}$$

And where the variance estimators are;

$$\overline{\sigma}_a^2 = \frac{1}{nq-1}\sum_{k-1}^{nq}(X_k - X_{k-1} - \hat{\mu})^2 \quad \text{..........(6)}$$

And,

$$\overline{\sigma}_c^2(q) = \frac{1}{m}\sum_{k=q}^{nq}(X_k - X_{k-q} - q\hat{\mu})^2 \quad \text{...................(7)}$$

Where,

$$m = q(nq - q + 1)(1 - \frac{q}{nq}) \qquad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

The tests are based on different aggregation levels, signaled by q. Besides the homoskedastic test statistic, Lo and Mackinlay (1989) also developed a test statistic that is robust to heteroskedasticity. This test statistic was developed using the knowledge that volatilities change over time, and that the error terms of financial time series are often not normally distributed.

Since $\overline{M}_r(q)$ still approaches zero, therefore we only have to calculate its asymptotic variance, which is defined as θ_q.

The variance ratio estimate as defined before, is asymptotically equivalent to a weighted sum of serial autocorrelation coefficient estimates, such that;

$$\overline{M}_r(q) = \sum_{j-1}^{q-1} \frac{2(q-j)}{q} \hat{\rho}(j) \qquad \ldots\ldots\ldots\ldots(9)$$

Where $\hat{\rho}(j)$ is the estimator of the j^{th} autocorrelation factor.

Here, the asymptotic distribution of $\overline{M}_r(q)$ under the null hypothesisis defined as follows;

$$\sqrt{nq}\,\overline{M}_r(q) \overset{a}{\approx} N(0, V(q)), \qquad \ldots\ldots\ldots\ldots\ldots\ldots(10)$$

Where $V(q)$ is the asymptotic variance of $\overline{M}_r(q)$ and can be calculated as

$$V(q) = \sum_{j=1}^{q-1} (2(q-j)/q)^2 \overline{\delta}(j), \qquad \ldots\ldots\ldots\ldots\ldots(11)$$

Where

$$\bar{\delta}(j)=\frac{(nq)\sum_{k=j+1}^{nq}(X_k-X_{k-1}-\bar{X})^2(X_{k-j}-X_{k-j-1}-\bar{X})^2}{\left[\sum_{k=1}^{nq}(X_k-X_{k-1}-\bar{X})^2\right]^2} \quad \ldots\ldots\ldots\ldots..(12)$$

And $\bar{\delta}(j)$ is the estimator for the weighted sum of the variances of $\hat{\rho}(j)$.

The standard normal Z-statistic under heteroscedasticity is computed as:

$$Z_2(q)=\sqrt{nq}\bar{M}_r(q)[V(q)]^{-1/2}\overset{a}{\approx}N(0,1). \quad \ldots\ldots\ldots\ldots..(13)$$

3.1.2. Automatic variance ratio test of Choi (1999)

While implementing the VR tests, the choice of holding period *k* is important. However, this choice is usually rather arbitrary and *ad hoc*. To overcome this issue, Choi (1999) proposed a data-dependent procedure to determine the optimal value of *k*. Choi (1999) suggested a VR test based on frequency domain since Cochrane (1988) showed that the estimator of *V*(*k*), which uses the usual consistent estimators of variance, is asymptotically equivalent to 2*π* times the normalized spectral density estimator at the zero frequency, which uses the Bartlett kernel.

However, Choi (1999) employed instead the quadratic spectral (QS) kernel because this kernel is optimal in estimating the spectral density at the zero frequency (Andrews, 1991).The VR estimator is defined as

$$VR(k)=1+2\sum_{i=1}^{T-1}h(i/k)\,\hat{\rho}(i) \quad \ldots\ldots\ldots\ldots\ (14)$$

Where R(i) is the autocorrelation function, and *h*(*x*) is the QS window defined as

$$h(x) = \frac{25}{12\pi^2 x^2}\left[\frac{\sin(\frac{6\pi x}{5})}{6\pi x/5} - \cos(\frac{6\pi x}{5})\right] \qquad (15)$$

The standardized statistic is

$$VR_f = \frac{VR(k)-1}{(2)^{\frac{1}{2}}(T/k)^{-1/2}} \qquad (16)$$

Under the null hypothesis the test statistic VR_f follows the standard normal distribution asymptotically. Note that it is assumed that $T \rightarrow \infty$, $k \rightarrow \infty$ and $T/k \rightarrow \infty$.Choi (1999) employed the Andrews (1991) methods to select the truncation point optimally and compute the VR test. Note that the small sample properties of this automatic VR test under heteroskedasticity are unknown and have not been investigated properly.

