The Efficiency of the Stock Market in the CARICOM sub-region: an Empirical Study

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Abstract

The objective of this paper is to determine whether the Stock Exchanges of Barbados, Jamaica, Trinidad & Tobago and the virtual CARICOM Regional Stock Exchange, as well as the Banking, Conglomerate, Financial and Manufacturing Sectors of these exchanges, are weak-form efficient or not. Three sets of tests are used: two parametric and one non-parametric. There is a lot of similarity in the evidence provided by the two parametric approaches: a traditional Box-Jenkins type 'correlation' analysis to test the random-walk hypothesis and the Lo-MacKinlay's heteroscedasticity-robust and non robust variance-ratio tests. However, a non parametric variant of the Lo-MacKinlay test due to Wright and based on ranks and signs generally provides quite different results, particularly the sign test. A recommendation is made to use Wright's tests in preference to the others when examining efficiency in the CARICOM and similar exchanges. This leads to the conclusion that all exchanges and their sectors are inefficient although the Box-Jenkins and Lo-MacKinlay parametric variance ratio tests suggest that the Barbados Stock Exchange and some of the sectors in this and the Jamaica Stock Exchange function efficiently.

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1. Introduction

The efficiency of a stock market, in the sense of Fama (1970), is an important issue to emerging economies as it reflects whether scarce financial resources are being used optimally, which is important to the wider issue of economic development as is underscored by Singh (1995) and Robinson (2005) for the particular case of the CARICOM region[2]. According to Robinson (2005), it is critical "to have efficient capital markets so as to ensure that prices provide accurate signals for the optimal allocation of very scarce resources, otherwise misallocation may occur", which "may severely retard the development process[3]".

Stock exchanges have been mushrooming in the CARICOM region. The Jamaica Stock Exchange (JSE) came into existence in 1969, the Trinidad & Tobago Stock Exchange (TTSE) in 1981, and the Barbados Stock Exchange (BSE) in 1987. Even more recently, the Eastern Caribbean Stock Exchange opened for trading in 2001 while the Guyana Stock Exchange was established in 2003. Further to this, agreement was reached as far back as 1989 on the establishment of a CARICOM Regional Stock Exchange (CRSE), which will allow, among other things, for the free trading of securities across national frontiers (CARICOM Secretariat 2008). Although this Exchange is not yet a physical entity, some of the arrangements made for its functioning (like free cross-border equity flows and cross-listing of shares) are already operational.

Market capitalization in the BSE, the JSE and the TTSE (the three main exchanges in the region), though by no means large even by emerging market standards (Robinson 2001), has grown phenomenally, especially since the 1990s. In the case of the BSE, the value of stock market capitalization increased from 16% of GDP in 1990 to 182% in 2005. In the case of the JSE, market capitalization as a percentage of GDP stood at 12% at the end of 1969 and was 150% by the end of 2005. At the TTSE, the value of stock market

[2] CARICOM (the Caribbean Community and Common Market) is a grouping of 14 Caribbean countries: Antigua and Barbuda, Belize, Grenada, Montserrat, St. Vincent and the Grenadines, The Bahamas, British Virgin Islands, Guyana, St. Kitts and Nevis, Suriname, Barbados, Dominica, Jamaica, Saint Lucia, Trinidad and Tobago.

[3] There is indeed a well established causal relationship between economic development and financial development generally (Rajan and Zingales 1998), and stock market development more specifically (Bose 2005 and Mala and White 2006).

capitalization grew from 17% of GDP in 1981 to 112% in 2005.

Given the emphasis being placed on stock market development, it is of obvious interest to know how efficiently they have been functioning given the implications for possible resource misallocation. The objective of this paper is to determine whether the BSE, the JSE, the TTSE and the virtual CRSE, as well as the Banking, Conglomerate, Financial and Manufacturing Sectors of these exchanges, are weak-form efficient or not. The study differs from previous studies of CARICOM stock exchanges principally in the use of a new and enlarged data set and in the use of the non parametric variance ratio tests due to Wright (2000), which are based on the use of ranks and signs. Another novelty is the analysis of the efficiency of the virtual CRSE. Daily data of composite indices as well as indices of the Banking, Conglomerate, Financial and Manufacturing Sectors, are used, covering the period January 2, 1998 to May 20, 2005. In addition to Wright's tests, the study also employs two parametric tests: a traditional Box-Jenkins type 'correlation' analysis (with the possibility of GARCH disturbances) and Lo-MacKinlay's heteroscedasticity-robust and non robust variance-ratio tests.

