

Rational Speculative Bubbles in the Frontier Emerging Stock Markets

(Gelembung Spekulatif Rasional Dalam Pasaran Saham Baharu Muncul Terkehadapan)

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ABSTRACT

We extend the rational speculative bubbles literature to the frontier emerging stock markets. For this purpose, this paper employs fractional integration tests and duration dependence tests based on the ARFIMA models and nonparametric smoothed hazard functions. Unlike traditional bubble tests, fractional integration tests and duration dependence tests do not show strong evidence of rational speculative bubbles in the frontier emerging stock markets.

Keywords: Rational speculative bubbles; frontier emerging stock markets; fractional integration tests; duration dependence tests

ABSTRAK

Kajian ini bertujuan menambah literatur gelembung spekulatif rasional dalam pasaran saham baharu muncul terkehadapan. Justeru, kertas ini menggunakan ujian integrasi pecahan dan ujian kebergantungan durasi berdasarkan model ARFIMA dan fungsi hazard terlicin tak berparameter. Berbeza dengan ujian gelembung tradisi, ujian integrasi pecahan dan ujian kebergantungan durasi tidak menunjukkan dapatan yang kukuh mengenai gelembung spekulatif rasional dalam pasaran saham baharu muncul terkehadapan.

Kata kunci: Gelembung spekulatif rasional; pasaran saham baharu muncul terkehadapan ; ujian integrasi pecahan; ujian kebergantungan durasi.

INTRODUCTION

According to International Finance Corporation (IFC), a member of the World Bank Group, frontier emerging stock markets are relatively small, illiquid, and undeveloped capital markets in different regions of the world. For the rapidly growing frontier emerging stock markets (e.g., Bangladesh, Botswana, Cote d'Ivoire, Ecuador, Ghana, Jamaica, Kenya, Mauritius, and Trinidad and Tobago), the correct detection of rational speculative bubbles is very important in policy-making decisions and international portfolio diversification. For example, Chan, Lee and Woo (2003) explicated that if rational bubbles are not present, then it is only necessary to take control of the market fundamentals. If, however, inflation is being driven by a bubble phenomenon, then positive action is needed to shock expectations from the bubble path.

Unfortunately, however, information on the frontier emerging markets to international and domestic investors who are seeking portfolio diversification for hedging purposes is generally less available than in other financial markets. Even worse, previous researches on

empirical tests to detect rational speculative bubbles concentrating on developed and emerging stock markets remain inconclusive. Therefore, although it might be a demanding task, reliable results of bubble tests of the frontier emerging stock markets can provide domestic and international investors as well as policy makers with invaluable benchmark to better understand the irregular and highly fluctuating stock market behaviors of the frontier emerging markets compared to other developed and emerging stock markets.

To the best of our knowledge, none of the previous studies has concentrated on rational speculative bubbles in the unfledged frontier emerging stock markets. Therefore, we extend the rational speculative bubbles literature to the frontier emerging stock markets using fractional integration tests and duration dependence test¹.

Koustantas and Serletis (2005) indicated that the notion of fractional integration allows more flexible modeling of the low frequency dynamics of stock prices, dividends, and their equilibrium relationship, while allowing significant deviations from equilibrium in the short run. Therefore, we checked the log dividend yields for a



fractional exponent in the differencing process based on ARFIMA models since the unit-root and cointegration tests allow for only integer orders of integration. In addition, many financial researchers have supported the duration dependence tests proposed by McQueen and Thorley (1994) in many distinct academic contexts (See Cameron & Hall 2003; Tudela 2004).

To complement and overcome shortcomings of the traditional bubble tests which mainly rely on expectations of future streams of dividends, we used hazard functions² to investigate duration dependence in runs of positive excess returns of the frontier emerging stock markets. On the other hand, traditional time series approaches for bubble detections provide no information concerning the probability that a run will end or that deviations from the mean will be completely dissipated although they can be useful in identifying mean-reverting components in monthly returns of the frontier emerging stock markets (Cochran & Defina 1996).

In the following, we summarize the main empirical results. Although frontier emerging stock markets have recently experienced extreme fluctuations, we did not find any strong evidence of rational speculative bubbles for the perspectives of both local and U.S. investors. Unlike traditional bubble tests, the fractional integration tests based on ARFIMA models do not support the possibility of bubbles in the frontier emerging stock markets. Similarly, the duration dependence tests based on nonparametric Nelson-Aalen (1978) hazard functions strongly reject the existence of bubbles. In addition, it appears that both local and U.S. investors do not observe rational speculative bubbles in the frontier emerging stock markets; and hazard functions are not affected by different currency denominations, evidenced by the statistically identical hazard functions across them.

REVIEW OF THE LITERATURE

PRESENCE OF RATIONAL SPECULATIVE BUBBLES

Although many financial economists have proposed different categories of formal econometric tests to detect rational speculative bubbles, the evidence of rational speculative bubbles is still mixed and has been in a longstanding disagreement for both developed and emerging stock markets. McQueen and Thorley (1994) rejected the no-bubble hypothesis based on duration dependence tests and found significant evidence of a negative hazard function in runs of positive abnormal returns for the equally-weighted portfolios of NYSE stocks. Ahmed, Rosser and Uppal (1999) found the evidence of nonlinear speculative bubbles in Pacific-Rim stock markets. They rejected the absence of trends which can be interpreted as speculative and they also rejected the absence of nonlinearities beyond ARCH effects in the residual series for all countries. Binswanger (2004)

also supported the 'bubble hypothesis' using a bivariate structural VAR model which includes growth rates of industrial production and stock prices. Cuñado, Gil-Alana and Perez de Gracia (2005) tested the presence of rational bubbles in the NASDAQ stock market index by means of a methodology based on fractional processes. They could not reject the unit root hypothesis when using monthly data on price-dividend ratios even though the existence of bubbles depends on the sampling frequency used in the analysis.