3.2.JOINT VARIANCE RATIO TESTS

3.2.1.Chow and Denning (1993) multiple variance ratio test

The Lo and Mackinlay (1988) test uses the property of the RWH to test individual variance ratios for different values of the aggregation factor q. Chow and Denning (1993) realized that the test lacks the ability to test whether all the variance ratios of the different observation intervals are equal to 1 simultaneously. This is a requirement of the RWH, and since Lo and Mackinlay(1988)overlooked this requirement, they used the standard normal tables to test the variance ratios on significance. Failing to control for the overall test size, leads to a large probability of a Type 1 error.

To circumvent this problem, Chow and Denning developed a test that controls for the joint test size, and also provides a multiple comparison of variance ratios. They used the Studentized Maximum Modulus (SMM) critical values to control for the overall test size and to create a confidence interval for the Variance Ratio estimates. They used the same test statistic of the Lo and MacKinlay (1988) Variance Ratio test. Only now they are simply compared to the SMM critical values, instead of the standard normal critical values to look for significance.

Since Chow and Denning(1993)consider multiple comparisons of the variance ratio estimates, and all variance ratio estimates should be above the SMM critical value, they use the following largest absolute value of the two test statistics as defined before in the Lo and MacKinlay(1988) procedure

$$Z_1^*(K) = \mathrm{Max}_{1\le i\le K}|Z_1(q_i)| \qquad \text{.............} (17)$$

$$Z_1^*(K) = \mathrm{Max}_{1\le i\le K}|Z_1(q_i)| \qquad \text{.............} (18)$$

$Z_1(q)$ and $Z_2(q)$ is calculated same as above

In which (q_i) are the different aggregation intervals for $\{q_i | i = 1,2,\ldots,m\}$.

The decision about whether to reject the null hypothesis or not can be based on the maximum absolute value of individual variance ratio test statistics.

3.2.2.Joint Variance Ratio Test of Chen and Deo (2006)

Chen and Deo (2006) suggested a simple power transformation of the VR statistic that, when *k* is not too large, provides a better approximation to the normal distribution in finite samples and is able to solve the well-known right-skewness problem. They showed that the transformed VR statistic leads to significant gains in power against mean reverting alternatives. Furthermore, the distribution of the transformed VR statistic is shown, both theoretically and through simulations, to be robust to conditional heteroscedasticity.

They defined the VR statistic based on the periodogram as

$$VR_p(k) = \frac{1}{1-{k}/{T}} \frac{4\pi}{T\hat{\sigma}^2} \sum_{j=1}^{[0.5(T-1)]} W_k(\lambda_j) I_y(\lambda_j) \qquad (19)$$

Where,

$$I_y(\lambda_j) = (2\pi T)^{-1} \left| \sum_{t=1}^{T} (Y_t - \hat{\mu}) \exp(-i\lambda_j t) \right|^2 \qquad (20)$$

$$\hat{\sigma}^2 = (T-1)^{-1} \sum_{t=1}^{T} (Y_t - \hat{\mu})^2 \qquad (21)$$

and$\lambda_j = 2\pi j/T$; while $W_k(\lambda) = k^{-1}\{\sin(0.5k\lambda)/\sin(0.5\lambda)\}^2$ is a weighting function. Chen and Deo (2006) found that the power-transformed statistic$VR_p^{\beta_K}$(k) gives a better approximation to a normal distribution than $VR_p(k)$, where

$$\beta_k = 1 - \frac{2}{3} \frac{\left(\sum_{j=1}^{[0.5(T-1)]} W_k(\lambda_j)\right)\left(\sum_{j=1}^{[0.5(T-1)]} W_k^3(\lambda_j)\right)}{\left(\sum_{j=1}^{[0.5(T-1)]} W_k^2(\lambda_j)\right)^2} \qquad (22)$$

Let $(k_1, \ldots, k_l)$ be a vector of holding periods satisfying the conditions given in Theorem 5 of Chen and Deo (2006). Conditions (A1) to (A6) in Chen and Deo(2006) allow the innovations $\varepsilon_t$to be a martingale difference sequence with conditional heteroskedasticity. They are explained below.

