Measuring the Size of Market Inefficiency: Trading Systems and Price Bubbles*

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Abstract:

The performance of trading systems in the stock markets has been studied by most of the previous literatures in terms of the costs or equivalently speeds for adjusting the stock prices. This paper proposes an alternative measure for accessing the trading systems called the size of market inefficiency which simultaneously takes care of the intrinsic value of stock and adjustment speed of price, and applies this measure to the stock market indices of nine countries during the tow sub-periods from1980 to 2010. We find that the trading system of the Indian market is the worst in the first period but Korea's is the worst in the second sub- period. The trading system of Japan, Canada, and India improve in the second period, while the trading systems of the USA, France, Italy, Korea, Singapore, and Malaysia become worse in the second period. This paper also shows that the net price overvaluation (intrinsic value minus fundamental value) is the sum of nominal price overvaluation (stock price minus fundamental value) and size of market inefficiency. This distinction of net and nominal overvaluations clarifies the role of our measure of market inefficiency. An application reveals that contribution of the size of market inefficiency to the net overvaluation is fairly large for the markets of some countries.

1. Introduction

Huge amounts of researches on the efficiency of security markets have been accumulated since Fama's (1970) pioneering work. Fama (1970) defined that the market is efficient if the prices fully and instantaneously reflect all information available at present time.

His concept of market efficiency was extended to explicitly incorporate market microstructures (or investor's behavior). Amihud and Mendelson (1987) and Damodaran (1993) propose a partial price adjustment model. They define the market is efficient when investors and specialists can instantaneously and fully adjust the market price of a security to its intrinsic value. In contrast, the market is inefficient when the price of its security does not adjust to its intrinsic value. Koutmos (1998, 1999) extend the above mentioned model to an asymmetric partial price adjustment model, where the adjustment speeds are different depending on whether the price increases or decreases. Empirical studies of Soydemir (2001), Bahng and Shin (2003), and Nam et al. (2003, 2005) support the asymmetric adjustment model. Most of the previous authors study the performance of trading systems in the stock markets in terms of the adjustment speeds of stock price but do not pay attention to intrinsic value.

This paper proposes an alternative measure for accessing the trading systems called the size of market inefficiency which simultaneously takes care of the intrinsic value of stock and adjustment speed of price. The size of market inefficiency is defined as the difference between market price and its intrinsic value. We investigate the performance of trading systems in terms of the size of market inefficiency. Our approach is more useful than the previous approaches for accessing the trading system in the following two senses.

First, the previous approach accesses the trading system only in terms of adjustment speed and ignores the fluctuations in intrinsic values: the trading system is better (worse) if the adjusting speed is higher (lower) regardless how vigorously the intrinsic value fluctuates. For example, Amihud and Mendelson (1989, 1991), Amihud et al. (1997), Lauterbach (2001), and Chang et al. (2008) assess whether the trading system of call market method or that of continuous auction method is better in terms adjustment speed. However, a higher adjustment speed will produce a large amount of discrepancy between intrinsic value and market price when the intrinsic value vigorously fluctuates. We feel that the difference between intrinsic value and market price is a more suitable measure for accessing the performance of trading system than the adjusting speed.

Second, a number of empirical papers including Campbell and Shiller (1987), Cheung and Lee (1998), Lee (1998), and Black et al. (2003) have estimated fundamental values by the dividend discount model, and used them to measure the magnitudes of overvaluation of the market price. The concept of overvaluation is used to evaluate the investor's speculative behaviors and bubble prices. The overvaluation is traditionally defined by the difference between market prices and fundamental value. A related concept is the difference between intrinsic value and fundamental value. We call the former as the nominal overvaluation and the latter as net overvaluation. Then, the net overvaluation is the sum of nominal overvaluation and size of market inefficiency. The concept of net overvaluation is preferable to the nominal overvaluation for evaluating the overvaluation of the market in practice.

We apply this measure to the stock market indices of nine countries during the tow sub-periods from1980 to 2010. The result reveals that the trading system of the Indian market is the worst in the first period but Korea's is the worst in the second sub- period. The trading system of Japan, Canada, and India improve in the second period, while the trading systems of the USA, France, Italy, Korea, Singapore, and Malaysia become worse in the second period. And the contribution of the size of market inefficiency to the net overvaluation is fairly large for the markets of some countries.

The paper is organized as follows. Section 2 outlines the model and give a precise definition of the size of market inefficiency. Section3 provides an estimation method for unknown parameters and unobserved intrinsic value using the observed market price. Section 4 reports the results of an application of our approach to the stock market indices for the nine countries of G7 and Asia. Section 5 provides some concluding remarks. All proofs of propositions of this paper are given in Appendices.

2. The Model and market inefficiency

2.1 The model

We essentially follow the model of Koutmos (1998, 1999), which is itself an extension of that of Amihud and Mendelson (1987) by incorporating asymmetric adjustment. This model consists of two parts: the intrinsic value process for a security and the market price adjustment process. The model distinguishes the unobserved intrinsic value of a stock (V_t) from the observed market price (P_t) of the stock, both expressed in natural logarithms.[1]

The intrinsic value process follows a random walk process with drift:

$$V_t = a + V_{t-1} + u_t, \quad u_t \mid I_{t-1} \sim N\left(0, \sigma_{\mathrm{ut}}^2\right), \ \mathrm{t} = 1, \ldots, \mathrm{T}, \tag{1}$$

where a is a constant and I_{t-1} denotes the information set up to time t–1. We assume that the disturbance term (u_t) has the EGARCH (Exponential Generalized Autoregressive Conditional Hetroskedastic) process proposed by Nelson (1991):

$$\log \sigma_{ut}^2 = \alpha_0 + \alpha_1 \mathrm{z}_{\mathrm{t-1}} + \alpha_2 (|\mathrm{z}_{\mathrm{t-1}}| - \mathrm{E}(|\mathrm{z}_{\mathrm{t-1}}|)) + \alpha_3 \log \sigma_{u\,\mathrm{t-1}}^2$$

where (2)

$$u_t = \sigma_{u\mathrm{t}} \mathrm{z}_{\mathrm{t}} : \ \mathrm{z}_{\mathrm{t}} \sim N(0, 1).$$

The partial asymmetric price adjustment process of P_t represents that adjustment speeds $(1-\theta^+, \ 1-\theta^-)$ are asymmetric in the upturn or downturn markets:

$$P_t - P_{t-1} = (1-\theta^+)(V_t - P_{t-1})^+ + (1-\theta^-)(V_t - P_{t-1})^-, \ -1 < \theta^+, \ \theta^- < 1, \tag{3}$$

where $(V_t - P_{t-1})^+ = \max\{V_t - P_{t-1}, 0\}$, and $(V_t - P_{t-1})^- = \min\{V_t - P_{t-1}, 0\}$. We note that θ^+, θ^- indicate the costs for adjusting prices. If $\theta^+ = \theta^- (\equiv \theta)$, equation (3) reduces to the (symmetric) partial price adjustment process proposed by Amihud and Mendelson (1987, p. 536). Koutmos (1998, p. 280; 1999, p. 86) formulated the asymmetric adjustment to intrinsic value in (3). After the intrinsic value V_t is recognized at t, the market price P_{t-1} is partially adjusted to P_t by (3).[2]

The partial price adjustment $(\theta^+ \neq 0$ and/or $\theta^- \neq 0)$ in (3) is attributed to the following costs that slow down the price adjustment of a security toward its intrinsic value: (i) the cost of acquiring and processing information by investors; (ii) attempts by market specialists to create orderly markets and ensure price continuity; and (iii) the particular institutional market mechanism by which securities are traded [3,4]. Moreover, the

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[1] This distinction is based on an idea by Black (1986; p. 533).

[2] When $V_t > P_{t-1}$ in (3), we have $P_t = (1-\theta^+)V_t + \theta^+ P_{t-1}$. Then, the condition $-1 < \theta^+ < 1$ is necessary for the price adjustment process to converge. Similarly, the condition $-1 < \theta^- < 1$ is also necessary.

[3] See Koutmos (1998, pp. 278, 285).

possibility of asymmetric adjustment ($\theta^+ \neq \theta^-$) reflects that investors may severely averse the downside risk, so they react more quickly to bad news. The use of stop-loss orders is an example of such aversion. Furthermore, traders (i.e., investors) may feel they are penalized more if they underperform in a falling market than in a rising market. This fact indicates that $\theta^+ > \theta^-$. Similarly, for the market makers (i.e., market specialists), the cost of not adjusting for the downward prices is higher than that of not adjusting for the upward prices. Market specialists, who are required to maintain price continuity, may find it easier and less costly to do so in the rising market than in the falling market. As the latter involves the inventory building up with overpriced securities, this also leads to $\theta^+ > \theta^-$. However, the negative adjustment cost (θ^+, $\theta^- < 0$) in (3) is difficult to interpret. Nevertheless, we allow the negative cost to generalize the model as done in the previous studies.

2.2 The size of market inefficiency and performance of trading systems

We define a concept of market inefficiency in terms of adjustment costs as follows.

Definition 1*: (i) The market is said to be inefficient if* $\theta^+ \neq 0$ *and / or* $\theta^- \neq 0$ *in (3) and efficient if and only if* $\theta^+ = \theta^- = 0$ *(adjustment cost is zero). (ii) The market price adjustment is said to be asymmetric if* $\theta^+ \neq \theta^-$ *and symmetric if* $\theta^+ = \theta^-$.