NON-EXISTENCE OF RATIONAL SPECULATIVE BUBBLES

On the other hand, the majority of studies do not support the existence of rational speculative bubbles in stock markets despite the frequent appearance of bubbles from popular financial press articles. For example, using duration dependence tests, Chan & McQueen (1998) confirmed that none of the U.S., Japan and Hong Kong, and four emerging stock markets (Korea, Malaysia, Taiwan and Thailand) is consistent with the theoretical prediction of rational speculative bubbles model, which conflict with those of McQueen and Thorley (1994) for U.S. stock markets. Koustas and Serletis (2005) yielded robust rejection of the null hypothesis of rational bubbles based on fractional integration tests. They concluded that a fractionally integrated dividend yield is inconsistent with rational bubbles in stock market prices.

THE FRONTIER EMERGING STOCK MARKETS DATA AND BUBBLE TESTS

DATA AND SUMMARY STATISTICS

We collected monthly³ S&P Global (S&P/IFCG) price index levels⁴ in local currency and U.S. dollar terms, market capitalizations, and dividend yields from 1996:01 to 2003:03 from EMDB (Emerging Markets Data Base) for the 9 frontier emerging stock markets (Bangladesh, Botswana, Cote d'Ivoire, Ecuador, Ghana, Jamaica, Kenya, Mauritius, and Trinidad and Tobago). We report summary statistics in Table 1 for the 9 frontier emerging markets (FM) monthly index returns in local currency along with those of FM composites as a benchmark to take a look at overall distinct patterns of the frontier emerging stock markets.⁵ As expected, during our sample periods (1996:01 – 2003:03), most of the frontier emerging markets experienced severe stock markets fluctuations compared to those of developed stock markets. Among them, Bangladesh is somewhat extreme, evidenced by 14.28% of standard deviation. For Bangladesh, maximum and minimum monthly returns are 90.65% and -30.15%, respectively. As a benchmark, FM composite index returns show 3.09% of standard deviation and 13.04% (maximum) and -6.48% (minimum). We also observed

TABLE 1. Summary statistics of the frontier emerging stock markets index returns

Countries	Mean	Med.	Max.	Min.	S.D.	Skew.	Kurt.	Jarque-Bera	$Q(12)$
Bangladesh	0.0025	-0.0128	0.9065	-0.3015	0.1427	3.2108	20.8708	1307.18 [0.0000]	0.0440 [0.0360]
Botswana	0.0256	0.0120	0.4390	-0.0957	0.0679	2.8946	17.5008	883.73 [0.0000]	0.0480 [0.8600]
Cote d'Ivoire	0.0026	-0.0020	0.1496	-0.1780	0.0545	0.2983	4.2112	6.61 [0.0367]	0.1850 [0.8140]
Ecuador	0.0174	0.0063	0.5590	-0.2824	0.0993	2.6000	15.1976	637.35 [0.0000]	0.0290 [0.5510]
Ghana	0.0078	0.0028	0.2414	-0.0980	0.0490	1.5418	9.5443	189.72 [0.0000]	-0.0520 [0.6210]
Jamaica	0.0169	0.0010	0.4377	-0.1286	0.0932	2.5546	11.8550	378.87 [0.0000]	-0.0390 [0.9590]
Kenya	0.0045	-0.0098	0.2290	-0.1262	0.0627	1.2526	5.5102	45.59 [0.0000]	0.1410 [0.2450]
Mauritius	0.0045	0.0030	0.1768	-0.1071	0.0445	1.0878	6.2438	55.30 [0.0000]	-0.0510 [0.8340]
Trinidad and Tobago	0.0177	0.0119	0.1659	-0.0776	0.0407	1.2640	6.0097	56.00 [0.0000]	-0.2180 [0.0000]
FM Composite	-0.0006	-0.0041	0.1304	-0.0648	0.0309	0.9471	5.6354	38.18 [0.0000]	-0.0130 [0.1330]

This table describes summary statistics of the 9 frontier emerging stock market (FM) monthly index returns and FM composites as a benchmark. Sample periods cover from 1996:01 to 2003:03. The $Q(12)$ is the Ljung-Box portmanteau test statistic for 12 autocorrelations. The p -values are reported in square brackets.

that monthly frontier emerging stock markets returns are far from normally distributed with positive skewness and leptokurtosis, confirmed by significant Jarque-Bera statistics.

We also illustrate time series plots of the monthly index levels and box-and-whisker plots of the monthly index returns in Figure 1. In particular, Figure 1B allows us to explore maximum, minimum, median, upper/lower quartiles, and near/far outliers in the monthly index returns of the 9 frontier emerging stock markets. Although some of countries show strong trends and outliers in their time-series patterns (Figure 1A), they might be the result of temporary or spurious shocks not directly related with bubbles. Therefore, we should be equipped with further formal econometric tests to detect the existence of bubbles in those rapidly growing frontier emerging stock markets for various practical and academic reasons such as investments, portfolio diversifications, risk managements, and monetary policy and regulation purposes. In addition, the bubble detection is important to examine co-movement dynamics of frontier stock markets (Kiviahio, Nikkinen & Piljak 2014) and investor herds and regime-switching (Balcilar, Demirer & Hammoudeh 2013).

