TESTING FOR BUBBLES IN HONG KONG STOCK MARKET

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I. INTRODUCTION

In the last decade, most central banks in the developed countries have succeeded in bringing down inflation. Price stability, however, is not necessarily accompanied by financial stability. In particular, the build-up of imbalances in asset markets, reflected in the increased volatility in asset prices, has led to occasional incidents of financial market instability. Since 1980s, the boom-bust cycles in the prices of equity and real estates have been observed in a number of industrialised and developing economies (Borio, Kennedy and Prowse (1994), Borio and Lowe (2002)). In many of these cases, a significant contraction in real economic activity followed the burst of asset price bubbles. For example, many economists attribute the 2001 recession in the United States to the sharp contraction in capital spending after the burst of technology stock bubble in 2000. The significant repercussion of financial market fluctuations on the economy has in turn triggered discussions on the role of central bank policy in handling asset price bubbles.

Views on this issue are diverse. Some argue that a central bank should implement monetary policy to achieve solely macroeconomic goals such as price stability and sustainable economic growth while applying its regulatory, supervisory and lender-of-last resort powers to help ensure financial stability (Bernanke (2002)). Others advocate for a monetary-policy response to cope with asset price bubbles as it is worthwhile in some cases for central banks to take pre-emptive actions against the formation of the bubbles to contain their potentially adverse consequences (Borde and Jeanne (2002), Borio and Lowe (2002), Cecchetti, Genberg, Lipsky and Wadhwani (2000), and International Monetary Fund (2000)).

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Before considering the appropriate policy response of central banks towards asset price bubble formation, a more fundamental issue of the debate is the identification of bubble formation from asset price movement. Conceptually, the bubble is said to exist if the asset price deviates significantly from its sustainable path. However, the sustainable asset price movement is empirically very difficult to identify. To address the issue, this paper focuses on testing for the existence of speculative bubbles using the Hong Kong stock prices as an example. Despite the popular impression that bubbles exist in the stock market, there are very few systematic studies that have applied formal empirical tests on the behaviour of domestic equity prices.[1] In this paper, the price behaviour in the Hong Kong stock market is examined against the various characteristics of bubbles using three different approaches. The results of these tests will provide additional insight on the identification of asset price bubble and thus shed light on the related policy debate. Specifically, if the detection of bubbles is found to be sensitive to the approach used in the test, the implementation of pre-emptive action against their formation in asset markets by policymakers during the bull run will be very difficult if not impossible to justify.

The remainder of the paper is organised as follows: Section II gives a summary of various methods employed in testing for the bubbles; Section III describes the data and the test results. Conclusions are presented in the last section.

II. METHODS FOR TESTING BUBBLES

It has long been recognised that prices of financial assets may be driven by self-fulfilling expectations of speculators instead of the fundamentals. If this happens, prices are said to be driven by a speculative bubble. As a bubble cannot persist indefinitely, it is commonly characterised by a long period of price rise followed by a crash. Given the huge loss in wealth and its consequences on the real economy after the crash, there has been keen interest in detecting the existence of bubbles in the

[1] The only study that we are aware of on testing bubbles in the Hong Kong stock market is Chan, McQueen and Thorley (1998). The work concluded that the characteristics of Hong Kong equity prices did not conform to the predictions of the rational speculative bubbles model.

stock market. In this study, three different approaches from the literature are used in identifying bubbles in the Hong Kong equity market, including the specification test by West (1987), the co-integration test by Diba and Grossman (1988) and the duration dependence test by McQueen and Thorley (1994). These three approaches are chosen due to their emphasis on different aspects of the asset price bubbles.