If the market is efficient, there is no adjustment costs of (i), (ii), and (iii) stated in Section 2.1 ($\theta^+ = \theta^- = 0$) and the market prices instantaneously and fully adjust to the intrinsic value as follows:

$$P_t - P_{t-1} = (V_t - P_{t-1})^+ + (V_t - P_{t-1})^- = V_t - P_{t-1}, \text{ and hence } P_t = V_t. \qquad (4)$$

On the other hand, when the market price is neither instantaneously nor fully adjusted toward the intrinsic value, the inefficient market and less efficient trading system evolve.

The speeds of price adjustment $(1-\theta^+ or\ 1-\theta^-)$ in the upturn and downturn markets could be a measure of accessing how far inefficient the markets are. Amihud and Mendelson (1989, 1991), Amihud et al. (1997), Lauterbach (2001), and Chang et al. (2008)

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[4] The continuous auction method is used in most countries. However, Japan and Singapore have no specialists that deal from their own accounts to set the price, although there are specialists in the other countries considered in this paper. See Inoue (2006).

used the adjustment speeds for evaluating the performance of trading systems. However, all of the previous studies ignore the role of intrinsic values.

Alternatively, we explicitly incorporate the intrinsic value into the consideration for analyzing the performance of trading systems. We know that the market price is equal to the intrinsic value from equation (4) if the market is efficient, but it is not equal if the market is inefficient. Hence, the difference between the intrinsic value and the market price ($V_t - P_t$) can be viewed as an indicator for the magnitude of market inefficiency. By deleting both sides of (3) from the identity $V_t = V_t$, equation (3) is expressed as follows:

$$V_t - P_t = \theta^+ (V_t - P_{t-1})^+ + \theta^- (V_t - P_{t-1})^- \ , \ \ -1 \ < \ \theta^+, \ \theta^- < 1 \, . \tag{5}$$

The size of market inefficiency is defined by the quantity ($V_t - P_t$) in this paper. The size of market inefficiency depends on both the intrinsic value and the adjustment costs . (θ^+or θ^-) .The condition of $\theta^+ \ = \ \theta^- = 0$ is equivalent to $V_t - P_t = 0$ in (5). The market price overshoots the intrinsic value in the sense that $P_t > V_t$ when $V_t > P_{t-1}$ if the condition $\theta^+ < 0$ and $\theta^+ < 0$ holds.

3. Measuring the size of market inefficiency and overvaluation of the stock price

3.1. Estimation of the size of market inefficiency

In order to determine the size of market inefficiency, we have to estimate the unobservable intrinsic value and the unknown parameters θ^+ and θ^-. The next proposition derives the relations among the observed market price, unobserved intrinsic value, and the size of market inefficiency[5].

Proposition 1: *(i) When the previous market price P_{t-1} is under (over) the intrinsic value V_t at the present period t, the market price P_t at the present period is adjusted to increase (decrease) as follows:*

$$V_t - P_{t-1} \le 0 \Leftrightarrow R_t \le 0 \quad and \, V_t - P_{t-1} > 0 \Leftrightarrow R_t > 0 \, , \tag{6}$$

where $R_t \equiv P_t - P_{t-1}$ is the return on the market price.

(ii) The size of market inefficiency $(V_t - P_t)$ *is computed by using the return* (R_t) *, and the adjustment speeds (1–θ^+ , and 1–θ^-) as follows:*

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[5] All the proofs of this paper are given in Appendix A.

$$\mathrm{V_t - P_t = R_t}\left(\frac{1}{\xi_t} - 1\right) \tag{7}$$

where $\xi_t \equiv \left(1-\theta^-\right) + \left(\theta^- - \theta^+\right)\mathrm{D_t}$, $\mathrm{D_t} = 1$ for $\mathrm{V_t - P_{t\text{-}1}} \geq 0$, and $\mathrm{D_t} = 0$ otherwise.

After the intrinsic value V_t is found at the beginning of period t and compared with the previous market price P_{t-1} (i.e., $V_t - P_{t-1}$), the market price P_t at period t is adjusted to increase when $V_t - P_{t-1} > 0$ and then the positive return follows ($R_t > 0$), as shown in (3) and (6). Although the intrinsic value V_t is directly unobservable, equation (7) indicates that it can be computed from the observed market price P_t, the return R_t, and the estimated parameters θ^+ and θ^- [6].

The model in this paper induces the process of return to a nonlinear autoregressive process as stated in the next proposition.

Proposition 2: The return process consisting of (1) and (3) has the following form:

$$R_t = \xi_t\left(\mathrm{a} + \frac{\theta^+}{1-\theta^+}\mathrm{R^+_{t\text{-}1}} + \frac{\theta^-}{1-\theta^-}\mathrm{R^-_{t\text{-}1}}\right) + \varepsilon_{\mathrm{t}}, \tag{8}$$

where $\varepsilon_t = \xi_t u_t$, $R^+_{t-1} \equiv Max\{R_{t-1}, 0\}$, $R^-_{t-1} \equiv Min\{R_{t-1}, 0\}$, and ξ_t *is defined in proposition 1.*

The conditional expectation of ε_t in (8) is not zero and the process of { ε_t } is serially dependent except for the case of $\theta^+ = \theta^-$ [7]. The conditional variance of ε_t does not follow an EGARCH process, unlike that of u_t. Considering (6) in Proposition 1, $\mathrm{R_t} \geq 0$ in (8) corresponds uniquely to $\mathrm{V_t - P_{t\text{-}1}} \geq 0$ in (7), which decides uniquely ξ_t. Then, the joint density function of the returns is expressed from equations (8) and (2) as follows.

Proposition 3: *The joint density function of* $\{R_1, \ldots, R_T\}$ *is given by:*

[6] Even though Amihud and Mendelson (1987) and Koutmos (1998, 1999) introduced the idea of intrinsic value $\mathrm{V_t}$ as a theoretical concept, they did not compute it.

[7] See Lemma 1 in the Appendix 1. If $\theta^+ = \theta^- (= \theta)$ and $\xi_t = 1 - \theta$, equation (9) reduces to $R_t = \mathrm{a}(1\text{-}\theta) + \theta\,\mathrm{R_{t\text{-}1}} + (1-\theta)u_{\mathrm{t}}$.

$$pdf\,(R_1,..,R_T \mid \omega)$$

$$= \prod_{t\in T^+}\left\{\frac{((1-\theta^+)\sigma_{ut})^{-1}\phi(\ (R_t-(1-\theta^+)\mu_t)/(1-\theta^+)\sigma_{ut}\ )}{\Phi(\mu_t/\sigma_{ut})}\right\} \tag{9}$$

$$\times\prod_{t\in T^-}\left\{\frac{((1-\theta^-)\sigma_{ut})^{-1}\phi(\ (R_t-(1-\theta^-)\mu_t)/(1-\theta^-)\sigma_{ut})}{\Phi(-\mu_t/\sigma_{ut})}\right\}$$

where

$$\mu_t = \mathrm{a}+\frac{\theta^+}{1-\theta^+}\mathrm{R}^+_{\mathrm{t-1}}+\frac{\theta^-}{1-\theta^-}\mathrm{R}^-_{\mathrm{t-1}},\ T^+=\{t\mid R_{\mathrm{t}}\ \geq 0,\ t\in N\},\ T^-=\{t\mid R_{\mathrm{t}}\ \leq 0,\ t\in N\},$$

N = {1, . . . , T}, and $\omega=\{a,\theta^+,\theta^-,\alpha_0,\alpha_1,\alpha_2,\alpha_3\}$ *is a vector of unknown parameters, and* Φ and ϕ *respectively denote the distribution and density functions of the standard normal distribution.*

We can estimate the unknown parameter vector of ω including (θ^+,θ^-) by the maximum likelihood method using the joint density of (9)[8]. Once we have the estimates of θ^+ and θ^-, the sizes of market inefficiency is estimated by $\hat{V}_t-\mathrm{P}_{\mathrm{t}}$, where the estimate of intrinsic value is given as

$$\hat{V}_t = \mathrm{P}_{\mathrm{t}}-\mathrm{R}_{\mathrm{t}}(1-(\hat{\xi}_t)^{-1}),\ \text{and}\ \hat{\xi}_t=\left(1-\hat{\theta}^-\right)+\left(\hat{\theta}^--\hat{\theta}^+\right)\mathrm{D}_{\mathrm{t}}. \tag{10}$$

Since V_t *and* P_t are expressed in terms of logarithms, the size of market inefficiency is the percentage discrepancy between the market price and the intrinsic value in levels[9].

3.3. Overvaluation of the stock price and market inefficiency

The concept of overvaluation is generally used to evaluate the speculative market price, where market prices should be compared with their fundamental value. This subsection analyzes the role of market inefficiency in overvaluation of the stock price bubbles. We define the over- (under-) valuation of the market price.

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[8] The conditional density function is different from that of the standard GARCH-type model. We are not able to prove an asymptotic normality of the maximum likelihood estimator for this model. Therefore, for simplicity, we assume that the estimated parameter will be consistent and asymptotically normal.

[9] Noting the fact $V_t = \log V_t^*$ *and* $P_t = \log P_t^*$, where V_t^* *and* P_t^* are the corresponding variables in level values, we have $V_t-P_t=\log(1+(V_t^*-P_t^*)/P_t^*)\cong(V_t^*-P_t^*)/P_t^*$.

Definition 2*: Let market price and fundamental value in levels be* P_t^* and S_t^* *. The market price is said to be overvalued if* $P_t^* > S_t^*$ *, undervalued if* $P_t^* < S_t^*$ *, and normal if* $P_t^* = S_t^*$.