The rest of the paper is made up as follows: a brief review of the literature examining the relevance of Fama's (1970) "efficient market hypothesis" (EMH) to CARICOM stock markets appears in the following section. The data and methodology used in the paper are laid out and discussed in the section that follows, and this section also contains a preliminary analysis of the data. The results and analysis of the tests of the weak form of the EMH for the four exchanges are then presented and discussed and, thereafter, the paper concludes.

2. Brief Review of the Literature on the EMH and CARICOM Stock Markets

Studies of the validity of the EMH to individual markets in the CARICOM region include Craigwell and Grandbois (1999), Alleyne and Craigwell (2007) and Robinson (2001), who study the BSE; Koot et al. (1989), Agbeyegbe (1994) and Robinson (2005), who look at the JSE and Sergeant (1995), Singh (1995) and Bourne (1998) who study the TTSE. Some of these are quite dated and, except for Robinson (2001), they all conclude that the markets are inefficient.

Craigwell and Grandbois (1999) apply unit root and co-integration procedures to data covering the period 1987-1997 to conclude that the BSE was not efficient in either the weak or semi-strong forms. Alleyne and Craigwell (2007) use monthly data covering the period 1989-2004 and apply Philips-Perron unit root tests to conclude that the market is inefficient. They also provide evidence that "most stocks show under-volatility, contrary to the emerging market literature", which "may be due to lack of activity on these stocks". Robinson (2001) employs a variety of parametric and non parametric tests to the prices of 18 stocks listed on the BSE and concludes that the efficiency hypothesis could not be rejected although, largely because of the thinness of the market, he also suggests strongly that this conclusion may be misleading.

Koot et al. (1989) use the non parametric runs test and data covering the period 1969-1986[4]to arrive at their conclusion. Agbeyegbe (1994) uses monthly data from January 1970 to December 1991 and provides evidence in support of the view that stock prices "temporarily drift away from fundamentals", which may be supporting the view that the market is inefficient. He bases his analysis on the examination of correlations and dependence between returns and interest rates. Robinson (2005) looks at the movement of the prices of all listed companies on the JSE (instead of the index) and, using daily data from January 2, 1992 to December 31, 2001, applies autocorrelations and runs tests. He concludes that "there is strong evidence that the JSE is not weak form efficient".

The analysis of Sergeant (1995) and that of Bourne (1998) are quite similar: the former uses monthly data for the TTSE covering the period November 1981 to December 1989 and the latter the period November 1981-December 1984. Both investigators, improperly in my view, test the random walk hypothesis using simple Ordinary Least Squares and standard significance tests, and both use runs tests. Singh (1995) investigates the weak form of the efficiency hypothesis for the TTSE and shows it to be weakly inefficient over both the short and long term horizons. He uses monthly data covering the period November 1981 to October 1981 and examines the correlations of returns (lags 1-5), the Ljung-Box Statistic and the runs tests. For a subset of the data, he uses the Varaince Ratio tests but fails to employ the asymptotic distribution associated with this test. Instead, he

[4] The frequency of the data is not clear from the study, which is a major shortcoming.

uses the actual value of the statistic, which he compares to unity, in order to draw his conclusions.

Studies of the EMH and other emerging economies include Groenewold et al. (2003) and Seddighi and Nian (2004) for the Chinese exchanges, Buguk and Brorsen (2003) for the case of the Istanbul exchange, Chang and Ting (2000) for the Taiwanese market, Ryoo and Smith (2002) for the Korean Stock Market, Urrutia (1995) for Latin American markets generally, Smith et al (2002) for African markets generally, Huang (1995) and Hoque et al (2007) for Asian markets generally and Karamera et al. (1999) and Kawakatsu and Morey (1999) for emerging markets generally.