(1) The Specification Test by West (1987)

The basic idea of this test is to compare two sets of estimates for calculating the expected present discounted value (PDV) of a given stock's dividend stream, with expectations conditional on current and past dividends. One set of the estimates is derived from a pair of equations: the arbitrage equation yielding the discount rate and the equation governing the stochastic (AR) process of the dividends (d_t). The second set of estimates is obtained by regressing the stock price on a suitable set of lagged dividends. These two sets of estimates will be consistent if there are no bubbles but inconsistent if bubbles exist, provided that the bubble is correlated with fundamentals.[2] Under this approach, the bubbles are tested for by checking whether the two sets of estimates are the same apart from sampling error. If these estimates are different, a bubble is said to be detected in the equity market.

According to a standard efficient markets model, the current stock price should be equal to the expected future price plus the dividend, discounted at the required return of the investors (Brealey and Myers (1981)). That is, the stock price is determined by:

$$p_t = \rho \; E(p_{t+1} + d_{t+1}) \mid I_t \qquad (1)$$

where p_t is the real stock price at time t;

ρ is the constant ex ante real discount rate;

d_{t+1} is the real dividend paid at time $t+1$;

I_t is the information common to traders at time t.

[2] The same idea can be applied by replacing d_t with Δd_t if Δd_t follows a AR process.

The stock price given in equation (1) may be solved recursively forward and rewritten as follows:

$$p_t = \sum_{i=1}^{n} \rho^i E(d_{t+i}) \,\big|\, I_t + \rho^n E(p_{t+n}) \,\big|\, I_t \equiv p^* + \rho^n E(p_{t+n}) \,\big|\, I_t \qquad (2)$$

If the transversality condition $\lim_{n\to\infty} \rho^n E(p_{t+n}) \,\big|\, I_t = 0$ fails, there is a family of solutions to equation (1) (Blanchard and Watson (1982)). In fact, any p_t that satisfies

$$p_t = p_t^* + B_t, \qquad E(B_t)\big|I_{t-1} = \rho^{-1} B_{t-1} \qquad (3)$$

is also a solution to equation (1) where B_t is by definition a speculative bubble. The test for the no-bubble null hypothesis is carried out by testing $p_t = p_t^*$ versus $p_t = p_t^* + B_t$.

Specifically, if the Δd_t follows AR(q), West (1987) shows that the two sets of parameters that are needed to calculate the expected PDV of the stock's dividend stream can be represented in the following system of equations.[3]

$$p_t = \rho\,(p_{t+1} + d_{t+1}) + \mu_{t+1} \qquad (4a)$$

$$\Delta d_{t+1} = \mu + \phi_1 \Delta d_t + \ldots + \phi_q \Delta d_{t-q+1} + \upsilon_{t+1} \qquad (4b)$$

$$\Delta p_{t+1} = m + \delta_1 \Delta d_t + \ldots + \delta_q \Delta d_{t-q+1} + \omega_{t+1} \qquad (4c)$$

The parameters in this system are estimated by the GMM method, with the variables on the right-hand side of the dividend equation (4b) as instruments.

Based on the cross-equations restrictions from the formulas of Hansen and Sargent (1981) regarding rational expectation, the relationship between two sets of parameter estimates can be derived. That is, the corresponding constraints for the parameters of the above system, $R(\theta)$, are given as follows:

[3] Two systems are originally proposed for testing for bubble: one is for the case whereby d_t follows AR(q) and the other is applied when Δd_t follows AR(q). As the data series of d_t is non-stationary in Hong Kong, only Δd_t is used in this study.

$$0 = m - [\rho(1-\rho)^{-1}\ \Phi(\rho)^{-1} + \Phi(\rho)^{-1} - 1]\mu$$

$$0 = \delta_j - \left\{ \Phi(\rho)^{-1} \sum_{k=j+1}^{q} \rho^{k-j}\, \phi_k + [\Phi(\rho)^{-1} - 1]\phi_j \right\} \qquad j = 1, \ldots, q-1$$

$$0 = \delta_q - [\Phi(\rho)^{-1} - 1]\, \phi_q$$

where $\hat{\theta}$ is the estimated parameter vector, $\hat{\theta} = (\hat{\rho}, \hat{\mu}, \hat{\phi}_1, \ldots, \hat{\phi}_q, \hat{m}, \hat{\delta}_1, \ldots, \hat{\delta}_q)$,

and $\Phi(\rho)^{-1} = \left[1 - \sum_{i=1}^{q} \rho^i \phi_i\right]^{-1}$.