THE FORMAL ECONOMETRIC TESTS TO DETECT RATIONAL SPECULATIVE BUBBLES

FRACTIONAL INTEGRATION TESTS

Most previous studies have applied bubble tests for integer orders of integration to the log dividend yield or have tested for integer cointegration between stock

dividends and prices. However, the fractionally-integrated autoregressive-moving average model, denoted ARFIMA (p, d, q), can be used for bubble detection of a univariate time series of log (dividend yields). The more familiar ARMA (or 'Box-Jenkins') models (when $d = 0$) or ARIMA (when d is a positive integer) are special cases. Therefore, fractionally integrated long memory processes are different from both stationary, $I(0)$, and unit-root processes, $I(1)$, in that they are persistent but are also mean reverting. With a fractional integration parameter d , the ARFIMA (p, d, q) is written as

$$\Phi(L)(1-L)^d(y_t - \mu_t) = (L)\varepsilon_t \quad (1)$$

where μ_t is the mean of y_t and L is the lag operator, $L^k y_t = y_{t-k}$, $\Phi(L) = 1 - \sum_{i=1}^p \phi_i L^i$ and $\Theta(L) = 1 + \sum_{i=1}^q \theta_i L^i$ represents stationary autoregressive and moving average polynomial in the lag operation L . The p and q are integers, but d is real values, respectively. The ARMA part of the model is also assumed invertible and stationary, which means that all roots of $\Phi(L) = 1$ and $\Theta(L) = 0$ are outside the unit circle.

The traditional bubble tests, such as unit-root and cointegration tests, allow for only integer orders of integration. To avoid this shortcoming, we checked the log dividend yields⁶ for a fractional exponent in the differencing process using the Exact Maximum Likelihood (EML). The standard errors are calculated by the inverse of the Hessian, estimated by Broyden, Fletcher, Goldfarb, and Shanno (BFGS) algorithm (Refer to Koustas & Serletis (2005) for further technical details). If rational speculative bubbles are present in the frontier emerging stock markets, the fractional integrating parameter of log dividend yields, d , should not be statistically equal to zero.