3. Data and Methodology

For the period January 2, 1998 to May 20, 2005, daily composite stock market indices for stock prices on the BSE, JSE and the TTSE, as well as sector indices for the Banking, Conglomerates, Financial and Manufacturing sectors, were constructed using original data on listed companies supplied by the Exchanges. This was done to ensure comparability of the data, which were also used to construct a CARICOM-wide index, also used in this paper if only as a preliminary indicator of the yet unborn CRSE[5]. A brief note in the calculation of the CARICOM composite and sector indices is given in appendix. See Pemberton and Watson (2004) for further details of index construction.

Weak-form efficiency implies that stock prices follow a random walk process such as

$$\ln p_t = \alpha + \beta t + \ln p_{t-1} + u_t \qquad (1)$$

where p_t is the stock price at time t, α and β are constant (drift and trend) terms and $\{u_t\}$ is an identically and independently distributed (IID) Gaussian process. A Box-Jenkins type 'correlation' analysis may be used to determine the existence or not of ARIMA type models for the stock market prices, other than the random walk. This requires, in the first instance, tests for the existence of one unit root in model (1) and the Augmented Dickey-Fuller (ADF) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests are used to do

[5] All indices are *ex dividend*. Use of a total returns index does not alter the results obtained.

this. If the presence of exactly one unit root is established, the autocorrelation function of $\Delta \ln p_t$ (the rate of return based on the index) is examined to determine whether the process (1) may be modeled as IID; (2) as a GARCH (q,p) process or (3) it may conform to a stationary ARMA model, with or without GARCH(q,p) disturbances. In cases (2) and (3), the process is predictable and consequently indicative of weak-form inefficiency. Procedures similar to the one being proposed here have been used by Kawakatsu and Morey (1999), Groenewold et al. (2003), Dragota and Mitrica (2004) and others.

A fundamental weakness of the Box-Jenkins approach is the underlying normality (Gaussian) assumption which is not at all a usual attribute of stock prices. Table 1 below displays some interesting descriptive statistics of returns derived from the various indices used in this study[6]. These are the mean return (*Mean*), the risk-adjusted mean return[7] (*Adj. Mean*), the standard deviation (*Std. Dev*), the *Sharpe* Ratio[8], *Skewness*, *Kurtosis* and the *Jarque-Bera* statistic (used to test the normality of the series). It also displays test statistics for the equality of means and variances (the square of the standard deviations) of the CRSE and national indices for both the composite and the sector level indices.

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[6] There was no marked difference in the results obtained using the total returns instead of the ex dividend indices and, henceforth, all reported results are based on the latter alone.

[7] The adjusted mean return is the mean of the series (r_t-r_{ft}), where r_t is the return on the asset and r_{ft} is the risk-free rate of interest, measured as the rate of return on the 90-day Barbados and Trinidad & Tobago Treasury Bill in the case of, respectively, the BSE and TTSE, and as the 180-day Treasury Bill rate of Jamaica for both the JSE and the CRSE.

[8] The ratio of the adjusted mean rate of return and the standard deviation (Sharpe 1966).