Under the null hypothesis that there is no bubble, $R(\theta) = 0$. A bubble test statistic (BTS) based on the variance-covariance matrix of the system, V, is derived as follows:

$$\text{Bubble test statistic (BTS)} = R(\hat{\theta})' \left[\left(\frac{\partial R}{\partial \hat{\theta}} \right) V \left(\frac{\partial R}{\partial \hat{\theta}} \right)' \right]^{-1} R(\hat{\theta}) \qquad (5)$$

Under the null hypothesis, the statistic BTS is asymptotically distributed as χ^2_{q+1}. In other words, if the null hypothesis is significantly rejected by the data in the chi-square test, this indicates the presence of bubbles in the stock market.

As there are possible sources of misspecification such as expectational irrationality (Ackley (1983)) and time varying discount rates (Leroy (1984)), four diagnostic checks suggested by West are also followed in this study. These include:

a) the serial correlation of the residuals;
b) the orthogonality between the instrument variables, $\Delta d_t, \ldots, \Delta d_{t-q-1}$ and the residual;
c) the stability of the regression coefficients; and
d) the sensitivity of the model to the number of lags in used for the dividend process.

It should be noted that the power of this bubble test is limited as it requires a detailed specification of the underlying equilibrium model. Rejection of the no-bubble hypothesis may not be due to the existence of bubbles but as a result of the imposition of a wrong model. Although several diagnostic checks have been applied in the study, these are by no means exhaustive. The application of this test should thus be cautioned as the underlying model may be mis-specified.

(2) Co-integration test by Diba and Grossman (1988)

The co-integration test of Diba and Grossman (1988) does not require a detailed specification of the underlying equilibrium model. Under rational expectation assumption, it is shown that:

$$p_t = (1+r)^{-1} E_t(p_{t+1} + \alpha d_{t+1} + \mu_{t+1}) = B_t + F_t \qquad (6)$$

where r is the constant real interest rate;

B_t is the bubble component;

$F_t = \sum_{j=1}^{\infty} (1+r)^{-j} E_t(\alpha d_{t+j} + \mu_{t+j})$ is the market-fundamentals component.

Re-arranging the equation (6) and solving it recursively forward will give:

$$p_t - \alpha r^{-1} d_t = B_t + \alpha r^{-1} \left[\sum_{j=1}^{\infty} (1+r)^{1-j} E_t \Delta d_{t+j} \right] + \sum_{j=1}^{\infty} (1+r)^{-j} E_t \mu_{t+j} \qquad (7)$$

If the levels of unobservable variables μ_{t+j} and Δd_t are stationary, and if bubbles do not exist, then stock prices and dividends are co-integrated with the co-integrating vector $(1, -\alpha r^{-1})$. In other words, if prices and d_t are not co-integrated, bubbles may exist provided other unobservable fundamentals are stationary. This approach is basically checking for the stationarity property of stock prices and fundamentals and any co-integration relationship between them.

Similar to the West's method, this approach has its own limitations when used in detecting the stock market bubbles as the co-integration test results are not conclusive. When stock prices and dividends are not co-integrated, the existence of bubbles is one of the many possible reasons. The non-stationarity property of unobservable variables may also upset the co-integration relationship. In addition, it is found that this test may not detect bubbles that burst partially but successively grow over time.

(3) Duration Dependence Test of McQueen and Thorley (1994)

In a rational speculative bubble framework, stock prices may deviate from their fundamental value as long as rational investors believe that the bubble will continue to expand with a certain probability such that its return is attractive enough to compensate for the potentially larger and larger crashes. As a result, the pattern of excess returns in the market can be used to identify the existence of bubbles. Specifically, a long period of positive excess returns suggests the presence of a bubble. If a bubble already exists in the market, the probability that a run of positive abnormal returns will end should decline with the length of the run. Based on this idea, McQueen and Thorley (1994) developed the duration dependence test for rational speculative bubbles.