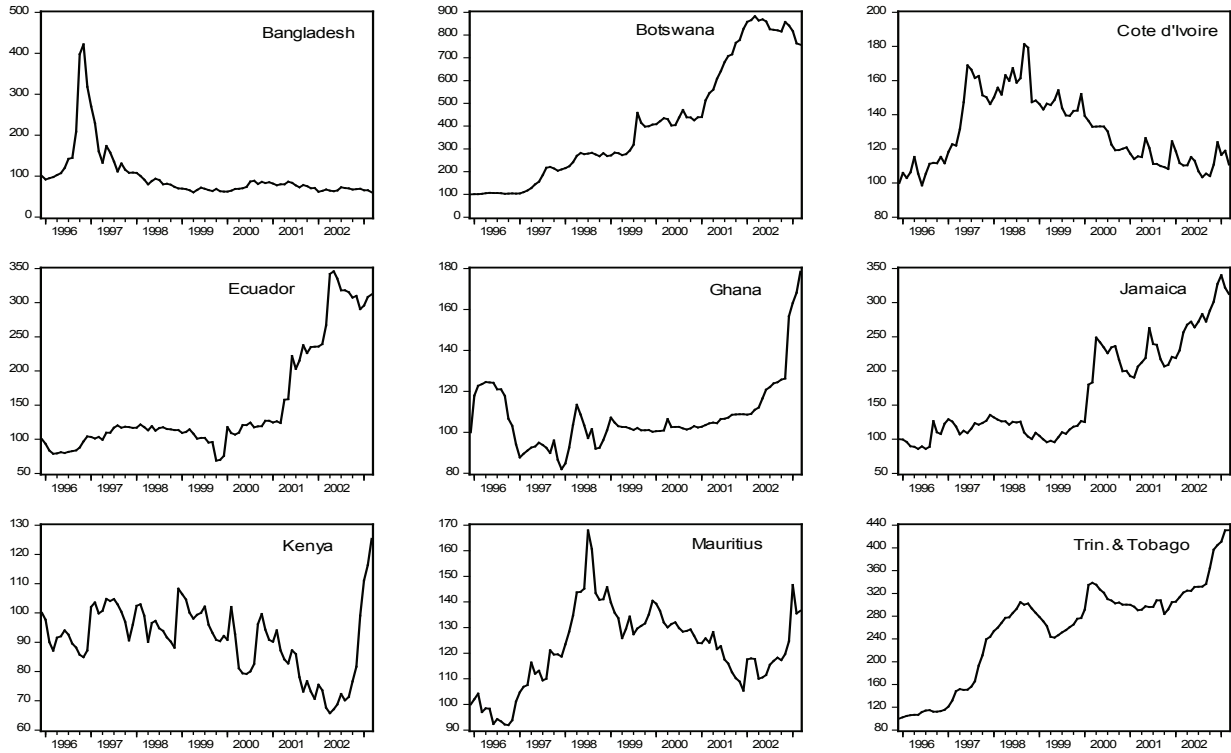


FIGURE 1A. Time series plots of the monthly index levels

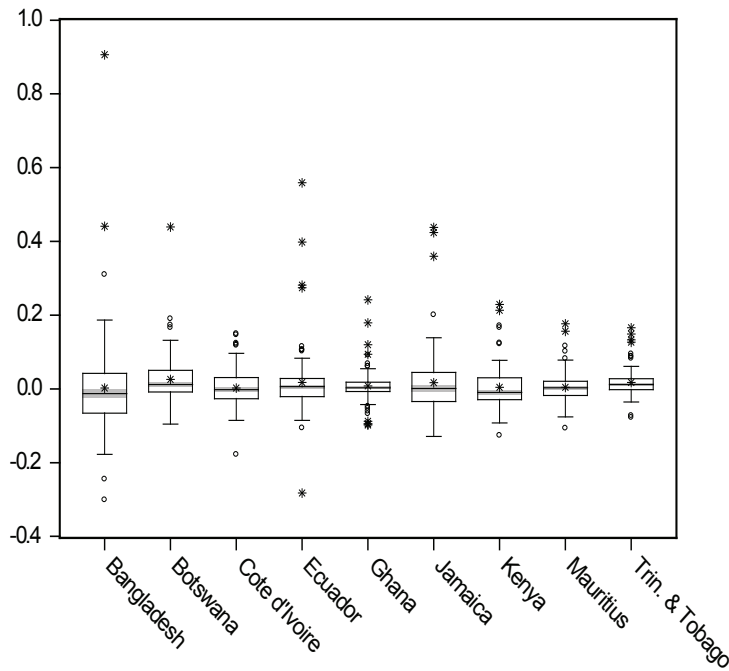


FIGURE 1B. Box-and-whisker plots of the monthly index returns

FIGURE 1. Market movements of the frontier emerging stock markets. The Figure 1A shows the time series plots of the monthly S&P Global (S&P/IFCG) price index levels in local currency for the 9 frontier emerging stock markets from 1996:01 to 2003:03. S&P Global Index reflects adjusted share price changes and represents stock market performance without taking into account of restrictions on foreign investors from the domestic investor perspective. The Figure 1B illustrates box-and-whisker plots, explore maximum, minimum, median, upper/lower quartiles, and near/far outliers in the monthly index returns of the 9 frontier emerging stock markets from 1996:01 to 2003:03.

DURATION DEPENDENCE TESTS OF MONTHLY EXCESS POSITIVE RETURNS

Most previous researches preferred fitting parametric hazard functions based on log-logistic, Weibull, and Gompertz regressions (for example, see McQueen & Thorley 1994; Chan, McQueen & Thorley 1998). However, we performed the bubble tests by plotting an estimate of the hazard function, $h(t)$, by taking the steps of the Nelson-Aalen cumulative hazard and smoothing them with a Gaussian kernel smoother as in Figure 2, rather than by directly estimating parameterized hazard functions to consider the relative small sample sizes of the frontier emerging stock markets.

We have relative small size of samples to fit parametric hazard functions. Therefore, we plotted nonparametric smoothed hazard functions to obtain the robust empirical results of duration dependence tests. This is because nonparametric smoothed hazard functions have much better small-sample properties and are more intuitive to interpret whether hazard functions is decreasing or increasing. The estimated hazard is calculated as a kernel smooth of the estimated hazard contributions as obtained by sample hazard rates (For economic interpretations of generalized duration models, hazard functions, and their coefficients, see Narendranathan & Steward 1993; Cleves, Gould & Roberto 2004).

The cumulative Nelson-Aalen estimator is defined as

$$H(t) = \int_0^t h(u)du \quad (2)$$

where $h(\cdot)$ is the hazard function. The following nonparametric Nelson-Aalen estimator of cumulative hazard function, $\hat{H}(t)$, has much better small-sample properties than corresponding parameterized ones.

$$\hat{H}(t) = \sum_{j|t_j \leq t} \frac{d_j}{n_j} \quad (3)$$

where n_j is the number at risk at time t_j , d_j is the number of failures at time t_j , and the sum is over all distinct failure times less than or equal to t . For each observed run ends time t_j , the estimated hazard contribution, $\Delta\hat{H}(t_j)$, can be obtained by

$$\Delta\hat{H}(t_j) = \hat{H}(t_j) - \hat{H}(t_{j-1}) \quad (4)$$

Therefore, we can estimate the hazard functions with

$$\hat{h}(t) = b^{-1} \sum_{j=1}^D K\left(\frac{t-t_j}{b}\right) \Delta\hat{H}(t_j) \quad (5)$$

for some symmetric Gaussian density function (the kernel) and bandwidth b , the summation is over the D times at which run ends occur.

In any case, the null hypothesis (H_0) of no duration dependence implies that the probability of a run ending is independent of the prior returns or that positive and negative abnormal returns are random. The alternative hypothesis (H_1) of duration dependence suggests that the probability of a positive run ending should have a

decreasing function of the run length. If there are rational speculative bubbles in the frontier emerging stock markets, we should be able to observe negative duration dependence represented by monotonically decreasing hazard functions (See McQueen and Thorley 1994; Chan et al. 1998). Therefore, if rational speculative bubbles are detected, the sample hazard rates⁷ should decrease as the run length increases.

DO RATIONAL SPECULATIVE BUBBLES EXIST IN THE FRONTIER EMERGING MARKETS?

PRELIMINARY ANALYSIS

Since rational speculative bubbles must be persistent to survive several months or years until market crashes, we should observe statistically significant positive autocorrelations, skewness, and leptokurtosis due to excess returns during bubble periods if bubbles exist in the frontier emerging markets. In our study, although summary statistics showed excess kurtosis and positive skewness, as evidenced by significant Jarque-Bera statistics, many other factors that are not directly related with bubbles can affect market returns. Therefore, much care should be taken to associate higher moments of market returns with the possibility of rational speculative bubbles. Unlike normality tests, most frontier emerging stock markets do not show significant positive autocorrelations, except for Bangladesh and Trinidad and Tobago, based on the Ljung-Box Portmanteau tests statistics for 12 autocorrelations, $Q(12)$, supporting no bubbles to some degree in the frontier emerging stock markets.

However, the results of these autocorrelation tests question whether the frontier emerging stock markets really experienced rational speculative bubbles during our sample periods even though they suffered a lot of extreme positive or negative monthly returns. As Koustas and Serletis (2005) insightfully point out, rational speculative bubbles must be continually expanding and persistent in order to survive since stock buyers will pay a price higher than that suggested by the fundamentals if they believe that someone else will subsequently pay an even higher price. Therefore, statistically significant positive autocorrelations among monthly returns are simply prerequisite for rational speculative bubbles to be present in the frontier emerging stock markets.