Table 1

Descriptive Statistics based on Stock Returns

Index	BSE	JSE	TTSE	CRSE	Tests of Equality
Composite					
• Mean	0.000785	0.001434	**0.001634**	0.001446	Mean: F=0.4899
• Adj. Mean	0.000101	**0.000934**	0.000783	0.000424	Adj. Mean: F=0.3271
• Std. Dev	0.015432	0.023082	**0.007077**	0.008736	Var: F=123.2[a]
• Sharpe	0.0065	0.0405	**0.1106**	0.0485	
• Skewness	6.59	1.14	0.946	2.07	
• Kurtosis	161.9	17.63	15.70	24.62	
• Jarque-Bera	844,170	7,279	5,473	16,090	
Banking					
• Mean	0.000726	**0.002363**	0.001753	0.001727	Mean: F=0.8449
• Adj. Mean	0.000686	0.000934	**0.001411**	0.000908	Adj. Mean: F=0.5006
• Std. Dev	0.022369	0.029960	**0.009566**	0.015628	Var: F=92.63[a]
• Sharpe	0.0307	0.0312	**0.14750**	0.05810	
• Skewness	6.64	0.751	0.639	2.211	
• Kurtosis	163.1	23.98	20.58	43.27	
• Jarque-Bera	857,564	14,694	10,315	54,515	
Conglomerates					
• Mean	0.001302	**0.002715**	0.002079	0.002274	Mean: F=0.8952
• Adj. Mean	0.001197	**0.002243**	0.001823	0.001716	Adj. Mean: F=0.4691
• Std. Dev	0.017552	0.023476	0.013911	**0.013770**	Var: F=76.60[a]
• Sharpe	0.0683	0.0955	**0.1310**	0.1246	
• Skewness	13.93	0.3522	0.7176	0.3167	
• Kurtosis	340.8	9.124	30.81	8.938	
• Jarque-Bera	3,815,875	1,262	25,746	1,184	
Financial	Not calculated due to insufficient variation in the data.				
• Mean		**0.004332**	0.003286	0.003482	Mean: F=0.2430
• Adj. Mean		**0.003765**	0.003044	0.002906	Adj. Mean: F=0.1653
• Std. Dev		0.051654	**0.013274**	0.014025	Var: F=107.9[a]
• Sharpe		0.0729	**0.2293**	0.2072	
• Skewness		4.64	3.23	2.10	
• Kurtosis		64.16	26.92	18.30	
• Jarque-Bera		127,061	20,383	8,356	
Manufacturing					
• Mean	0.000683	**0.001308**	0.000837	0.001072	Mean: F=0.1525
• Adj. Mean	0.000591	**0.000859**	0.000631	0.000563	Adj. Mean: F=0.0365
• Std. Dev	0.010757	0.032091	**0.000978**	0.018052	Var: F=140.4[a]
• Sharpe	0.0549	0.0268	**0.0645**	0.0319	
• Skewness	13.39	-3.875	1.355	-0.6123	
• Kurtosis	274.6	74.54	34.70	22.97	
• Jarque-Bera	2,473,367	171,976	33,608	13,293	

a: sig at 1%. Otherwise, not significant. The highlighted values show the highest returns (adjusted and unadjusted), the largest Shape ratios and the lowest risk in each index category.

The very large values of the Jarque-Bera statistics in all cases (significance level close to 0) indicate outright rejection of the normality assumption. This may put in doubt the results arrived at using the Box-Jenkins type approach, especially if the random walk hypothesis is 'verified'. An alternative approach, whose validity need not depend on the

Gaussian assumption, is based on the Variance Ratio. The heteroscedasticity-robust variant of this ratio is robust not only to nonnormality but to many forms of heteroscedasticity (Lo and MacKinlay 1988). The latter property is not negligible given the fact that financial time-series, in addition to being non Gaussian, often possess time varying volatilities. The Variance Ratio test, in particular its heteroscedasticity-robust variant, has been widely used in the literature, including in the analysis of the efficiency of emerging markets. See, for example, Buguk and Brorsen (2003), Chang and Ting (2000), Huang (1995), Abraham et al. (2002), Grieb and Reyes (1999), Ryoo and Smith (2002), Smith et al (2003), Karemera et al. (1999), Ojah and Karemera (1999) and Urrutia (1995).

The third approach is the application of a nonparametric variant of the variance ratio test, first proposed by Wright (2000), which employs signs and ranks, rather than mean deviations. Applications of this procedure to be found in the emerging market literature include Hoque et al (2007), Al-Khazali et al. (2007) and Buguk and Brorsen (2003).

Table 1 makes for some interesting observations other than the absence of normality (which was expected). Based on the Sharpe ratio, the very best investment is in the Trinidad & Tobago financial sector. On the basis of this same ratio, the Trinidad & Tobago market generally outperforms its rivals. The F-statistic value of 0.4899 for comparing the means of the returns based on the composite index, using the classic ANOVA test, indicates that the null of equality of the means cannot be rejected even at very low significance levels. This is interpreted to mean that there is no difference in the mean return of the CRSE taken as a whole and the mean return of the various national jurisdictions. There is also no significant difference in the returns of all the sectors across the jurisdictions. However, the very high values of the F-statistics associated with the tests of equality of the variances means that the various portfolios are not of equal risk. In many cases, the portfolio with the lowest risk, that of the TTSE, is also the portfolio with the largest estimated mean return (adjusted and unadjusted).