A1)$\{\varepsilon_t\}$ is ergodic and $E(\varepsilon_t/\vartheta_{t-1})=0$ for all t, where ϑ_t is a sigma field,ε_t is ϑ_t measurable

And$\vartheta_{t-1} \subset \vartheta_t$ for all t.

(A2) $E(\varepsilon_t^2) = \sigma^2 < \infty$

(A3) For any integer q, $2 \leq q \leq 8$ and for q non negative integers s_i, $E(\prod_{i=1}^{q} \varepsilon_{t_i}^{s_i})=0$ when at least one s_i is exactly one and $\sum_{i=1}^{q} s_i \leq 8$

(A4) For any integer r, $2\leq r \leq 4$ and for r non negative integers s_i, $E(\prod_{i=1}^{q} \varepsilon_{t_i}^{s_i}/\vartheta_t)=0$
when at least one s_i is exactly one and $\sum_{i=1}^{r} s_i \leq 4$
(A5)$\lim_{n-\to\infty} \mathrm{Var}[E(\varepsilon_{t+n}^2\, \varepsilon_{t+n+j}^2|\vartheta_t)] = 0$ uniformly in j for every j>0
(A6) $\lim_{n-\to\infty} E(\varepsilon_t^2 \varepsilon_{t-n}^2) = \sigma^4$
Under the assumption that given time series Y_t follows a conditionally heteroskedastic martingale difference sequence Chen and Deo Showed that

$$V_{p,\beta} \equiv (VR_p^{\beta_1}(k_1), \dots\dots, VR_p^{\beta_l}(k_l))'. \qquad (23)$$

approximately follows $N(\mu_\beta, \Sigma_\beta)$. The details of μ_β and Σ_β are given in Chen and Deo(2006). Based on this, Chen and Deo (2006) proposed a joint test statistic of the form

$$QP = (V_{p,\beta} - \mu_\beta)' \Sigma_\beta^{-1} (V_{p,\beta} - \mu_\beta) \qquad (24)$$

It approximately follows a chi-squared distribution with l degrees of freedom under H_0: $V(k_1) = \dots = V(k_l) = 1$ against H_1: $V(k_i) \neq 1$ for some i.

3.3. EFFICIENCY INDEX

As we explained before, the variance ratio test works on the principle that under null hypothesis V(n)=n X V(1) where V(n) is the variance at the n^{th} lag and V(1) is the variance at first lag. In other words, V(n)/nV(1)=1. Here we subtract the ideal value (i.e. 1) from the absolute value of actual variance ratio V_R . For an efficient market, value of Abs(V_R)-1 will be equal to 0. For our purposes, the difference between Abs(V_R)-1 will give us an indication about the extent by which a market deviates from informational efficiency. We calculate the value for lags of 2, 5 and 10.

4.RESULTS AND DISCUSSION

Results of the individual and joint variance ratio tests are reported in table 1 &2 respectively

Table 1

Result of individual VR tests

TEST	statsitc	Lags countries	BU	CRO	CZR	HU	PO	RO	RU	SLOK	SLOV
Lo-Mackinlay	Z_1	2	3.221*	2.636*	3.168*	4.298*	5.777*	8.402*	5.900*	4.069*	7.942*
		5	4.662*	1.524	2.350*	3.677*	4.524*	8.138*	6.966*	4.100*	8.257*
		10	6.207*	0.424	1.132	2.493*	2.578*	7.494*	6.410*	3.647*	6.839*
	Z_2	2	0.714	2.020*	2.258*	3.390*	4.280*	2.096*	2.291*	3.177*	4.784*
		5	1.165	1.285	1.829	2.923*	3.403*	2.487*	3.273*	3.494*	5.526*
		10	1.911	0.375	0.932	1.947	1.982	2.925*	3.504*	3.036*	5.052*
Choi	AV(K)		4.140 [0.17]	1.943 [0.050]	2.512 [0.013]	3.779 [0.003]	3.855 [0.010]	10.420 [0.000]	7.518 [0.000]	3.882 [0.000]	8.008 [0.000]

Source: Authors' calculations
*indicates Significance at 5% Level. P values are in the [ ]