FRACTIONAL INTEGRATION TESTS

The Table 2 reports the estimation results of fractional integration tests via exact maximum likelihood (EML) methods. We also tested whether fractional integrating parameter (\hat{d}) is statistically 0 (no unit root) or 1 (unit root) by performing linear restriction tests. The parameters, $\hat{\phi}$, are the estimators of the first order

TABLE 2. Fractional integration tests for dividend yields of the frontier emerging markets

Countries	Parameters		Tests for linear restriction		Residual tests for model adequacy		
	\hat{d}	\hat{f}	$\hat{d}=0$	$\hat{d}=1$	Normality	ARCH	Portmanteau
Bangladesh	0.1119 [0.3900]	0.9295 [0.0000]	0.7468 [0.3875]	47.0382 [0.0000]	29.1610 [0.0000]	5.9408 [0.0170]	22.7430 [0.9293]
Botswana	0.4567 [0.0000]	0.0320 [0.8260]	61.4769 [0.0000]	86.9621 [0.0000]	78.5970 [0.0000]	30.0710 [0.0000]	39.3900 [0.2414]
Cote d'Ivoire	-0.0933 [0.4030]	0.9359 [0.0000]	0.7066 [0.4005]	96.9304 [0.0000]	14.4530 [0.0007]	0.1987 [0.6570]	33.2270 [0.5053]
Ecuador	0.2166 [0.3930]	0.1298 [0.6730]	0.7379 [0.3903]	9.6432 [0.0019]	43.8410 [0.0000]	1.5069 [0.2232]	42.3860 [0.1532]
Ghana	0.3515 [0.0050]	-0.1172 [0.4750]	8.4966 [0.0036]	28.9052 [0.0000]	70.6850 [0.0000]	1.7172 [0.1938]	14.4910 [0.9986]
Jamaica	0.0563 [0.7150]	0.7377 [0.0000]	0.1338 [0.7145]	37.5557 [0.0000]	4.2423 [0.1199]	1.6079 [0.2084]	38.2320 [0.2832]
Kenya	0.4099 [0.0000]	-0.0173 [0.9070]	20.8075 [0.0000]	43.0915 [0.0000]	35.0700 [0.0000]	0.5617 [0.4557]	17.2410 [0.9925]
Mauritius	-0.0350 [0.6440]	0.9878 [0.0000]	0.2156 [0.6424]	87.9570 [0.0000]	80.1040 [0.0000]	14.3710 [0.0003]	30.0820 [0.6602]
Trinidad and Tobago	0.2244 [0.1510]	0.0642 [0.7470]	2.1015 [0.1472]	25.0968 [0.0000]	87.8850 [0.0000]	1.6157 [0.2073]	6.2248 [1.0000]

The table reports the estimation results of fractional integration tests via exact maximum likelihood (EML) methods. We also test if fractional integrating parameter (\hat{d}) is statistically 0 (no unit root) or 1 (unit root) by performing linear restriction tests. The parameters, $\hat{\phi}$, are the estimators of the first order autoregressive (AR(1)) processes in ARFIMA (1, d , 0) models. To check model adequacy, we also tabulate residual tests for normality, ARCH effects, and serial correlations (Portmanteau tests) in last columns. The p -values are reported in square brackets.

autoregressive processes, AR(1), in ARFIMA (1, d , 0) models. To check model adequacy, we also tabulate the residual tests for normality, ARCH effects, and serial correlations (Portmanteau tests) in last the columns of Table 2 along with the p -values in square brackets.

Unlike previous traditional studies that tested for integer orders of integration⁸, our analysis results showed robust rejections of unit roots in the log dividend yields and did not revealed any statistically significant evidence of rational speculative bubbles for all of the 9 frontier emerging stock market. Therefore, the log dividend yields are fractionally integrated processes for Botswana, Ghana, and Kenya, which do not comply with rational speculative bubbles. The remaining 6 frontier emerging stock markets also revealed no bubbles based on ARFIMA approaches, implying stationarity of log dividend yields.

In recent study, Koustas and Serletis (2005) also reported similar empirical findings as ours using S&P 500 log dividend yields in that they also found the possibility of bubbles based on unit root tests, but they rejected null hypothesis of bubbles based on ARFIMA methods. As shown in Koustas and Serletis (2005), fractional integration tests are robust to the choice of parametric estimator of the fractional differencing parameter and

data frequency, and bootstrap inference fully supports the estimation results. Therefore, our results of the fractional integration tests are inconsistent with rational speculative bubbles in the frontier emerging stock markets.

Residual test results for model adequacy are reported in Table 2. For the entire frontier emerging markets, the null hypothesis of normality of residuals is rejected even after the ARFIMA fitting, which suggests using alternative fatter-tailed distributions such as skewed t -distribution or generalized error distribution (GED) rather than simply assuming normal distributions. For ARCH tests, it is likely that constant volatility assumption is not well-suited to fit residuals in some of frontier emerging stock markets including Bangladesh, Botswana, and Mauritius, which implies time-varying conditional volatility modeling such as GARCH-families. For Portmanteau tests, it is likely that our ARFIMA (1, d , 0) model successfully captures the serial correlations of residuals. However, although further complexity of model setups considering alternative fatter-tailed distributions and GARCH specifications might improve the overall fits of our ARFIMA models, these additional computational efforts may not change our main results of fractional cointegration tests to detect rational speculative bubbles in the frontier emerging stock markets.

DURATION DEPENDENCE TESTS

Table 3 reports the results of duration dependence tests to detect the possibility of rational speculative bubbles. For this purpose, we computed the actual number of positive runs⁹ for monthly positive excess index returns from 1996:01 to 2003:03. Table 4 tests for the equality of hazard functions to investigate whether hazard functions remain the same between local and U.S. investors.