This definition was used by Campbell and Shiller (1987), Cheung and Lee (1998), Lee (1998), and Black et al. (2003) for comparing market prices and fundamental values. As shown in Section 3, however, the intrinsic value is generally different from the market value because of market inefficiency. Hence, we distinguish the size of net overvaluation $(V_t^* - S_t^*)$ from the size of nominal overvaluation ($P_t^* - S_t^*$). The following relation in terms of a percentage of the market price clarifies the role of market inefficiency:

$$\frac{V_t^* - S_t^*}{P_t^*} = \frac{P_t^* - S_t^*}{P_t^*} + \frac{V_t^* - P_t^*}{P_t^*}. \tag{11}$$

The size of net overvaluation is a sum of the size of nominal overvaluation and that of market inefficiency.

It is necessary to estimate the fundamental value for analyzing how much are the actual markets over- (under-) valued. In this paper, we define the fundamental value of the market as the discounted sum of future dividends per share:

$$S_t^* = \sum_{j=1}^{\infty} \frac{Q_{t,\mathrm{j}}}{(1+\rho_t)^j}, \tag{12}$$

where $Q_{t,j}$ is dividend per share for the j-periods ahead from time *t*, ρ_t is a discount rate at time t, which is assumed to be constant over the future periods. Assuming that the investors expect the dividend growth rate (λ_t) at time t will stay fixed over the entire future periods, we have $Q_{t,\mathrm{j}} = Q_t(1+\lambda_t)^j$, where Q_t denotes the dividend per share at time t. The fundamental value is expressed as:

$$S_t^* \equiv \sum_{j=1}^{\infty} \frac{Q_t(1+\lambda_t)^j}{(1+\rho_t)^j} = (\frac{1+\lambda_t}{\rho_t - \lambda_t})Q_t, \tag{13}$$

under the condition $\rho_t > \lambda_t$. Finally imposing a simplifying condition that the dividend growth rate (λ_t) is equal to the GDP growth rate (g_t): (*i.e.* $\lambda_t = g_t$), the fundamental value is approximated in terms of the GDP growth rate and the initial value (S_0^*) as[10]:

$$S_t^* = S_{t-1}^*(1+g_t) = S_0^* \prod_{j=0}^{t}(1+g_j). \tag{14}$$

We have to determine the initial value S_0^* in application as will be explained in the next section.

4. Applications to the stock markets

4.1 Characteristics of the data

We investigate the stock markets of the nine countries of Japan, USA, France, Italy, Canada, Korea, Singapore, India, and Malaysia to illustrate how our model works. The monthly stock price indices are taken from International Financial Statistics (IFS) (line 62.ZF.). The nine series of stock prices from the G7 and Asian countries are chosen for the reason of availability of data.[11] The time span of observation is roughly from January 1969 to June 2009, but different among the countries depending on the availability of data.

Figure 1 illustrates the market prices (in a semi-logarithm scale) adjusted for 100 in January 2000 and their returns (in percentage) for each country. Figure 1(1) shows that Japan's stock prices exhibit an uptrend until the end of the 1980s, but a downtrend in the 1990s. The returns move mildly in the former period in comparison with the latter one. Based on these visual observations, the sample period is divided into the two sub-periods. These movements suggest a structural change in the EGARCH model, which is represented by equations (1) to (3). Similarly, from Figure 1(1)–(9) we would observe a structural change for the stock price series of other countries than Japanese series, even though the point of change differs from country to country, reflecting the collapse of the stock price bubble or economic crisis. For example, the Japanese stock price collapsed

[10] See Appendix B for deriving (4).

[11] German prices are distorted by German integration after October 1990; therefore, we cannot evaluate the trading systems independent of integration. UK (1994M1~) and Thai (~1996M12) prices are not available from IFS. The Philippines' prices in 2007 are 100 times higher than 2003 prices, a trend that has continued: 50 times at 2008M5 price, 100 times at 2008M12 price. Its movement is too abnormal and thus excluded.

because of the burst of the stock price bubble. The stock prices of Singapore and Malaysia collapsed because of the Asian currency crisis in1997, the USA stock price collapsed because of the dot com bubble burst. The stock prices of other countries may have their own reason of structural change though we do not mention here. To circumvent this problem, in this paper we separate the sample period into the two sub-periods. We analyze the market prices for the same 10 years of observations over all nine countries in order to correctly compare the results across countries.

Table 1 reports the two sub-periods of asmaples and the summary statistics such as mean of returns, standard deviation, skewness, excess kurtosis and Ljung–Box $Q^2(12)$-statistics for no serial correlation in the monthly squared returns for each of the countries. At the 5% significance level, both the null hypothesis of no excess kurtosis and no serial correlation for squared returns are rejected for the most countries. The monthly time series still have the typical features of stock returns, displaying a fat-tailed distribution, a spiked peak, and variance persistence.[12] Therefore, the GARCH-type model expressed by (8) with error terms of (2) seems to be preferable to the AR model for analyzing these series.

[INSERT Figure 1, Table 1]

4.2 Adjustment speed, size of market inefficiency and trading systems

This sub-section determines the size of market inefficiency and then evaluates trading systems in terms of this size after stating the estimation results of the parameters in the model for each of the nine countries.

Table 2 indicates the estimates of parameters of our model. The estimates of the GARCH effect (α_3) are very close to unity for all countries and for the periods I and II, which strongly imply persistency of variance.[13] Table 2 also shows that the estimates of θ^+ and θ^- are statistically significant for most of the countries we examined and for both

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[12] All computations in the paper were performed using the computer package WinRATS-32 Version 4.30.

[13] Few of the values of α_3 exceed 1 as in previous studies. For France, $\theta^- < -1$ despite (3). Few of the values of α_2 have significant negative signs, in contrast to previous studies. These results require careful consideration.

periods I and II with a few exceptions. We formally test the null hypothesis of market efficiency in terms of Definition 2 (H_0: $\theta^+ = 0$ and $\theta^- = 0$*)*. As shown inTable3, this hypothesis is clearly rejected for all the countries and for the both subsamples except for the period I of the USA. This fact implies the stock markets are inefficient in the sense of Definition 2. The results of the t-tests for θ^+ and θ^- shown in Table 2 indicate that one of the two coefficients is either significantly positive or negative and the other is insignificant for all nine countries, supporting the asymmetry of θ^+ and θ^-. This indicates that our model with possible asymmetric adjustment speeds is appropriate for analyzing market inefficiency in these nine countries.

[INSERT Table 2, Table 3]

We evaluate the trading system of each country in terms of the size of market inefficiency. At first, we look at the trading systems based on the adjustment speed along the line of studies by Amihud and Mendelson (1989, 1991), Amihud et al. (1997), Lauterbach (2001), and Chang et al. (2008) for the purpose of comparison with our method. As seen in Period I of Table 2, both the upward adjustment speed and the downturn adjustment speed vary in large amounts across the countries and between the two sub-sample periods. The adjustment speed of the upturn market of Japan is slowest among the nine countries $(1-\theta^+ = 1-0.440)$, while that of the downturn market of Malaysia is overshooting $(1-\theta^- = 1+0.690)$ and worst. In period II, on the other hand, the adjustment speed of the upturn market of Italy $(1-\theta^+ = 1-0.476)$, while that of the downturn market of Korea $(1-\theta^- = 1\text{-}0.581)$ and those of Canada $(1-\theta^- = 1+767)$ and France $(1-\theta^- = 1+1.656)$ are overshooting. After observing these results, we feel that it is not easy to determine the best trading system among the nine countries based on the adjustment speeds.

Figure 2 illustrates the estimated values of the sizes of market inefficiency ($\hat{V}_t -$ $\mathrm{P_t}$) all over the sample periods for each county. These sizes changes over time for all the countries, and take both positive and negative values for most countries. The average values of the size of market inefficiency over each of the sub-sample period are shown in Table 4.

[INSERT Figure 2, and Table 4]

We evaluate the trading systems for the two sub-periods for each country by using an average of the size of market inefficiency. The worst trading system is India (2.5%) in period I and Korea (6.1%) in period II, as seen in Table 4. In period II (i.e., after deterioration of market prices), Japan's, Canada's and India's trading systems become better in terms of size of market inefficiency. However, the trading systems of the USA, France, Italy, Korea, Singapore, and Malaysia become worse. In period II, most countries have overshooting adjustment speeds in downturn markets: $\theta^{-} < 0$, as seen in (5).

4.3. Overvaluation of the stock price and market inefficiency

Since the initial value S_0^* is unknown in practice, we determine it by using the following strategy. Suppose $S_s^* = P_s^*$ for a particular period and compute S_{s-j}^* for *j* (j = 1,…, J). If the condition

$$S_{s-j}^*(1-0.05) \le P_{s-j}^* \le S_{s-j}^*(1+0.05) \quad , \tag{15}$$

holds for all j = 1,…,J, we call this period an initial period, and set s = 0 with $S_0^* = P_0^*$. When P_{s-j}^* satisfies the inequality in (15), we virtually regard that the market price is normal in spite of definition 2. Behind this strategy, we have an idea that the market price might be close to the fundamental value, and the growth rate of the fundamental value would be roughly equal to that of the market price during the periods of typical economic environments. Hence, it may be reasonable to choose some value of J greater than one. Moreover, when the next condition holds:

$$S_{0+t}^*(1+0.05) < P_{0+t}^* \text{ for all } t \text{ from } T^* \text{ to } T^{**} \ , \tag{16}$$

for some T* and T**, the stock price P_t^* is overvalued at the priods from T* to T**. We call the quantity $(P_{0+t}^* - S_{0+t}^*)$ for these periods as the size of bubble.