4. Stock Market (in)efficiency in the CARICOM sub-region: results and analysis

The ADF and the KPSS tests are used to establish the existence of a unit root in the {ln

$p_t\}$ process. This is equivalent to determining whether ϕ=1 in the following:

$$\ln p_t = \alpha + \beta t + \phi \ln p_{t-1} + u_t$$

The null hypothesis, in the case of the ADF, is that ϕ=1 and the alternative is ϕ<1. In the KPSS case, the roles of the null and alternative are swapped. Table 3 below shows the results of these tests on the various indices:

Table 3

ADF and KPSS Tests of Stock Price Indices

Index	BSE	JSE	TTSE	CRSE
Composite				
• ADF Level	-1.5820	-2.1599	-1.2406	-0.5094
• ADF 1st Diff	-29.87[a]	-24.51[a]	-9.2147[a]	-24.48[a]
• KPSS Level	0.3679[a]	0.4423[a]	0.7067[a]	0.7412[a]
• KPSS 1st Diff	0.1723	0.2313	0.4117[c]	0.5238[b]
Banking Sector				
• ADF Level	-2.2112	-2.6189	-2.3592	-1.5850
• ADF 1st Diff	-30.19[a]	-26.67[a]	-8.8123[a]	-28.48[a]
• KPSS Level	0.2664[a]	0.2985[a]	0.5966[a]	0.6484[a]
• KPSS 1st Diff	0.0857	0.1684	0.3779[c]	0.2477
Conglomerates Sector				
• ADF Level	-0.8120	-2.3722	0.2217	-0.0517
• ADF 1st Diff	-28.15[a]	-27.50[a]	-13.36[a]	-25.69[a]
• KPSS Level	0.5371[a]	0.5424[a]	0.7693[a]	0.7674[a]
• KPSS 1st Diff	0.2594	0.3149	0.5109[b]	0.5082[b]
Financial Sector	Not calculated due to insufficient variation in the data.			
• ADF Level		-2.2799	-1.9762	-0.1430
• ADF 1st Diff		-26.81[a]	-8.9643[a]	-26.95[a]
• KPSS Level		0.1973[a]	0.3198[a]	0.2281[a]
• KPSS 1st Diff		0.1383	0.0956	0.0762
Manufacturing Sector				
• ADF Level	-2.7792	-3.2950	-1.1792	-2.8780
• ADF 1st Diff	-16.74[a]	-28.84[a]	-23.78[a]	-28.57[a]
• KPSS Level	0.1848[b]	0.1339[c]	0.4941[a]	0.1534[b]
• KPSS 1st Diff	0.0662	0.0452	0.2691	0.0988

a: sig at 1%. b: sig at 5%. c: sig at 10%. Otherwise, not significant.
Tests at levels include constant and trend terms. Tests in 1st diff include constant only.

All indices are I(1): they are non stationary. But this does not prove that they are random walks. A follow-up step is a Box-Jenkins type examination of the autocorrelation functions of the returns,$\{\Delta \ln p_t\}$, to identify any discernible patterns. A returns series is considered to be IID for sufficiently small values of the Box-Ljung Q-statistic over a sustained period (or, equivalently, for sufficiently large corresponding p-values) and if, on the basis of Engle's (1982) LM test, there is no evidence of GARCH effects. If the Q-statistics are sufficiently large, then the returns are not an IID process (they are predictable) and an ARMA model, an ARMA model with GARCH residuals, or a purely GARCH process is sought. The results of this exercise are summarized in Table 4 below.

Table 4
Structure of Stock Returns based on Box-Jenkins Analysis

Index	BSE	JSE	TTSE	CRSE
Composite	IID	ARMA-GARCH	ARMA-GARCH	ARMA-GARCH
Banking Sector	IID	ARMA-GARCH	GARCH	GARCH
Conglomerates Sector	IID	GARCH	GARCH	GARCH
Financial Sector	NC	IID	GARCH	GARCH
Manufacturing Sector	GARCH	IID	ARMA	GARCH

NC = Not calculated due to insufficient variation in the data.

The BSE, based on the behaviour of its composite index, is the only efficient exchange on the basis of the Box-Jenkins analysis. The other two exchanges, as well as the virtual CRSE, display returns that fit ARMA patters with GARCH residuals. The banking and conglomerate sectors of the BSE, as well as the JSE's financial and manufacturing sectors, are also efficient. All other sectors are not. The TTSE is a particularly inefficient operation and its weight in the CRSE index may be going a long way to making that market inefficient as well.