From Figure 2, none of the nonparametric smoothed hazard functions is monotonically decreasing, implying

non-existence of bubbles in the frontier emerging stock markets. We found that for the perspective of local investors, Cote d'Ivoire, Ecuador, Ghana, Jamaica, and Mauritius have upward trends of hazard functions, which are not acceptable if bubbles exist in those markets. Bangladesh, Botswana, Kenya, and Trinidad and Tobago also show distinct patterns which are not completely consistent with bubbles. Similarly, for the perspective of U.S. investors, Botswana, Ecuador, Ghana, Jamaica, and Mauritius generally show increasing hazard functions. In the case of Bangladesh, Cote d'Ivoire, Kenya, and

TABLE 3 Run lengths and run counts for positive runs of monthly excess index returns (1996:01 – 2003:03)

Countries	Run length	Run counts		Countries	Run length	Run counts		Countries	Run length	Run counts	
		Local	U.S.			Local	U.S.			Local	U.S.
Bangladesh	1	8	9	Botswana	1	6	8	Cote d'Ivoire	1	15	14
	2	5	5		2	3	0		2	7	9
	3	1	1		3	1	4		3	2	1
	4	0	0		4	1	1		4		0
	5	0	0		5	0	0		5		1
	6	0	0		6	0	0				
	7	1	1		7	2	1				
	8	0	0		8		1				
	9	0	0								
	10	1	1								
Ecuador	1	13	13	Ghana	1	10	10	Jamaica	1	8	9
	2	6	3		2	2	2		2	6	6
	3	1	2		3	2	0		3	3	3
	4		2		4	2	3		4	2	1
	5		0		5	0	0				
	6		1		6	1	1				
	7		1				1				
Kenya	1	8	10	Mauritius	1	9	9	Trinidad and Tobago	1	7	8
	2	2	1		2	5	2		2	5	4
	3	5	4		3	1	1		3	2	2
	4	1	1		4	2	1		4	0	1
	5	0	0		5	1	2		5	1	0
	6	0	0		6	1	0		6	0	0
	7	1	1				1		7	0	0
									8	0	0
									9	0	0
									10	1	1

This table reports the results of duration dependence tests to detect the possibility of rational speculative bubbles. For this purpose, we compute the actual number of positive runs for monthly positive excess index returns from 1996:01 to 2003:03. A run is defined as a sequence of excess returns of the same sign.

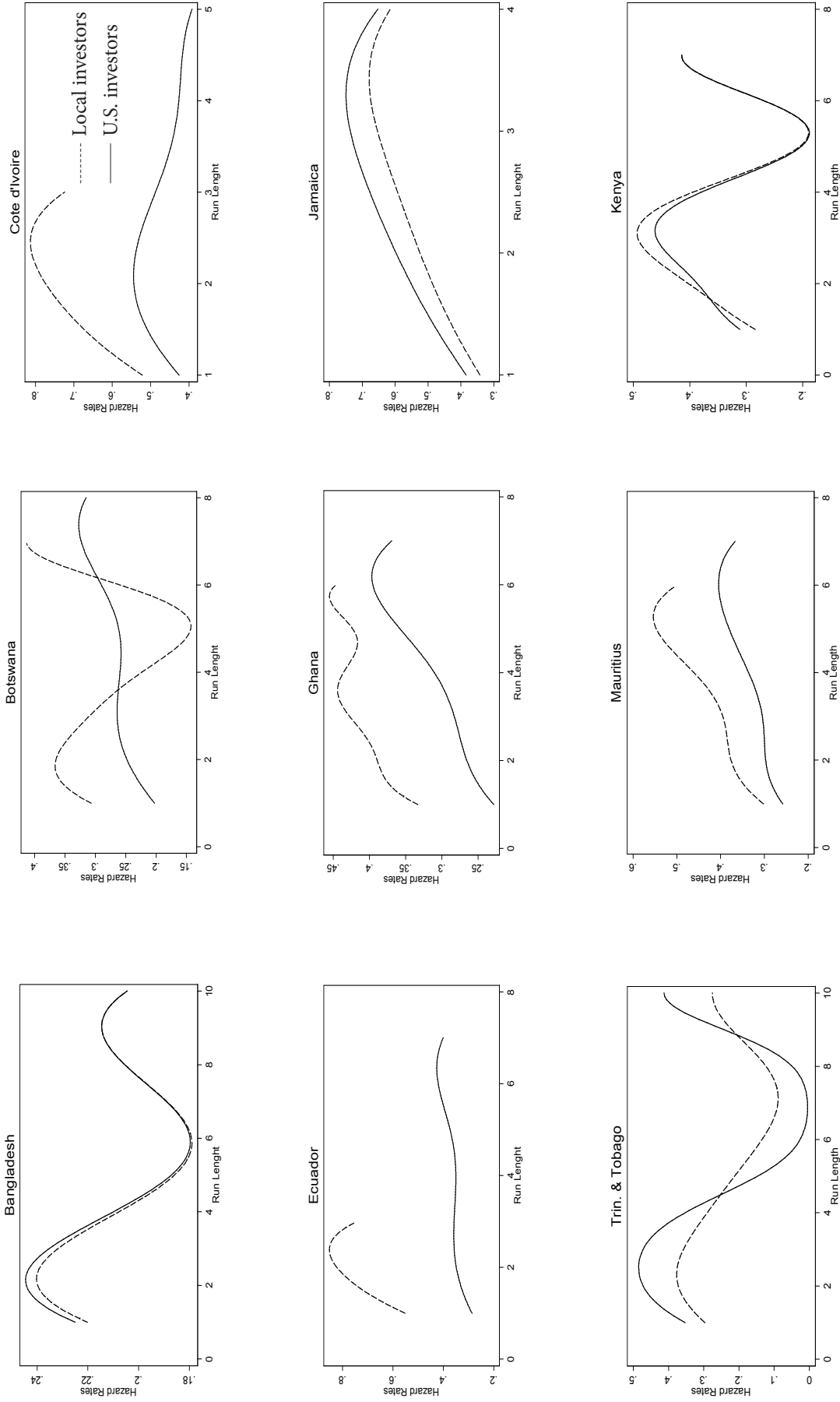


FIGURE 2. Nonparametric smoothed hazard functions. The graphs plot the estimates of the nonparametric hazard functions, h_i , by taking the steps of the nonparametric Nelson-Aalen cumulative hazard and smoothing them with a Gaussian normal kernel functions. The estimated hazard is calculated as a kernel smooth of the estimated hazard contributions as obtained by sample hazard rates. In nonparametric smoothed hazard functions, dotted (solid) lines represent hazard rates for domestic (U.S.) investors, respectively.