In this test, positive or negative excess monthly returns are defined relative to the sample mean, while the excess weekly returns are defined as the residuals of an AR(4) model. The duration dependence test divides excess returns into series of run length where a run is defined as a sequence of excess returns of the same sign with a random length I. Here, I is a positive discrete random variable generated by the density function f_i = Prob($I = i$) and its corresponding cumulative density function $F_i \equiv$ Prob($I < i$). If N_i is the count of completed runs in the sample, then the density version of the log likelihood is:

$$L(\theta \mid S_T) = \sum_{i=1}^{\infty} N_i \ln f_i$$

where θ is a vector of parameters, S_T is a data set which contains T observations on the random run length, I.

Instead of focusing on the unconditional probabilities represented by the density function, a hazard function, h_i = Prob($I = i \mid I \geq i$), which is the probability that a run ends at i given that it lasts at least until i, is introduced. The conditional probabilities given by the hazard function are more appropriate in capturing the relationship between the probability that a run continues and the length of the run in the duration dependence test. The hazard function is related to the density function by:

$$h_i = \frac{f_i}{(1-F_i)} \quad \text{and} \quad f_i = h_i \prod_{j=1}^{i-1}(1-h_j).$$

Using the above relationship, the hazard function version of the log likelihood is:

$$L = \sum_{i=1}^{\infty}\left[N_i \ln h_i + M_i \ln(1-h_i)\right] \qquad (8)$$

where M_i is the number of runs with a length greater than i.

To perform the duration dependence test, a functional form must be chosen for the hazard function h_i. Similar to McDonald, McQueen and Thorley (1993), the log-logistic functional form is chosen here for h_i, where $h_i = (1 + e^{-(\alpha+\beta\ln(i))})^{-1}$. The choice of this log-logistic function allows us to transform the unbounded range of $\alpha + \beta\ln(i)$ into (0, 1) space of h_i, the conditional probability of ending a run.

Under the null hypothesis of no bubbles, the abnormal returns are random and there is no duration dependence. That is, $\beta = 0$. If bubbles exist, the probability of a positive run ending should decrease with the run length, that is, $\beta < 0$ for positive run. Tests are performed by maximising the log likelihood function with respect to α and β. The likelihood ratio test of $\beta = 0$ is asymptotically distributed as χ^2_1.

Like the previous two methods, there are some limitations in applying the duration dependence test for detecting the bubbles. First, the measure of the abnormal return is sensitive to its definition. Despite alternative specifications of abnormal returns are examined in the study, a correct definition is still not warranted. In addition, the selection of the hazard function is also crucial in the test, though the log-logistic functional form is quite common in transforming the unbounded range of a parameter into (0,1) probability space.

III. DATA AND RESULTS

a. DATA

Monthly data of Hang Seng Index and its dividend ratio from July 1974 to May 2002 are used in the West and Diba and Grossman's tests. Both series are deflated by the Consumer Price Index before being seasonally adjusted. These adjusted data are shown in Chart 1. For the duration dependence test, both monthly and weekly Hang Seng Index in the same period are used. The basic summary statistics of the data used in the test is reported in Table 1.

b. RESULTS

The results from the regression and the diagnostic checks under the West's approach are reported in Tables 2a-2c. From the Tables, the estimated discount rate (ρ) from equation (4a) is found to be at a reasonable level and robust under different dividend processes. Parameter estimates in equation (4b) are fairly stable for various dividend specifications. As for the diagnostic checks, no serial correlation in residuals is detected in most cases. Moreover, the instrumental variables used in the estimation are found to be orthogonal with the residuals. Finally, regarding the stability of the regression coefficients, both mid-sample and the regime shift in exchange rate arrangement in 1983 are tested. In all these cases, the null hypothesis of stability in coefficients is not rejected. Thus, there is no mis-specification problem based on these diagnostic checks.