Table 5 below shows the results of testing for weak-form efficiency based on the Lo-MacKinlay Variance Ratio and heteroscedasticity-robust Variance Ratio test statistics (Z(q) and Z*(q), respectively) as well as Wright's non parametric variants of these tests - those based on rank (R_1 and R_2, respectively) and the one based on sign (S) - for lags 2, 4, 8 and 16. Under the null hypothesis of a random walk (i.e. that the market is weak-form efficient), all the underlying distributions are asymptotically normal with zero mean and unit variance.

Table 5
Variance ratio tests

Indices ↓	**BSE**				**JSE**				**TTSE**				**CRSE**			
Interval →	2	4	8	16	2	4	8	16	2	4	8	16	2	4	8	16
Composite																
• Z(q)	**-1.64**	**-1.22**	**-1.00**	**-0.58**	3.92	3.64	4.22	4.94	7.31	11.60	15.03	16.52	3.94	4.23	5.06	5.95
• Z*(q)	**-1.63**	**-0.93**	**-0.74**	**-0.51**	2.25	2.18	2.64	3.43	5.31	7.65	10.33	12.72	2.98	3.18	3.87	4.92
• R_1	**1.45**	2.97	4.14	5.46	4.25	5.23	6.09	6.54	9.78	14.41	19.04	22.00	6.06	8.49	10.87	12.85
• R_2	**0.63**	2.31	3.37	4.73	4.30	4.87	5.61	6.25	9.66	14.42	19.28	22.36	5.88	7.65	9.64	11.48
• S	5.21	9.13	13.24	17.48	2.44	2.95	3.67	3.15	9.88	15.54	22.00	28.57	6.13	7.82	10.29	12.53
Banking																
• Z(q)	**-1.95**	**-1.21**	**-1.02**	**-0.74**	**0.52**	**-0.15**	**0.59**	**1.77**	3.53	6.19	8.69	9.24	**-0.31**	**-0.72**	**0.39**	**1.21**
• Z*(q)	**-1.87**	**-0.93**	**-0.75**	**-0.63**	**0.16**	**-0.06**	**0.28**	**1.03**	2.10	3.67	5.39	6.60	**-0.09**	**-0.25**	**0.17**	**0.65**
• R_1	**-0.91**	**0.40**	**0.80**	2.10	3.22	**1.52**	**1.29**	2.06	8.68	12.96	16.26	17.71	3.18	3.67	4.17	5.19
• R_2	**-1.52**	**0.09**	**0.49**	**1.71**	2.82	**1.21**	**1.15**	2.04	7.87	11.82	15.34	16.91	2.82	3.00	3.67	4.77
• S	20.30	32.83	48.11	68.67	4.07	2.67	2.26	3.27	9.32	14.29	18.61	22.37	2.94	3.24	3.46	4.19
Conglom.																
• Z(q)	**0.03**	**0.15**	**0.61**	**0.96**	**0.69**	**0.39**	**0.98**	**1.88**	2.97	4.38	4.28	6.12	2.60	**1.88**	2.93	4.71
• Z*(q)	**0.09**	**0.40**	**1.54**	2.23	**0.59**	**0.32**	**0.82**	**1.62**	**1.90**	3.09	2.65	3.85	**1.67**	**1.26**	2.10	3.52
• R_1	**1.72**	2.67	3.68	4.63	**1.04**	**1.96**	2.96	3.84	8.09	13.34	17.35	20.57	2.25	3.48	5.82	8.14
• R_2	**1.48**	2.42	3.58	4.69	**0.93**	**1.37**	2.20	3.16	6.93	11.71	15.15	18.20	2.17	2.81	4.82	7.15
• S	10.52	16.43	23.82	32.65	2.09	3.77	5.18	5.74	10.10	15.68	21.22	26.75	3.58	5.42	7.75	9.15
Financial																
• Z(q)					**1.40**	**0.71**	**0.50**	**1.34**	2.73	4.46	6.71	8.23	**1.25**	2.22	4.22	5.67
• Z*(q)	NA	NA	NA	NA	**1.60**	**0.71**	**0.48**	**1.14**	**1.80**	3.35	5.32	6.28	**1.01**	1.96	3.72	4.62
• R_1					3.34	3.24	2.83	2.66	8.90	12.78	15.68	16.50	5.00	6.31	7.44	7.60
• R_2					3.14	2.94	2.49	2.43	7.72	11.39	14.39	15.20	3.93	5.23	6.61	6.98
• S					9.32	13.14	17.96	23.71	9.17	13.01	15.61	16.91	5.21	6.68	8.10	9.06
Manufact.																
• Z(q)	5.79	4.22	**0.80**	**-0.53**	**-0.65**	**-1.15**	**-1.19**	**-0.63**	4.73	6.20	7.85	6.88	**-0.39**	**-0.88**	**-0.72**	**-0.34**
• Z*(q)	**1.04**	**0.94**	**0.21**	**-0.17**	**-0.39**	**-0.80**	**-0.97**	**-0.59**	3.48	4.66	6.45	6.16	**-0.19**	**-0.48**	**-0.46**	**-0.25**
• R_1	**-0.31**	**-0.41**	**0.35**	**0.62**	2.83	2.98	2.92	3.04	6.65	9.39	11.16	10.56	2.94	4.19	4.59	4.49
• R_2	**0.33**	**0.06**	**0.43**	**0.51**	2.19	**1.80**	**1.84**	2.26	6.39	9.29	11.50	10.63	2.43	2.92	3.18	3.23
• S	23.06	36.75	53.85	76.24	3.37	3.39	2.36	2.20	5.77	8.03	9.60	9.83	2.51	3.94	4.47	4.36