We chose only one country among the nine countries for each of the periods I and II for analyzing the size of bubble in order to illustrate how our method works in the real market. The market of India is worst in terms of the size of market inefficiency for period I. However, we chose the second worst market of Japan since there is no available monthly GDP data for the Indian market. Korea is chosen for the period II because it is worst.

We apply the above strategy for the Japanese market to determine the initial date and value. We choose January 1980 as an initial date and set $S_0^* = P_0^*$. Figure 3(a) indicates that the market price P_{0-j} satisfies the condition of (15) at least from 1975 to 1985. Figure 3(a) also shows that P_{0+t}^* meets the condition of (16) approximately from the year of 1985 to 1998.That is, the Japanese market in this period is under the bubble development, and the size of the bubble is measured by the quantity of $P_{0+t}^* - S_{0+t}^*$. Similarly, Figure 3(b) illustrates the Korean market. We choose the year of 1985 as the base year for the market of Korea. The Korean market is overvalued during the periods approximately from 1986 to1997, and after these periods this market is undervalued.

[INSERT Figure 3]

The concept of overvaluation is generally used to evaluate investors' speculative behaviors. We restrict the analytical period for the overvaluation to the periods of market inefficiency shown in Table 1. For Japan's market, as seen in Table 4, in period I, the maximum of 8 percentage points out of the net overvaluation of $(V_{0+t}^* - S_{0+t}^*)/P_{0+t}^*$ percentage points relative to the market price is a result of market inefficiency $(V_{0+t}^* - P_{0+t}^*)/P_{0+t}^*$. The average of 1.9 percentage points is also a result of market inefficiency. Similarly, in period II, the maximum of 12.8 percentage points out of Korea's net overvaluation, the minimum of –32.7 percentage points, and the average of 6.1 percentage points are the results of market inefficiency.[14]

[14] Previous papers estimated the fundamental value using annual or quarterly data with nonmonetary variables, whereas this paper is interested in monthly data for the sake of practical use and hence has to use a simpler model than the previous ones. However, both the present and the previous definitions of the fundamental value are based on the dividend discount model.

We show the detailed contribution of Japan's market inefficiency $(V^*_{0+t} - P^*_{0+t})/P^*_{0+t}$ to the net overvaluation in Figure 4(a). According to (20), the overvaluation for 1987M4 (49 percentage points, $(P^*_{0+t} - S^*_{0+t})/P^*_{0+t}$ shown in Figure 4(a')) plus the market inefficiency (8.4 percentage points, $(V^*_{0+t} - P^*_{0+t})/P^*_{0+t}$) yields the net overvaluation (57.4 percentage points, $(V^*_{0+t} - P^*_{0+t})/P^*_{0+t}$). The market inefficiency prevents the market price from increasing to the intrinsic value by 8.4 percentage points. On the other hand, for Korea, shown in Figure 4(b'), the overvaluation for 1993M1 (29.1 percentage points) plus the market inefficiency (11.4 percentage points) yields the net overvaluation (40.5 percentage points). The market inefficiency prevents the market price from increasing to the intrinsic value by 11.4 percentage points.

[INSERT Figure 4]

5. Concluding remarks

This paper proposed a new measure of size of market inefficiency for accessing the trading systems, which simultaneously takes care of the intrinsic value of stock and adjustment speed of price. Application this measure to the stock market indices of nine countries during the tow sub-periods from1980 to 2010 reveals that the trading system of the Indian market is the worst in the first period but Korea's is the worst in the second sub- period. The trading system of Japan, Canada, and India improve in the second period, while the trading systems of the USA, France, Italy, Korea, Singapore, and Malaysia become worse in the second period. This paper distinguished the net overvaluation from the nominal overvaluation. This distinction clarifies the significant role of our measure of market inefficiency for analyzing the overvaluation during the periods of bubbles in the markets of Japan and Korea.

Appendix A: Proofs of Propositions

We drive all the propositions stated in this paper without proofs and give a lemma.

Proof of Proposition 1: Rewrite the adjustment process (3) as:

$$\begin{aligned} \mathrm{R_t} &= \left(1-\theta^{+}\right)\left(\mathrm{V_t}-\mathrm{P_{t\text{-}1}}\right)\mathrm{D_t} + \left(1-\theta^{-}\right)\left(\mathrm{V_t}-\mathrm{P_{t\text{-}1}}\right)\left(1-\mathrm{D_t}\right) \\ &= \left\{\left(1-\theta^{-}\right) + \left(\theta^{-}-\theta^{+}\right)\mathrm{D_t}\right\}\left(\mathrm{V_t}-\mathrm{P_{t\text{-}1}}\right) \\ &= \xi_{\mathrm{t}}\left(\mathrm{V_t}-\mathrm{P_{t\text{-}1}}\right). \end{aligned} \tag{A.1}$$

Then, the relation of (6) in (i) holds. On the other hand, from (A.1) we obtain $\mathrm{P_{t\text{-}1}} + (\mathrm{R_t}/\xi_t) = \mathrm{V_t}$. By using this relation, we have (7) in (ii):

$$\mathrm{V_t}-\mathrm{P_t} = \frac{R_t}{\xi_t} - (\mathrm{P_t}-\mathrm{P_{t\text{-}1}}) = R_t\left(\frac{1}{\xi_t}-1\right).$$ **Q.E.D.**

Proof of Proposition 2: Noting that $\mathrm{V_t} = \xi_t^{-1}R_t + \mathrm{P_{t\text{-}1}}$ from (7), we see that

$$\mathrm{V_t}-\mathrm{V_{t\text{-}1}} = \xi_t^{-1}R_t - \xi_{t\text{-}1}^{-1}R_{t-1} + \mathrm{P_{t\text{-}1}} - \mathrm{P_{t\text{-}2}} = \mathrm{a} + \mathrm{u_t} \tag{A.2}$$

because of (1). We have from (A.2)

$$\xi_t^{-1}R_t = \mathrm{a} + (1-\xi_{t-1})\xi_{t-1}^{-1}(R_{t-1}^{+} + R_{t-1}^{-}) + \mathrm{u_t} \tag{A.3}$$

where $\mathrm{P_{t\text{-}1}}-\mathrm{P_{t\text{-}2}} = \mathrm{R_{t\text{-}1}} = \mathrm{R_{t\text{-}1}^{+}} + \mathrm{R_{t\text{-}1}^{-}}$. Considering (6) in Proposition 1, $\mathrm{R_{t\text{-}1}^{+}} = \mathrm{R_{t\text{-}1}} \geq 0$ in (9) corresponds uniquely to $\mathrm{V_{t\text{-}1}}-\mathrm{P_{t\text{-}2}} \geq 0$ in (7), which determines uniquely the value of ξ_{t-1} ($\equiv\left(1-\theta^{-}\right) + \left(\theta^{-}-\theta^{+}\right)\mathrm{D_{t\text{-}1}}$). Similarly, $\mathrm{R_{t\text{-}1}^{-}} = \mathrm{R_{t\text{-}1}} \leq 0$ determines the value of $\xi_{\mathrm{t\text{-}1}}$.

According to (A.3), the return process follows the expression in (8). **Q.E.D.**

Next, we prove the following lemma, which states the expectations of ξ_t and ε_t conditional on the information set I_{t-1}.

Lemma 1: *The conditional expectations of ξ_t and $\varepsilon_t = \xi_t u_t$ are respectively given as*

$$\mathrm{E}\{\xi_t \mid I_{t-1}\} = (1-\theta^{+})\Phi + (1-\theta^{-})(1-\Phi), \tag{A.4}$$

$$\mathrm{E}\{\varepsilon_t \mid I_{t-1}\} = (\theta^{-}-\theta^{+})\sigma_{\mathrm{ut}}\varphi, \tag{A.5}$$

where $\mu_t = \mathrm{a} + (1-\theta^{+})^{-1}\theta^{+}\mathrm{R_{t\text{-}1}^{+}} + (1-\theta^{-})^{-1}\theta^{-}\mathrm{R_{t\text{-}1}^{-}}$, $\Phi = \Phi(\mu_{\mathrm{t}}/\sigma_{\mathrm{ut}})$, $\phi = \phi(\mu_{\mathrm{t}}/\sigma_{\mathrm{ut}})$, *and* Φ and ϕ *respectively denote the distribution and density functions of the standard normal distribution. Moreover, each process of ξ_t and ε_t is serially dependent.*

Proof: Let us define the set $A = \{ R_t \mid R_t \geq 0\}$ and its complement $A^c = \{ R_t \mid R_t < 0\}$. We note that $\xi_t = 1-\theta^+ (\equiv \xi^+$ for all t) if $R_t = R_t^+$, and $\xi_t = 1-\theta^- (\equiv \xi^-$ for all t) if $R_t = R_t^-$. Then, we can write that

$$\xi_t = \xi^+ I_A + \xi^- I_{A^C} \text{ and } \varepsilon_t = \xi_t u_t = \xi^+ u_t I_A + \xi^- u_t I_{A^C}, \tag{A.6}$$

where I_A and I_{A^C} are respectively the indicator functions of the sets A and A^c.