TABLE 4. Tests for equality of hazard functions

Countries	Tests for equality of hazard functions between local and U.S. investors				
	Log-rank	Wilcoxon-Breslow-Gehan	Tarone-Ware	Peto-Peto	Cox
Bangladesh	0.02 [0.9018]	0.02 [0.8750]	0.02 [0.8832]	0.03 [0.8740]	0.9710 [0.9330]
Botswana	0.12 [0.7260]	0.00 [1.0000]	0.02 [0.8813]	0.06 [0.8043]	1.1077 [0.7910]
Cote d'Ivoire	0.29 [0.5885]	0.18 [0.6710]	0.19 [0.6591]	0.21 [0.6496]	1.0958 [0.7510]
Ecuador	2.78 [0.0956]	0.84 [0.3602]	1.52 [0.2171]	1.11 [0.2919]	1.4280 [0.2820]
Ghana	0.52 [0.4692]	0.05 [0.8167]	0.18 [0.6696]	0.17 [0.6819]	1.1963 [0.6090]
Jamaica	0.29 [0.5901]	0.19 [0.6628]	0.23 [0.6296]	0.18 [0.6748]	0.8879 [0.7150]
Kenya	0.07 [0.7870]	0.26 [0.6110]	0.17 [0.6803]	0.18 [0.6707]	0.9390 [0.8550]
Mauritius	0.17 [0.6802]	0.02 [0.8863]	0.01 [0.9424]	0.00 [0.9794]	1.1153 [0.7530]
Trinidad and Tobago	0.04 [0.8337]	0.07 [0.7937]	0.06 [0.8111]	0.08 [0.7774]	0.9473 [0.8790]

We test for equality of hazard functions between local and U.S. investors to investigate whether hazard functions are affected by different currency denominations.

Trinidad and Tobago, nonparametric smoothed hazard functions initially increase then decrease. Therefore, we confirmed that the results of duration dependence tests do not support rational speculative bubbles in the frontier emerging stock markets although hazard functions between local and U.S. investors remain equal based on all of log-rank, Wilcoxon-Breslow-Gehan (1970), Tarone-Ware (1977), Peto-Peto (1972), and Cox (1972) tests in Table 4.

FURTHER JUSTIFICATIONS ON THE RESULTS ON BUBBLE TESTS

Many researchers have reported that it is very difficult to precisely detect bubbles using traditional econometric tests especially in small samples (see Gurkaynak 2005). Taylor and Peel (1998) also pointed out that although

rational speculative bubbles imply non-cointegration of index or stock prices and dividends, the traditional cointegration tests are subjected to size distortion or specification error especially in small samples. Due to these undesirable properties of cointegration tests, they applied the robust non-cointegration test with much smaller size distortion and good power characteristics to a long run of U.S. real stock price and dividend data, then rejected the bubbles hypothesis on U.S. data.

Using S&P 500 log dividend yields, Koustas and Serletis (2005) showed that ADF and PP unit-root tests are unable to reject a unit root in the price-dividend ratios (dividend yields); which suggests the lack of cointegrating relationship between stock prices and dividends. Our results are also consistent with Taylor and Peel (1998), Gurkaynak (2005), and Koustas and Serletis (2005) in that we are exposed to size distortion

TABLE 5. Regime-switching of dividends in the frontier emerging markets

	Bangladesh	Botswana	Cote d'Ivoire	Ecuador	Ghana	Jamaica	Kenya	Mauritius	Trinidad and Tobago
μ_1	-0.0016 [0.1848]	0.0056 [0.0079]	0.0015 [0.1207]	0.0095 [0.0324]	0.0014 [0.3781]	0.0115 [0.0000]	0.0004 [0.4541]	0.0009 [0.2819]	0.0056 [0.0079]
μ_2	0.0286 [0.0965]	0.0368 [0.2555]	-0.0091 [0.2412]	0.4665 [0.1129]	0.0996 [0.1690]	0.0037 [0.3570]	0.0249 [0.3890]	0.0121 [0.1118]	0.0368 [0.2555]
σ_1	0.0134 [0.0000]	0.0177 [0.0000]	0.0065 [0.0000]	0.0398 [0.0000]	0.0368 [0.0000]	0.0101 [0.0001]	0.0270 [0.0000]	0.0100 [0.0000]	0.0177 [0.0000]
σ_2	0.0811 [0.0000]	0.2373 [0.0000]	0.0810 [0.0000]	0.1715 [0.0000]	0.4111 [0.0000]	0.0722 [0.0000]	0.3312 [0.0000]	0.0486 [0.0000]	0.2373 [0.0000]
p_{12}	0.1289 [0.0100]	0.1346 [0.0076]	0.3965 [0.0000]	0.1800 [0.0001]	0.1020 [0.0117]	0.7292 [0.0000]	0.0370 [0.0882]	0.2514 [0.0019]	0.1346 [0.0076]
p_{21}	0.6116 [0.0002]	0.8053 [0.0001]	0.4372 [0.0013]	0.7295 [0.0000]	0.6072 [0.0002]	0.3913 [0.0014]	0.2940 [0.0293]	0.6446 [0.0000]	0.8053 [0.0001]

The table shows the results of regime-switching of dividends in the frontier emerging stock markets. The unknown parameters, ($\mu_1, \mu_2, \sigma_1, \sigma_2, p_{12}, p_{21}$), can be estimated using maximum likelihood via Kalman filter and the standard errors (S.E.) are retrieved by inverting the Hessian matrix.

of relatively small sample sizes in the frontier emerging stock markets. If only a few traditional bubble tests like many other previous papers are relied upon to achieve consistent results, we may jump to biased conclusions.