Table 2

Results of Joint Variance Ratio Tests

TEST	Statistic	Lags\ countries	BU	CRO	CZR	HU	PO	RO	RU	SLOK	SLOV
Chen-Deo	QP_K	2,5,10	5.795	4.768	5.158	10.119*	15.112**	6.182	7.647	10.268*	18.94**
Chow-Denning	CD_1	2 ,5,10	6.207**	2.636*	3.168**	4.298**	5.777**	8.402**	6.966**	4.100**	8.257**
	CD_2	2,5,10	1.191	2.020	2.258	3.390**	4.280**	2.925*	3.504**	3.494**	5.526**

Source: Authors' calculations
*indicates significance at 5% level ** indicates significance at 1% level

The holding periods/ lags (*k*) under consideration are (2, 5, 10) as advised by Deo and Richardson (2003).We use relatively short holding periods when testing for mean reversion using VR tests. Note: The country codes BU, CRO, CZR,HU, PO,RO,RU,SLOK, SLOV represent the countries Bulgaria, Croatia, Czech Republic, Hungary Poland, Romania, Russia, Slovakia and Slovenia respectively.
Analysing the individual variance ratio test results, we can see that for Lo and Makinley test under the assumption of homoscedasticity, all markets except Croatia and Czech Republic reject the null hypothesis of weak form efficiency at all lags. Croatia and Czech Republic are not weak form efficient under the lag of 2 months while showing efficiency for the other 2 lags. Under the assumption of heteroscedasticity, Bulgarian market is shown to be efficient. Croatia and Czech Republic reject the EMH only at the lag of 2 months. All the other countries are shown not to be weak form efficient at all lags. Results from Choi's test shows that while Bulgaria remains weak form efficient, all the other markets are rejecting the EMH at all lags.
Moving forward to the joint variance ratio test analysis , we observe the following for Chen-Deo test results: the forex markets Hungary, Poland,Slovakia and Slovania are not weak form efficient while Bulgaria,Croatia, Russia, Czech Republic and Romania are weak form efficient. Considering the Chow-Denning result, it is shown that under the assumption of homoscedasticity, all markets are weak form inefficient .Bringing heteroscedasticity into picture shows that the forex markets of Bulgaria, Croatia and Czech Republic are weak form efficient while the other markets are not efficient.
From the test results it could be said that the forex markets of Bulgaria, Croatia and Czech Republic shows tendencies towards weak form efficiency, at least for short lags. The other markets are found to be weak-form inefficient.

In the next stage, we analyse the extent to which the markets are efficient by computing a measure of relative efficiency as discussed in section 3.3. The results are shown in table 3.

Table 3

Measure of Relative Market Efficiency

Market/Lags	2	5	10
Bulgaria	0.207	0.659	1.352
Croatia	0.17	0.216	0.926
Czech Republic	0.204	0.332	0.246
Hungary	0.277	0.52	0.543
Poland	0.372	0.639	0.561
Romania	0.542	1.15	1.633
Russia	0.38	0.985	1.397
Slovakia	0.262	0.579	0.794
Slovenia	0.512	1.167	1.49

Source: Authors' Calculation

From the table, certain facts are evident. At lag 2, Croatia, Czech Republic and Bulgaria respectively have the smallest values compared to others, indicating that they are relatively efficient considering a shorter period while compared to other markets. At lag of 2 and 5, the forex market of Croatia has the least value, followed by Czech Republic. Here it could be said that our previous claim about the forex markets of Croatia, Czech Republic and Bulgaria tending towards informational efficiency is validated to an extent.

CONCLUSION

This study attempted to analyze the presence of weak form market efficiency in the forex markets of a set of European emerging markets namely Bulgaria, Croatia, Czech Republic, Hungary Poland, Romania, Russia, Slovakia and Slovenia. We carried out the analysis using the monthly NEER data ranging from jan-1994 to Dec-2013 for all the countries.

We employed a two step methodology where in the first place we tested for weak form efficiency using a family of individual and joint variance ratio tests. The test results showed that while the markets of Croatia, Czech Republic and Bulgaria may be weak form efficient at a shorter lag, the other six markets are not informationally efficient.

In the second stage, we calculated a measure of relative efficiency to show the extent to which a market is weak-form inefficient. From the results, it was evident that the forex markets of Croatia, Czech Republic and Bulgaria are least weak form inefficient.

Although we have reached a conclusion that majority of the markets under analysis are not informationally efficient, there are few questions remaining unanswered. First, we have to find the actual behavior of the market if they are not efficient. Next, the reasons that lead to informational inefficiency also should be examined. Further research is required to answer these questions.

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