The conditional expectations of I_A and I_{A^C} on I_{t-1} are obtained by:

$$E\{I_A \mid I_{t-1}\} = P\{u_t \geq -\mu_t \mid I_{t-1}\} = 1-\Phi(-\mu_t / \sigma_{ut}) = \Phi, \tag{A.7}$$

and

$$E\{I_{A^C} \mid I_{t-1}\} = 1 - E\{I_A \mid I_{t-1}\} = 1-\Phi. \tag{A.8}$$

Then, (A.4) follows from (A.7) and (A.8).

Next, we calculate the conditional expectation of ε_t. Noting that:

$$\begin{aligned} E\{I_A u_t \mid I_{t-1}\} &= \int_{-\mu_t}^{\infty} u_t (\sigma_{ut})^{-1} \varphi(\mu_t / \sigma_{ut}) du_t \\ &= \sigma_{ut} \int_{-\mu_t/\sigma_{ut}}^{\infty} v\varphi(v) dv = \sigma_{ut}\varphi(\mu_t / \sigma_{ut}) \end{aligned}, \tag{A.9}$$

$$E\{I_{A^C} u_t \mid I_{t-1}\} = \int_{-\infty}^{-\mu_t} u_t (\sigma_{ut})^{-1} \varphi(\mu_t / \sigma_{ut}) du_t = -\sigma_{ut}\varphi(\mu_t / \sigma_{ut}), \tag{A.10}$$

we have (A.2). Because Φ in (A.1) is a function of R_{t-1}^+ *and* R_{t-1}^-, and hence Φ is a function of ξ_{t-1}, it follows that $E\{\xi_t \mid \xi_{t-1}\} \neq E\{\xi_t\}$. Similarly, we can show the serial dependence of ε_t. **Q.E.D.**

Proof of Proposition 3: From (9) and $\xi_t \equiv \left(1-\theta^-\right) + \left(\theta^- - \theta^+\right) D_t$, the return process is rewritten as:

$$R_t = \begin{cases} (1-\theta^+)\mu_t + (1-\theta^+)u_t & \text{for } R_t \geq 0 \\ \\ (1-\theta^-)\mu_t + (1-\theta^-)u_t & \text{for } R_t < 0. \end{cases} \tag{A.11}$$

The conditional density of R_t given I_{t-1} is written as:

$$
\text{pdf}(\mathrm{R}_t;\omega|\,\mathrm{I}_{t-1}) = \begin{cases} \dfrac{((1-\theta^+)\sigma_{ut})^{-1}\phi((R_t-(1-\theta^+)\mu_t)/(1-\theta^+)\sigma_{ut})}{\Phi(\mu_t/\sigma_{ut})} & \text{for } R_t \geq 0 \\ \\ \dfrac{((1-\theta^-)\sigma_{ut})^{-1}\phi((R_t-(1-\theta^-)\mu_t)/(1-\theta^-)\sigma_{ut})}{\Phi(-\mu_t/\sigma_{ut})} & \text{for } R_t \leq 0 \end{cases} \tag{A.12}
$$

Substituting equation (A.12) into the following relation:

$$
\text{pdf}(\mathrm{R}_1,\ldots,\mathrm{R}_T|\omega) = \prod_{t\,\in\,T} \text{pdf}(\mathrm{R}_t;\omega|\mathrm{I}_{t-1}) \ , \tag{A.13}
$$

the required joint density in (9) is obtained. **Q.E.D.**

Appendix B: Derivation of (13)

From equation (12) the growth rate of the fundamental value(η_t) is given by

$$
\eta_t \equiv \frac{S_t^*}{S_{t-1}^*} - 1 = \frac{Q_t}{Q_{t-1}} \frac{1+\lambda_t}{1+\lambda_{t-1}} \frac{\rho_{t-1}-\lambda_{t-1}}{\rho_t - \lambda_t} - 1 \cong \frac{Q_t}{Q_{t-1}} - 1 \ , \tag{A.14}
$$

where an approximation $\frac{1+\lambda_t}{1+\lambda_{t-1}} \frac{\rho_{t-1}-\lambda_{t-1}}{\rho_t-\lambda_t} \cong 1$ is used. Equation (A.14) implies that the growth rate of fundamental value equals the growth rate of dividend ($\eta_t = \lambda_t$). This leads to $\eta_t = \lambda_t = g_t$ by a simplifying assumption. Then, equation (15) follows.

Appendix C: Estimation procedure of Koutmos

This appendix gives some comments on the estimation procedure of Koutmos (1998, 1999). "*Equation (8)*" in Koutmos (1998, p. 280) imposes strong approximation and then should be developed as equations (8) and (9) in this paper. (i) As shown by Lemma 1 in Appendix A in this paper, the conditional expectation of ε_t is not zero and {ε_t} is serially dependent. Hence, ε_t cannot follow the GARCH-type model. (ii) Extending Koutmos (1998), "*equation (4)*" of Koutmos (1999, p. 86) introduces an error term in the asymmetric price adjustment process. However, the error term in "*equation (4)*" causes a discrepancy in the stochastic orders between u_t and ε_t in his "*equations (4) and (5)*" because ε_t is expressed as the difference between u_t and u_{t-1}. In other words, if ε_t is an I(0) process, then u_t becomes an I(1) process. (iii) "*Equation (7)*" of Koutmos (1998, p. 280) and "*(5)*" of Koutmos (1999, p. 86) seem to be approximated in a crude manner. If they might use the approximation of $\theta^+ / (1-\theta^+) \cong \theta^+$ *around* $\theta^+ = 0$, his formula becomes similar to the formulation (8) in this paper. However, his formulation omits ξ_t in (8).

Although his model with rough approximation would provide a useful model for practitioners of empirical analysis, the partial asymmetric adjustment model of Koutmos (1998, 1999) does not logically induce the threshold GARCH model that is used for his empirical analysis.

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Table 1. Summary Statistics for Monthly Returns in Two periods

country		sample period	N of obs.	mean [a]	St.dev.	Skewness [a]	Ex-Kurt [a]	$Q^2(12)$ [b]
Period I :	Japan	1980M1 - 1989M12	120	1.529*	3.323	-0.394	0.985*	61.54*
	USA	1990M2 - 2000M1	120	1.228*	3.081	-0.094	1.576*	12.81
	Canada	1990M9 - 2000M8	120	1.067*	4.223	-1.345*	7.301	6.34
	France	1990M9 - 2000M8	120	1.253	5.456	-0.323	-0.224	14.62
	Italy	1990M4 - 2000M3	120	0.923	6.046	0.037	-0.049	22.56*
	Korea	1979M4 - 1989M3	120	1.662*	5.390	0.096	1.951*	13.19
	Singapore	1986M2 - 1996M1	120	1.184	8.080	-2.479*	15.938*	2.39
	Malaysia	1987M3 - 1997M2	120	1.133*	6.112	-2.071	11.497	3.36
	India	1987M7 - 1997M6	120	1.781*	8.344	0.567*	1.434*	24.30*
Period II :	Japan	1990M1 - 1999M12	120	-0.438	5.152	-0.047	0.855	21.68*
	USA	2000M2 - 2008M5	100	0.197	3.386	-0.983*	2.201*	22.14*
	Canada	2000M9 - 2007M10	86	0.406	3.935	-1.130	1.543	30.35*
	France	2000M9 - 2008M5	93	-0.242	5.323	-0.862*	1.868*	27.53*
	Italy	2000M4 - 2007M10	91	0.029	4.053	-1.640*	5.469*	11.44
	Korea	1989M4 - 1999M3	120	-0.418	7.652	-0.003	0.949*	140.91*
	Singapore	1996M2 - 2006M1	120	0.114	7.507	-0.123	1.829*	42.33*
	Malaysia	1997M3 - 2007M2	120	0.007	7.300	0.029	2.206*	136.26*
	India	1997M7 - 2007M6	120	1.020	6.419	-0.636*	0.000	20.03#

Notes: [a] "*" denotes significant at 10% level. [b] Distributed as $\chi^2(12)$ under the null hypothesis of non-serial correlation with lags of up to 12. "*" ,"#" denotes significant at 5% , 10% levels where the critical values are 21.03 and 18.55.

Table 2. Estimates of Parameters (1) Period I：

Country	a	θ^{+} [a]	θ^{-} [a]	α_0	α_1	α_2	α_3
Japan	1.043	0.440**	0.203	0.049	-0.347	0.170	0.974
	(0.676)	(0.102)	(0.169)	(0.009)	(0.136)	(0.078)	(0.000)
USA	0.759	0.131	0.115	1.003	0.210	-0.303	0.609
	(1.039)	(0.198)	(0.383)	(0.783)	(0.256)	(0.227)	(0.234)
Canada	0.604	0.353**	0.317	-0.032	-0.202	-0.006	1.012
	(1.524)	(0.100)	(0.220)	(0.019)	(0.092)	(0.204)	(0.000)
France	-0.605	0.093**	0.126**	0.035	-0.327	0.004	0.990
	(1.492)	(0.039)	(0.027)	(0.006)	(0.119)	(0.049)	(0.000)
Italy	0.017	-0.056	0.190**	0.111	-0.313	0.004	0.975
	(0.950)	(0.175)	(0.095)	(0.002)	(0.128)	(0.039)	(0.000)
Korea	1.037	0.082**	0.051	0.186	-0.418	0.129	0.948
	(0.273)	(0.009)	(0.094)	(0.000)	(0.055)	(0.002)	(0.000)
Singapore	0.577	0.037**	-0.119	-0.012	-0.398	0.171	0.988
	(0.591)	(0.015)	(0.116)	(0.021)	(0.018)	(0.056)	(0.000)
Malaysia	3.633	0.115**	-0.690**	0.117	-0.191	0.066	0.989
	(0.320)	(0.052)	(0.140)	(0.002)	(0.017)	(0.029)	(0.000)
India	2.910	0.229	0.360**	0.689	0.131	0.138	0.857
	(2.949)	(0.219)	(0.164)	(0.655)	(0.196)	(0.081)	(0.137)

Notes：Robust standard errors are in parentheses. [a] "*" denotes significant at 10% level and "**" denotes significant at 5% level.