Results of the test of the null hypothesis of no bubbles based on the BTS from equation (5) are reported in Table 3. The null is strongly rejected in different sample periods under various dividend processes. That is, the West's test detects the existence of bubbles in the Hang Seng Index.

The results of co-integration test based on Diba and Grossman's approach are given in Table 4. Stock prices and dividends are not co-integrated both for the full sample and sub-samples. In other words, the lack of significant co-integration results under this approach suggest that bubbles may exist in the Hong Kong equity market.

Table 5 reports the results of the duration dependence test based on McQueen and Thorley's approach. The maximum likelihood estimates of the log-likelihood function parameters α and β for the positive run of test are also reported. Although the estimated β for the full sample and the first sub-sample of monthly excess returns are negative, which is an indication of the existence of bubbles, results of their likelihood ratio tests are insignificant. Different from the previous two approaches, the null hypothesis of no bubbles in the Hong Kong stock prices can not be rejected.[4]

IV. CONCLUSION

Despite the importance of the asset price volatility on the real economy, there are very few systematic studies on testing the existence of bubbles in the domestic equity market. This paper attempts to fill the gap by examining this issue using three alternative approaches in the rational speculative bubbles literature. The results from the specification test by West and the co-integration test by Diba and Grossman are similar. Their test statistics suggest the possible existence of bubbles in the Hong Kong stock market. In contrast, no bubbles are detected in the domestic equity market based on the results of the duration dependence test developed by McQueen and Thorley.

The mixed results from these tests have important implication in the current debate of whether the central banks should respond to the asset market volatility and prick the equity price bubbles at the early stage. Given the difficulty in the identification of bubbles in the asset market, any pre-emptive action to deter bubble formation should be cautioned. Instead of relying on monetary tools to deal with the boom and bust cycle in asset price, it might be more appropriate to focus on micro-level policies such as measures in strengthening the supervision and payment systems

[4] Based on a different study period, Chan, McQueen and Thorley (1998) finds similar conclusion for the Hong Kong stock market.

to reduce the impact of bubble bursting and to protect the financial systems against its potentially disastrous effects.

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Chart 1: Real Monthly Hang Seng Index and Dividend (Seasonal-adjusted)