Since low statistical power of traditional bubble tests tends to bring biased results, we also investigated whether there have been regime changes¹⁰ in the frontier emerging stock markets in Table 5 to test for the existence of rational speculative bubbles. If regime changes play an important role in deviation between indexes and dividends in the frontier stock markets, the statistical evidence of bubbles based on traditional tests should be interpreted as shift in the fundamental price resulting from a change of regime as in Driffill and Sola (1998).

Suppose the unobservable state variable is S_t , then the Markov (1998) two-state process would be represented by

$$\begin{aligned}
 p_{11} &= pr[S_t = 1|S_{t-1} = 1] \\
 p_{12} &= 1 - p_{11} = pr[S_t = 2|S_{t-1} = 1] \\
 p_{22} &= pr[S_t = 2|S_{t-1} = 2] \\
 p_{21} &= 1 - p_{22} = pr[S_t = 1|S_{t-1} = 2]
 \end{aligned}
 \tag{6}$$

Thus, p_{11} is the probability that dividends in the frontier emerging markets, which are currently in regime-1, will remain in regime-1. In a two-regime specification (high and low dividends regimes), the unknown parameters, ($\mu_1, \mu_2, \sigma_1, \sigma_2, p_{12}, p_{21}$), can be estimated using maximum likelihood via Kalman filter and the standard errors are retrieved by inverting the Hessian matrix.

From Table 5, all of p_{12} and p_{21} are statistically significant in the frontier emerging stock markets except p_{12} of Kenya, implying that dividends that are currently of a low dividends regime will move to a high dividends

regime in next period, and vice versa. Therefore, we found that dividends do not remain in the same regimes over time and regime-switching of dividends provides a better explanation for indexes than rational speculative bubbles in the frontier emerging stock markets.

CONCLUSION

This paper extended the speculative bubble literature to the frontier emerging stock markets. It is well established that traditional bubble tests have shortcomings of low statistical power and small sample biases. To overcome these weaknesses, this paper has employed fractional integration techniques and duration dependence tests based on the ARFIMA models and nonparametric smoothed hazard functions in the frontier emerging stock markets. In addition, the strong possibility of regime-switching of dividends also supports our empirical results of fractional integration tests and duration dependence tests which do not show the evidence of the speculative bubbles in the frontier emerging stock markets.

Since the most frontier emerging markets are recent entrants to the global capital markets, it is important to analyze their market behavior including rational speculative bubbles in these markets to help international and domestic investors in their portfolio decisions and hedging purposes. These results of bubble tests will be also helpful to policymakers in these countries to take actions as to improve the functioning of these markets.

ENDNOTES

1 We also performed traditional bubble tests, including cointegration tests, unit root tests, and variance ratio tests

- for comparison. We believe that traditional bubble tests can still be valuable at understanding the undiscovered behavior of frontier emerging stock markets (For comprehensive survey on the traditional econometric tests of asset price bubbles, refer to Gürkaynak, 2005).
- 2 Hazard functions are appropriate to examine duration dependence since they specify the probability that a particular state will end conditional on the time which has been spent in the state.
 - 3 EMDB only provides monthly data for frontier emerging markets due to the illiquidity of their stock markets. However, previous bubble studies seldom used high-frequency daily data for bubble tests to simply increase sample sizes because bubbles should last over several months or years until market crashes. We also computed simple returns rather than continuous compound returns obtained by log differences since our frontier emerging markets data frequency are monthly. We limit the sample periods from 1996:01 to 2003:03 due to the EMDB license.
 - 4 S&P Global Index reflects adjusted share price changes and represents stock market performance without taking into account of restrictions on foreign investors from the domestic investor perspective.
 - 5 To save the space, we do not report summary statistics and box-and-whisker plots in Figure 1 for the U.S. dollar-denominated index returns. We found that the dollar-denominated index returns resemble those in local currency in that most common market characteristics, such as standard deviations, Jarque-Bera statistics, and autocorrelations, are very close to each other. The more detailed results are available upon requests.
 - 6 In EMDB, dividend yields (%) are defined as total cash dividends paid as a percent of market capitalization at the end of the period.
 - 7 The sample hazard rates, $\hat{h}_i = N_i / (M_i + N_i)$, represents the conditional probability that a run ends at i , given that it lasts until i , where N_i is the count of runs of length i and M_i is the count of runs with a length greater than i .
 - 8 Although this study also performed traditional bubble tests based on cointegration tests, unit root tests, and variance ratio tests for comparison, tables on traditional bubble tests are not reported as to conserve the space. In general, traditional bubble tests supported the existence of bubbles due to a very low statistical power to reject the null hypothesis of rational speculative bubbles, stemming perhaps from small sample sizes of the frontier emerging stock markets or an indication of regime-switching of dividends. The detailed estimations results can be provided upon request.
 - 9 A run is defined as a sequence of excess returns of the same sign.
 - 10 We will assume the true parameters are constant within any regime, but they are different in different regimes. The Markov property implies that the probability distribution of an observed variable lying in the interval $\{a, b\}$ depends only on their state at time $t - 1$ and not on any earlier states.

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