Table 2. Estimates of Parameters (2) Period II：

Country	a	θ^{+} [a]	θ^{-} [a]	α_0	α_1	α_2	α_3
Japan	-0.545	0.199*	0.247**	0.202	-0.377	-0.217	0.942
	(0.397)	(0.108)	(0.049)	(0.014)	(0.088)	(0.035)	(0.000)
USA	-0.493	0.270*	-0.062	0.409	0.087	-0.229	0.859
	(1.064)	(0.152)	(0.314)	(0.321)	(0.213)	(0.127)	(0.105)
Canada	1.316	0.164	-0.767**	0.129	-0.496	-0.244	0.946
	(0.270)	(0.102)	(0.172)	(0.044)	(0.117)	(0.017)	(0.000)
France	1.752	0.135	-1.656**	0.306	0.165	-0.288	0.747
	(0.464)	(0.116)	(0.708)	(0.314)	(0.321)	(0.182)	(0.177)
Italy	-0.479	0.476**	0.255**	0.956	-0.929	-0.446	0.727
	(0.517)	(0.044)	(0.117)	(0.012)	(0.207)	(0.212)	(0.001)
Korea	-2.863	0.390**	0.581**	0.010	-0.217	-0.165	1.008
	(0.963)	(0.151)	(0.051)	(0.009)	(0.059)	(0.152)	(0.000)
Singapore	1.344	0.332**	-0.052	0.076	0.235	-0.119	0.973
	(1.361)	(0.131)	(0.284)	(0.141)	(0.122)	(0.081)	(0.028)
Malaysia	0.980	0.278**	0.093	0.094	0.391	-0.091	0.971
	(1.133)	(0.120)	(0.273)	(0.140)	(0.157)	(0.102)	(0.032)
India	0.037	0.153*	-0.072	0.007	-0.277	0.003	1.001
	(1.135)	(0.079)	(0.152)	(0.004)	(0.105)	(0.009)	(0.000)

Notes：Robust standard errors are in parentheses. [a] "*" denotes significant at 10% level and "**" denotes significant at 5% level.

Table 3. Testing Results

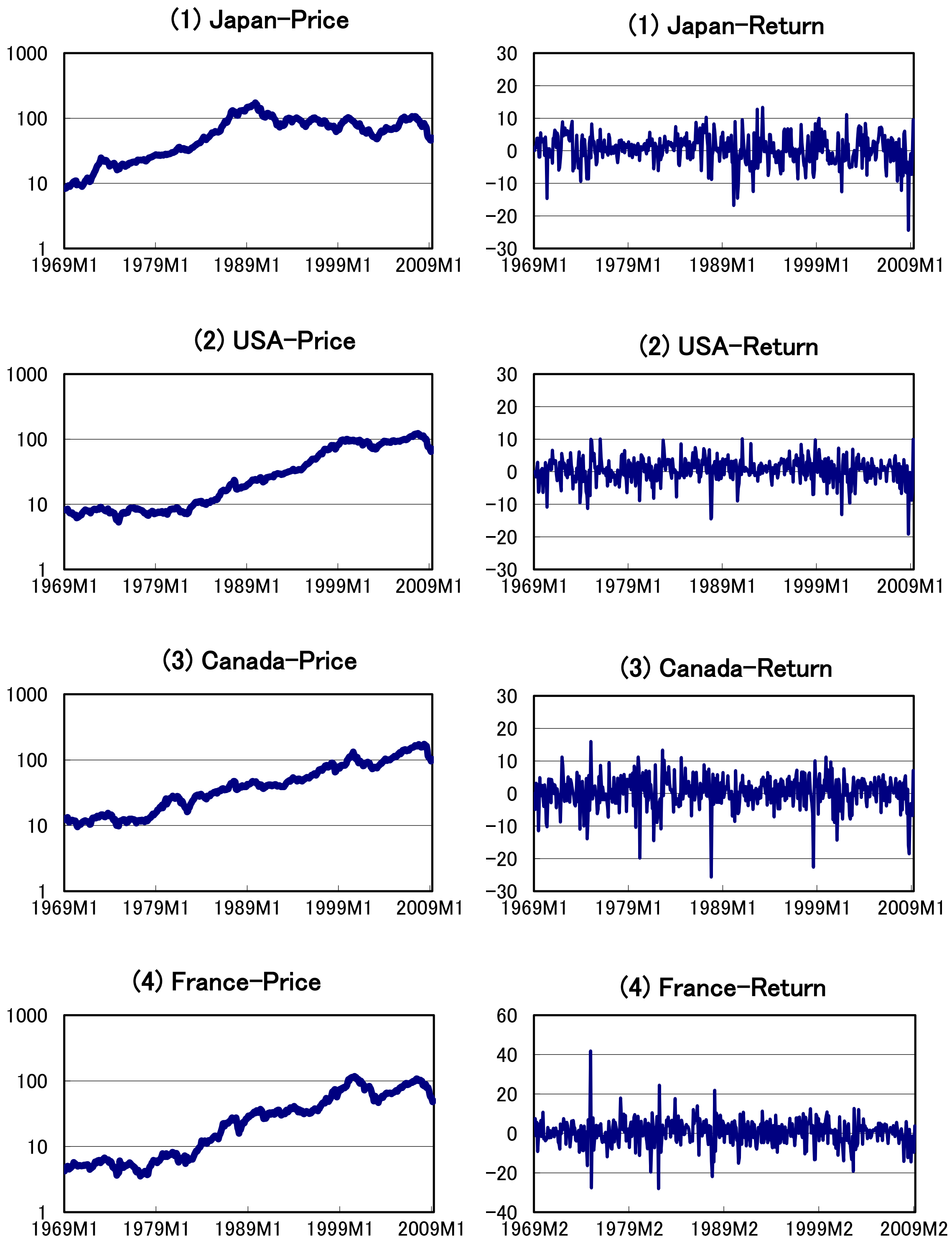
	Period I	Period II
	$H1: \theta^{+}=0$ & $\theta^{-}=0$ ($\chi^2(2)$)	$H1: \theta^{+}=0$ & $\theta^{-}=0$ ($\chi^2(2)$)
Japan	18.93**	35.00**
USA	0.45	4.26*
Canada	473.42**	25.63**
France	33.53**	7.31**
Italy	4.13*	140.42**
Korea	82.11**	167.45**
Singapore	11.99**	9.18**
Malaysia	27.90**	5.44#
India	5.85*	5.67#

Notes : "**" ," * ", "#" denotes significant at 1%,5% and 10% level. The critical values of $\chi^2(2)$ distributions are respectively 9.21, 5.99 and 4.61.

Table 4. $V_t - P_t$: Discrepancy of V_t from P_t

	Period I				Period II			
	Max	Min	Average	Average in $\lvert V_t - P_t \rvert$	Max	Min	Average	Average in $\lvert V_t - P_t \rvert$
Japan	0.080	-0.023	0.016	0.019	0.033	-0.055	-0.003	0.011
USA	0.015	-0.012	0.002	0.004	0.027	0.000	0.006	0.006
Canada	0.061	-0.105	0.007	0.017	0.062	0.000	0.009	0.009
France	0.013	-0.019	0.001	0.005	0.120	0.000	0.016	0.016
Italy	0.000	-0.038	-0.006	0.006	0.066	-0.068	0.009	0.019
Korea	0.015	-0.011	0.002	0.003	0.128	-0.327	-0.026	0.061
Singapore	0.056	0.000	0.003	0.003	0.123	0.000	0.015	0.015
Malaysia	0.150	0.000	0.010	0.010	0.097	-0.025	0.007	0.013
India	0.103	-0.115	-0.001	0.025	0.021	0.000	0.007	0.007

Figure 1. Stock Prices and Their Returns



Notes : Each stock prices are adjusted such that 2000M1 = 100.