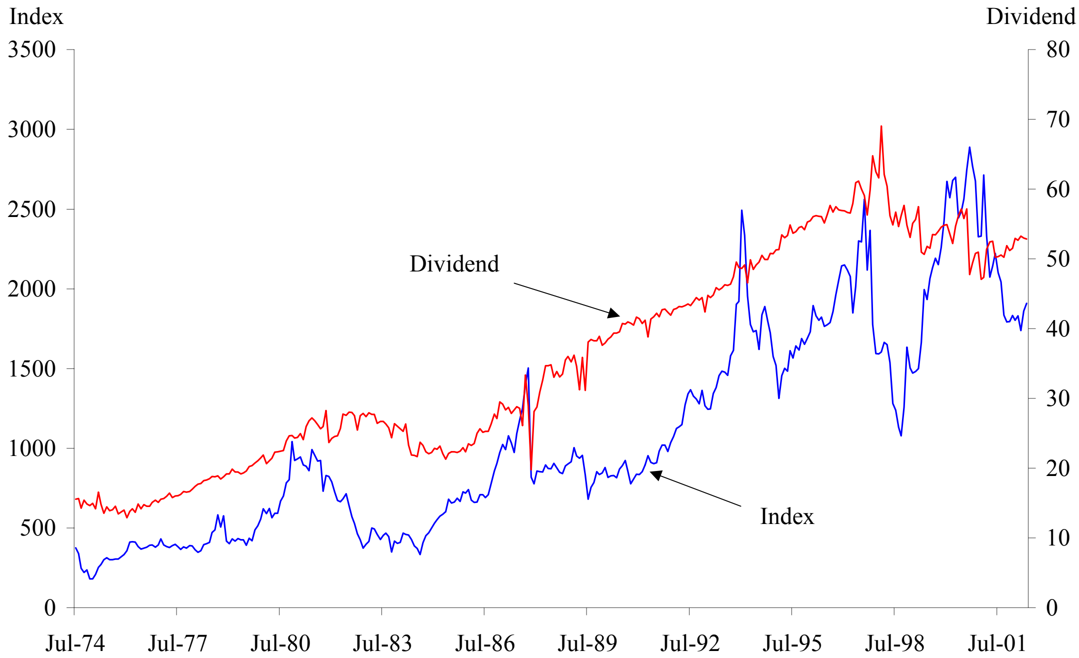

Table 1: Summary Statistics of Returns of Hang Seng Index

	Monthly	Weekly
From To	Jul 74 May 02	3 Jul 74 29 May 02
Mean	1.87%	0.39%
Standard Deviation	0.0942	0.0399
Skewness	0.1767	-0.2421
Kurtosis	1.8908	2.9160

Note:

1) All returns are annualised by continuously compounding.
2) Weekly nominal returns are calculated from Wednesday close to Wednesday close. In the case of a holiday or non-trading on Wednesday, the Tuesday close is used. If Tuesday data are also unavailable, the Monday close is used.

Table 2a: Regression Results of West's Specification Test

Equation (4a): $p_t = \rho \ (p_{t+1} + d_{t+1}) + \mu_{t+1}$

	$q = 1$	$q = 2$	$q = 3$	$q = 4$
ρ	0.9641 (0.0000)	0.9639 (0.0000)	0.9635 (0.0000)	0.9634 (0.0000)
Serial correlation	0.0140 (0.9057)	0.0146 (0.9037)	0.0097 (0.9217)	0.0033 (0.9540)
Orthogonality	0.7099 (0.7837)	3.3437 (0.4547)	19.5181 (0.0002)	20.8815 (0.0002)
Stability (mid-sample)	0.6172 (0.8054)	0.6631 (0.8643)	0.6968 (0.9084)	0.6957 (0.9515)
Stability (1983:10)	0.0902 (0.9289)	0.1200 (0.9473)	0.1520 (0.9741)	0.1560 (0.9998)

Note: The serial correlation test for residuals refers to the Breusch-Godfrey serial correlation LM test. The statistics for orthogonality test and stability test follow χ^2 distribution with degree of freedom equal to q and 1 respectively. The p-value of each statistic is shown in the bracket. In general, the diagnostic tests perform well.

Table 2b: Regression Results of West's Specification Test

Equation (4b)	$\Delta d_{t+1} = \mu + \phi_1 \Delta d_t + \ldots + \phi_q \Delta d_{t-q+1} + \upsilon_{t+1}$			
	$q = 1$	$q = 2$	$q = 3$	$q = 4$
μ	0.1430 (0.1135)	0.1776 (0.0486)	0.1805 (0.0432)	0.2021 (0.0228)
ϕ_1	-0.2790 (0.0103)	-0.3370 (0.0006)	-0.3416 (0.0004)	-0.3441 (0.0002)
ϕ_2		-0.2079 (0.0294)	-0.2164 (0.0108)	-0.2409 (0.0035)
ϕ_3			-0.0260 (0.7473)	-0.0634 (0.4634)
ϕ_4				-0.1087 (0.2168)
Serial correlation	14.4038 (0.0001)	0.1525 (0.6961)	2.0610 (0.1511)	2.2406 (0.1344)
Orthogonality	0.0485 (0.9386)	0.0712 (0.9652)	0.0624 (0.9965)	0.0000 (0.9999)
Stability (mid-sample)	0.0001 (0.9999)	3.5643 (0.4210)	5.0943 (0.3781)	5.8876 (0.4192)
Stability (1983:10)	0.0702 (0.9335)	0.1008 (0.9503)	0.1943 (0.9690)	0.1659 (0.9998)

Note: The serial correlation test for residuals refers to the Breusch-Godfrey serial correlation LM test. The statistics for orthogonality test and stability test follow χ^2 distribution with degree of freedom equal to q and q +1 respectively. The p-value of each statistic is shown in the bracket. In general, the diagnostic tests perform well.