Boldface values are not significant at 5%, indicating non rejection of the null (random walk) hypothesis at this level of significance.

All markets and sectors identified as efficient using the Box-Jenkins type analysis are similarly identified by the Z statistics but, in addition, the latter identify the JSE Banking and Conglomerate sectors as efficient. The non robust Z almost always tells the same story as the robust Z* just as the non robust R_1 almost always tells the same story as the robust the R_2 statistic. But there is significant conflict between the Z and R statistics, in particular in the BSE Composite and Conglomerate cases, in all the JSE sub sector cases and in the CRSE. It is noteworthy that use of Wright's R-statistics results in rejection of the hypothesis of weak-form efficiency in all cases where use of the Z-statistics does, but use of the R-statistics results in rejection of this hypothesis in the cases just cited when use of the Z-statistics does not. In addition, the R-statistics always provide more convincing rejection of the efficiency hypothesis than does the Z-statistics. Once again, the TTSE is inefficient at the global and sectoral levels, no matter what test is used[9].

Wright's Sign statistic (S) stands out in one important respect: it never provides evidence of efficiency in any market, either at the global or sectoral level. This statistic, like the R-statistics, corrects for some of the shortcomings of Lo-MacKinlay's variance ratio which, in turn, corrects for shortcomings in the traditional Box-Jenkins type 'correlation' analysis. Rejection of the null is also the most convincing using this statistic.

What to make of all this? Fama (1970) argues that the efficiency of a market has certain pre-requisites, among them an active market with a sufficiently large number of traders and traded stocks. Many of the previous studies of the CARICOM markets cited in this paper point to the thinness of the markets and the tendency to buy and hold securities so as to keep ownership within certain families. All this is likely to make the markets of the CARICOM region inefficient, and this accords with intuition. The Wright R and S tests, which provide this result much more convincingly than the Box-Jenkins and even the Lo-MacKinlay tests, are therefore arguably the most reliable way to test for the presence of inefficiency in these and similar markets. These tests, in particular the S test, have also led to the most intuitive conclusion that the markets in question are indeed inefficient in

[9] In two TTSE cases, Z* is not significant at 5% but is at 10%.

all their aspects. Hoque et al (2007), in their study of Asian markets, arrive at a similar conclusion about Wright's tests as opposed to the Lo-Mackinlay and other tests.

In many respects, this is not a surprising result. The Lo-MacKinlay tests are, after all, asymptotic tests, so their sampling distributions in finite samples are approximated by their limiting distributions. In the case of the Wright rank tests, it is often possible to compute their exact distributions since there is no need to make any asymptotic approximation, and thus there is no size distortion effect when the rank test is used (Buguk and Brorsen. 2003). Further, the Lo-MacKinlay tests assume that stock returns are at least identically, if not normally, distributed. But the sampling distribution of the Lo-MacKinlay statistics need not be normal in finite samples and may "suffer from serious test-size distortions or low power, especially in relatively small samples" (Al-Khazali et al 2007). Wright's tests, on the other hand, do not rely on approximate sampling distributions and they are more powerful than the conventional variance ratio tests when return data are highly nonnormal as is the case in the CARICOM markets, which are also relatively small and characterized by thin trading.