Figure 1. Stock Prices and Their Returns (continued)

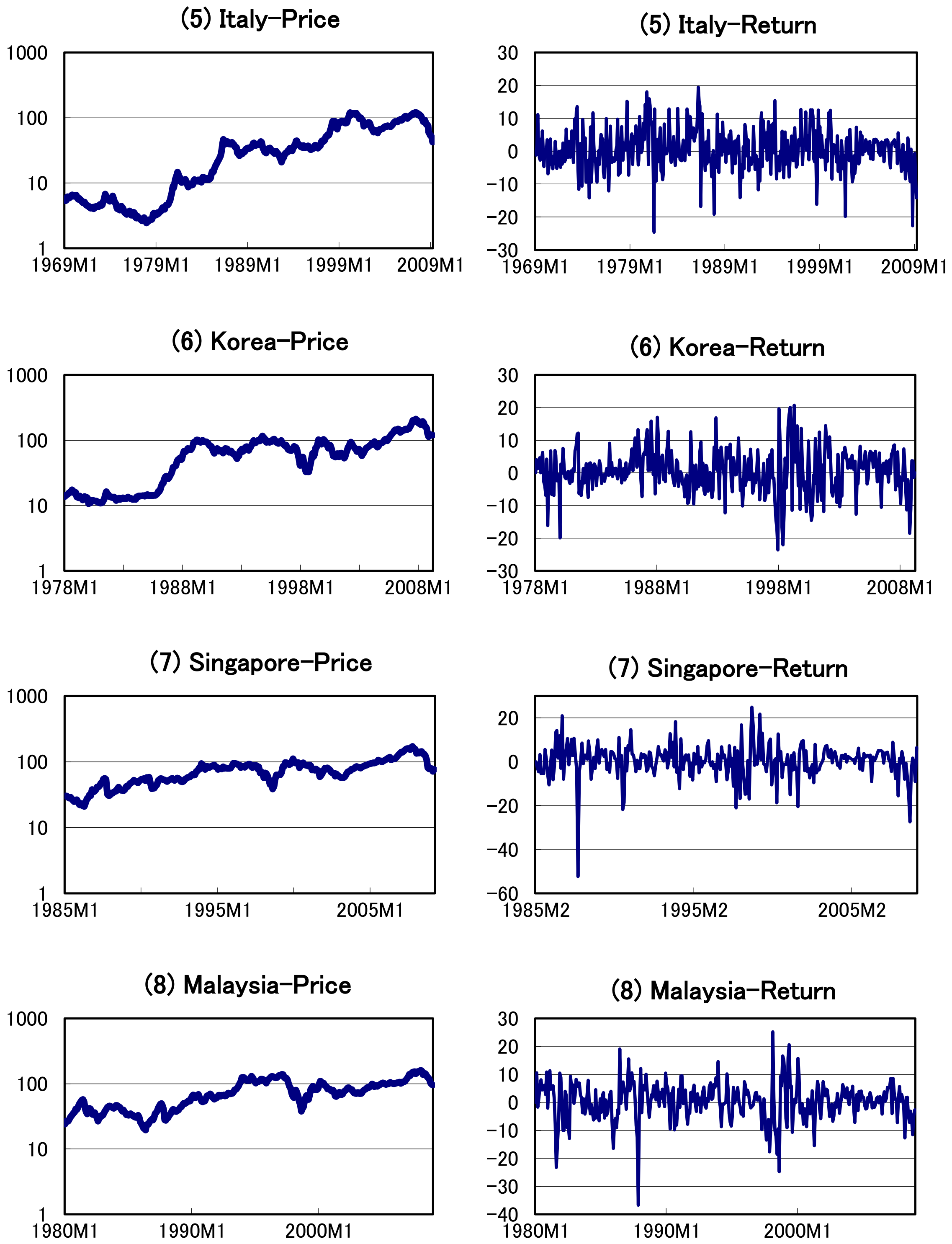
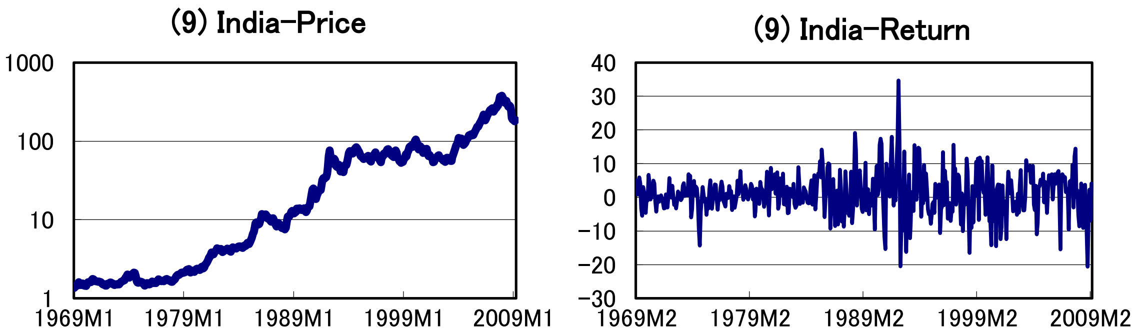


Figure 1. Stock Prices and Their Returns (continued)



Notes : Each stock prices are adjusted such that 2000M1 = 100.

Figure 2. Sizes of Market Inefficiency

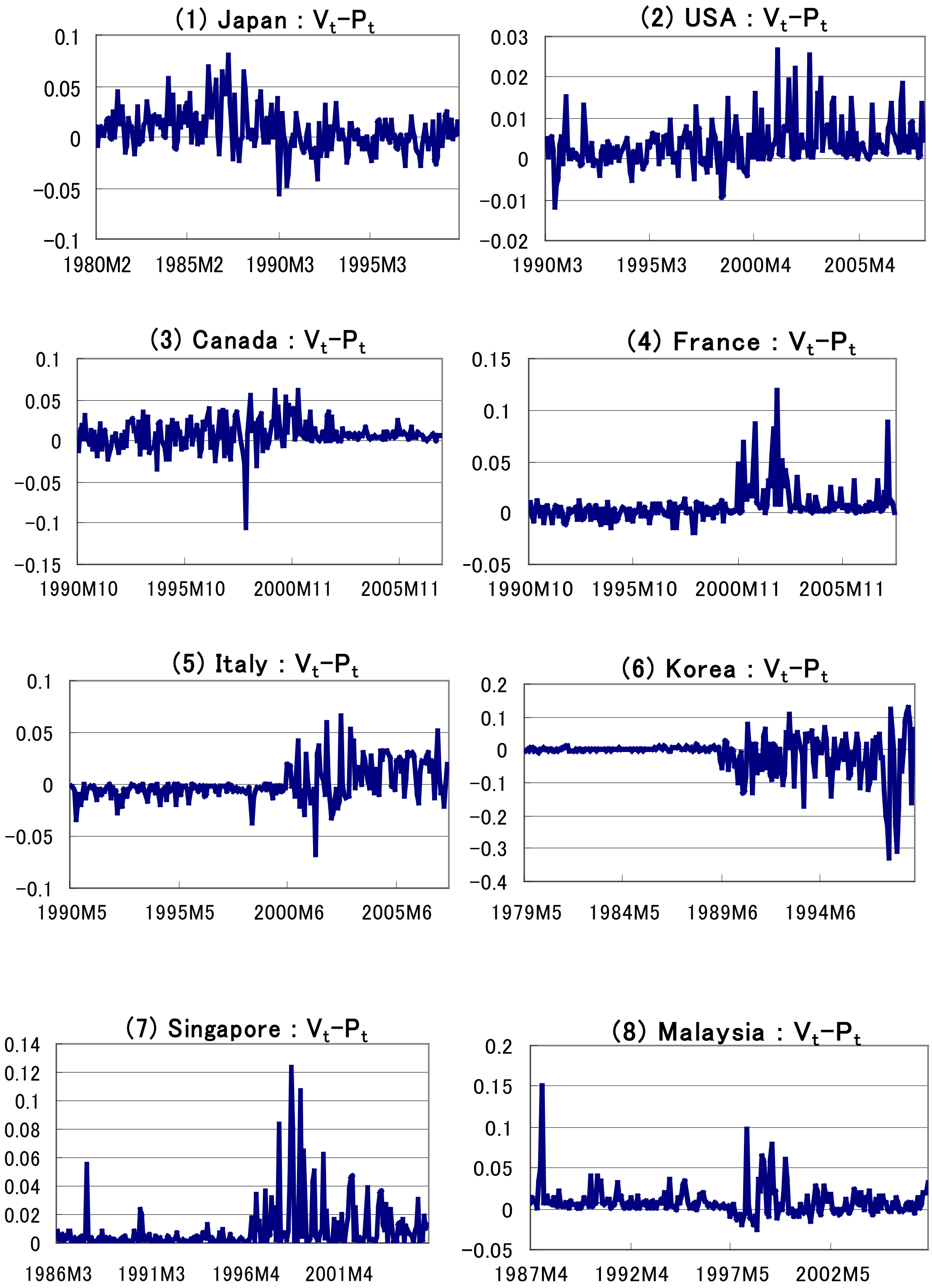
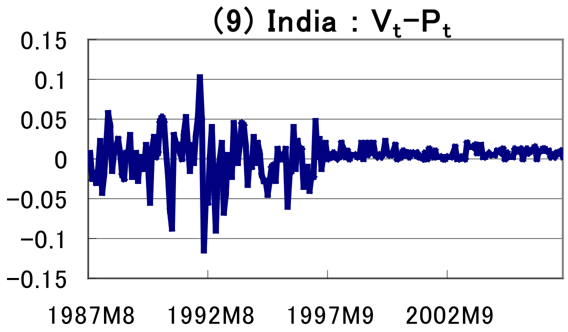
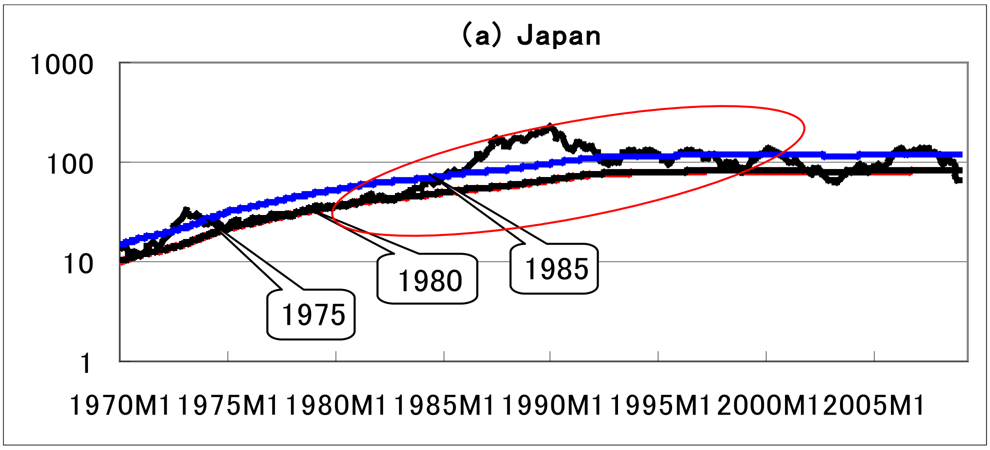