Table 2c: Regression Results of West's Specification Test

Equation (4c): $\Delta p_{t+1} = m + \delta_1 \Delta d_t + \ldots + \delta_q \Delta d_{t-q+1} + \omega_{t+1}$

	$q = 1$	$q = 2$	$q = 3$	$q = 4$
m	4.4237 (0.4666)	3.8836 (0.5159)	1.2927 (0.8214)	0.0955 (0.9864)
δ_1	2.5774 (0.0050)	4.1782 (0.0012)	7.3221 (0.0002)	7.4742 (0.0001)
δ_2		5.7426 (0.0000)	10.8857 (0.0000)	12.2786 (0.0000)
δ_3			15.2933 (0.0000)	17.4500 (0.0000)
δ_4				6.2781 (0.0070)
Serial correlation	0.2311 (0.6307)	0.7566 (0.3844)	1.9205 (0.1658)	1.5417 (0.2144)
Orthogonality	0.6656 (0.7941)	0.6279 (0.8697)	0.5640 (0.9244)	0.0000 (0.9999)
Stability (mid-sample)	6.3885 (0.0110)	16.3574 (0.0000)	23.5829 (0.0000)	23.3077 (0.0000)
Stability (1983:10)	0.0213 (0.9450)	0.6503 (0.8663)	1.9134 (0.7617)	2.2871 (0.7884)

Note: The serial correlation test for residuals refers to the Breusch-Godfrey serial correlation LM test. The statistics for orthogonality test and stability test follow χ^2 distribution with degree of freedom equal to q and q +1 respectively. The p-value of each statistic is shown in the bracket. In general, the diagnostic tests perform well.

Table 3: Bubble Test Statistics of Monthly Hang Seng Index given by West's Test

Number of lags (q)	Full Sample (1974:07~2002:05)	Sub-sample (1974:07~1987:10)	Sub-sample (1987:11~2002:05)
1	7.8443 (0.0188)	20.0661 (0.0000)	13.081 (0.0000)
2	18.9156 (0.0000)	50.5468 (0.0000)	17.2772 (0.0000)
3	37.1426 (0.0000)	60.5754 (0.0000)	26.0371 (0.0000)
4	51.1151 (0.0000)	60.2051 (0.0000)	34.6765 (0.0000)

Note: The bubble statistic follows $\chi^2(q+1)$ distribution. The p-value in the bracket shows that the null hypothesis of no-bubble is rejected at 5% level of significance.

Table 4: Co-integration Test of Diba and Grossman's Approach

Data	Full Sample (1974:07~2002:05)	Sub-sample (1974:07~1987:10)	Sub-sample (1987:11~2002:05)
Hang Seng Index	10.4646	10.4911	13.0797
Number of Observations	330	155	175

Note: The statistic for co-integration test is insignificant at 5%. That is, the null-hypothesis of no-bubble is rejected.

Table 5: Maximum Likelihood Estimates of Duration Dependence Test

		Number of Returns	α	β	Likelihood Ratio (P-value)
Monthly	Full Sample (1974:07 ~ 2002:05)	78	0.0811	-0.0306	0.0110 (0.9474)
	Sub-sample (1974:07 ~ 1987:10)	36	0.2364	-0.3930	0.9817 (0.7200)
	Sub-sample (1987:11 ~ 2002:05)	44	0.0287	0.5157	1.1547 (0.6795)
Weekly	Full Sample (3 Jul 74 ~ 29 May 02)	359	-0.1133	0.11 38	0.7773 (0.7679)

Note: The likelihood ratio test statistic follows the $\chi^2(1)$ distribution. The p-values in the bracket show that all the test statistics are insignificant at 5% significant level. In other words, the null hypothesis of no-bubble is not rejected.