Harvey (1993) stated that stock returns of emerging countries are highly predictable, as we have determined for the CARICOM markets, and that they have low correlation with stock returns of developed countries. He recommends that investors incorporate emerging market stocks into their portfolios to obtain higher return and lower risk. Does inefficiency in markets such as those of the CARICOM region imply that investors are able to earn abnormal returns? The anecdotal evidence is that this is not the case. However convincingly the random walk hypothesis may be rejected, as in the case of the S statistics, there may be no profit opportunities because the market is thin and it would be impossible to trade at the quoted prices. This may well be the case with many emerging markets, in which case the statistical rejection of efficiency is not very interesting in economic terms. Conversely, market prices may be statistically indistinguishable from a random walk because of the lower power of the tests used in the presence of thin markets but there may be profit opportunities nonetheless. One possible explanation for this may be because the mean square error loss function used in the statistical analysis does not correspond to a profit based loss function (Elliott and Timmerman 2008)[10].

5. Conclusion

Testing for the existence of weak-form efficiency is likely to result in different conclusions depending on the method employed, as was the case in this study where three different approaches are used with conflicting results in some cases. We nevertheless opted for the preferred use of Wright's rank and sign statistics, in particular the latter. Using the sign test, we conclude that all the markets, in all their aspects, are inefficient and this is also the most intuitive conclusion given the Fama (1970) pre-requisites of an efficient market.

Stock Exchanges are expected to play a major role in the economic growth process in emerging economies like those of the CARICOM region. Yet, there is strong evidence that they function inefficiently and that may lead to resource misallocation. Since it is more likely that the efficacy of the exchange in promoting growth and development will improve with greater efficiency, there is work to be done. The main issues to be addressed may be largely legal, institutional, political, regulatory and managerial. In Trinidad and Tobago, the Security Industry Act (1995) is currently under review[11], a worthwhile step towards improving the legal and regulatory framework under which the securities market operates. The competent authorities should also engage in programmes geared toward encouraging more people to invest and to restoring investor confidence by introducing appropriate tax laws, and strengthening the capability of regulatory agencies. They should also consider introducing new and innovative products on the stock exchanges. Furthermore, it should also be the intention of the authorities to encourage new issues of shares on the market.

There remains, of course, the ongoing discussion and debate about the opening of a regional CARICOM Regional Stock Exchange and the CARICOM Single Market and

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[10] I owe this observation to an anonymous referee of this journal.

[11] The consultants, Stikeman Elliot LLP, who were mandated by the TTSEC to review the existing Act and recommend a way forward, have recommended that the existing Act be repealed and replaced with a new securities Act (2005) given the numerous amendments proposed.

Economy (CSME). Steps should be taken to advance these processes as the existence of one or the other (or both) is likely to result in more active trading on the exchanges.

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Appendix

CARICOM Composite and Sector Stock Price Indices

The CARICOM Composite and Sector[12] Stock Price Indices (respectively, CCSPI and CSSPI) are calculated on the basis of daily data as

$$\mathrm{CXSPI}_t = \sum_{j=1}^{m} \mathrm{SPI}_{j,t} \mathrm{W}_j$$

Where
- CXSPI is either CCSPI or CSSPI
- $SPI_{j,t}$ is the composite or sector index of the j^{th} market
- W_j is the weight of each market based on the relative share of total market capitalization in US$

The indices of the exchanges are weighted by their issued share capital and indeed this index is commonly referred to as a market capitalization weighted index. When amalgamated like this, the CCSPI and CSSPI give a picture of all equity price movements across the individual exchanges or the corresponding sectors.

An adjustment for free float market capitalization is taken into account from January 1, 2004 as the requisite historical data are not readily available before that. As an illustration, the time path of the CCSPI for the first 600 days is shown in Figure A below and the composite TTSE index is shown for comparison:

[12] Indices are calculated for the following sectors of the economy: banking, conglomerates, finance and manufacturing.

Figure A

CARICOM and Trinidad & Tobago Composite Stock Price Indices compared