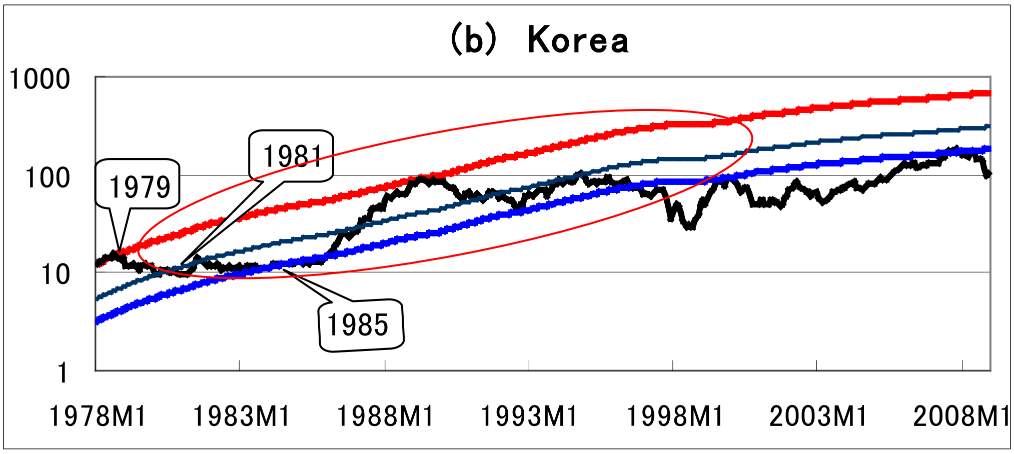
Figure 2. Sizes of Market Inefficiency (continued)



Notes : The size of market inefficiency $V_t - P_t$ implies $(V_t^* - P_t^*)/P_t^*$ of market prices in level.

Figure 3. Market Price vs Fundamental Value

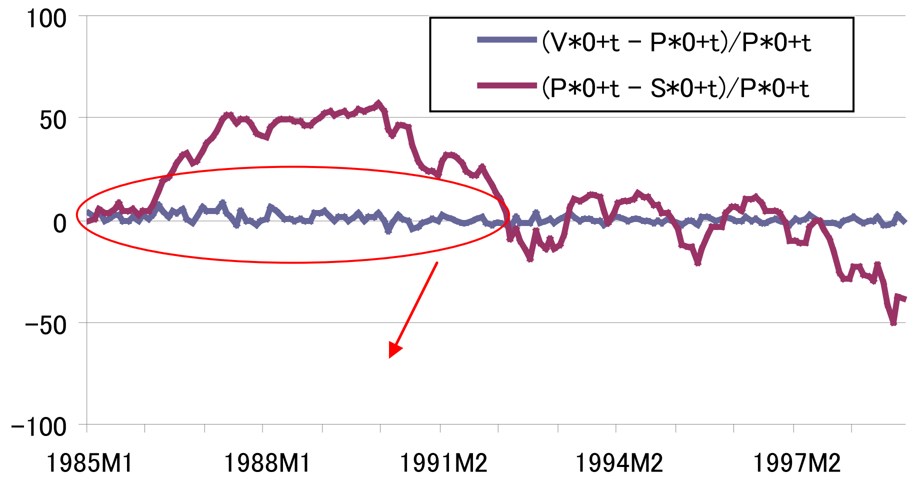




Note: The red circle means the analytical periods.

Figure 4. Contribution of market inefficiency against over-evaluation or under-evaluation (%)

(a) Japan



(a') Japan

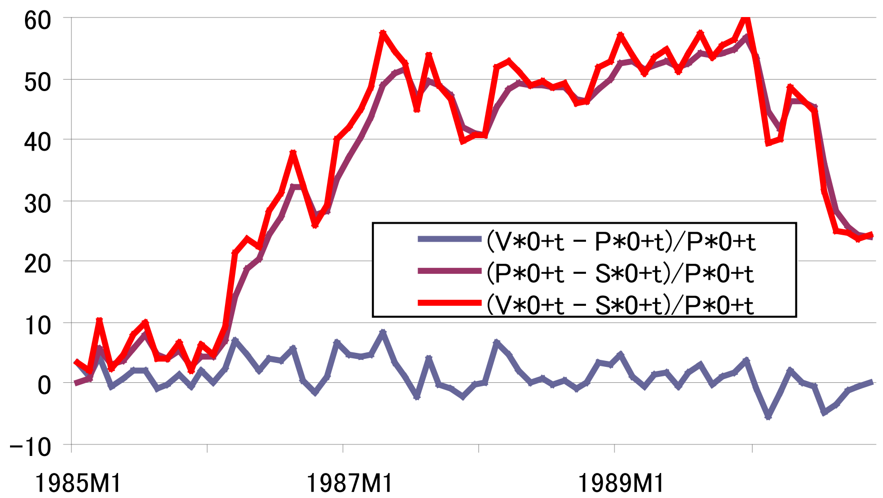
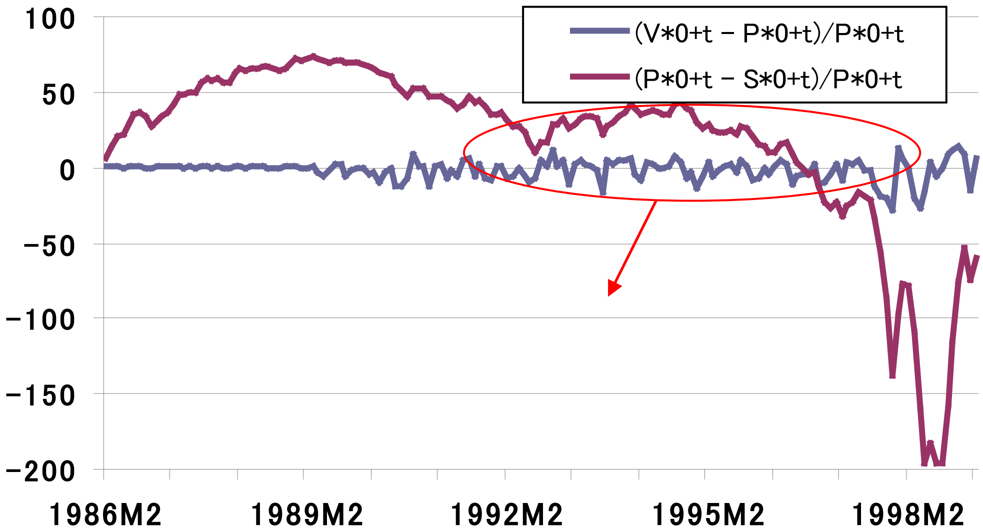
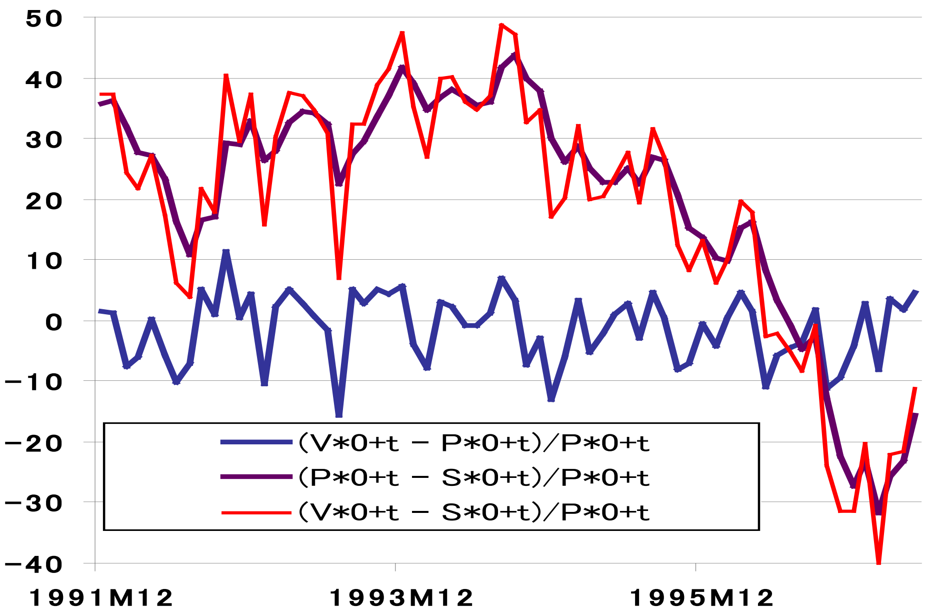


Figure 4. Contribution of market inefficiency against over-evaluation or under-evaluation (%) **(continued)**

(b) Korea



(b') Korea



Note: $(P^*_{0+t} - S^*_{0+t})/P^*_{0+t} + (V^*_{0+t} - P^*_{0+t})/P^*_{0+t} = (V^*_{0+t} - S^*_{0+t})/P^*_{0+t}$

The $(V^*_{0+t} - S^*_{0+t})/P^*_{0+t}$ is a net over-evaluation if positive and a net under-evaluation if negative.