

Market Efficiency, Asymmetric Price Adjustment

and Over (under)-evaluation:

Linking Investor Behaviors to EGARCH

by

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*Abstract:*

The paper incorporates a partial asymmetric price adjustment model for individual actions into an EGARCH model and clarifies the relationship between the price adjustment speed and the market efficiency, asymmetric price adjustment, and over(under)-evaluation of stock prices. The stock price instantaneously and fully adjusts to the intrinsic value if and only if the market is efficient. Thereby, the paper provides a hypothesized individual action with the market efficiency. As an operational example, the Tokyo stock market is found to be inefficient during 1980-2005. The speed of price adjustment is asymmetric in the 80s but symmetric in the 90s and 2000s. The over (under)-evaluation of the stock prices are observed in both periods.

## 1. Introduction.

We get some information shedding the covered truth, looking through the figures. In Figure 1, we can induce to think that during 1980 and 1990 the TOPIX (Tokyo Stock Exchange Price Index) goes up and down around the particular stochastic trend, and that the stock prices over the stochastic trend of its intrinsic value adjust to its trend more quickly than the price under its trend (sometime approaching to its trend instantaneously). After adjustment, the price is still over its trend. How does the investor behave and evaluate its prices over its trend? Can the previous model answer this question?

The stock price formation is silent about the market processes that might deliver the hypothesis on investor behavior. However, there are, so far, some hypotheses on investor behavior. The first idea was formalized by Grossman and Stiglitz (1980). In their theoretical model, the market price does not fully incorporate all knowable information because informed investors make returns by exploiting deviations of prices from security values.<sup>1</sup> Second, without explicitly characterizing investor behaviors, [Busse and Green \(2002\)](#) empirically find that news reports about individual stocks on the financial television network CNBC are incorporated into stock prices within few minutes. They shed light on the degree of efficiency and conclude that the market is efficient enough that a trader cannot generate profits based on widely disseminated news unless he acts almost immediately. Third, Amihud and Mendelson (1987) and Koutmos(1998, 1999) developed and linked the partial adjustment price model for investor behavior to an ARCH-type model. The stock price is adjusted to intrinsic values by portfolio managers and the adjustment speed is different depending on whether the stock price is over or under the intrinsic value.<sup>2</sup>

The purpose of this paper is twofold. First, we explain three propositions like the market efficiency in the framework of a partial price adjustment model for investor behavior, the asymmetric stock price adjustment, the over (under)-evaluation of stock price, and finally link the partial adjustment price model for investor behavior to an EGARCH model to test these propositions. Second, as an operational example of the

<sup>1</sup> Later, [Busse and Green \(2002\)](#) found that the small profits available to very short horizon traders (i.e., informed investors) are consistent with compensation for continuously monitoring information sources, supporting the theory by Grossman and Stiglitz (1980).

<sup>2</sup> Koutmos (1998, 1999) also offered an empirical new finding that the adjustment speed is faster when the stock price is over the intrinsic value. Motivated by his new finding, Pagan and Soydemir (2001), Bang and Shin (2003), and Nam et al. (2003, 2005) have got the same finding as Koutmos (1998, 1999).

model, we examine whether the Tokyo Stock Market is efficient, the asymmetric stock price adjustment works in its market, and the Tokyo stock price is still over (under)-evaluated after adjustment.

The three propositions are all important. First, the definition of market efficiency by Fama (1976) is based on informational concept. It is characterized as one in which security prices fully reflect all available information. In the framework of empirical researches, it is defined as the expectation of the returns conditional on the previous information is constant, i.e.  $E\{R_t | I_{t-1}\} = \text{constant}$ , which is a so-called Fama's random walk form of the market efficiency. The concept of Fama's market efficiency is silent, however, about the market processes that might deliver the hypothesis on investor behavior. Second, Koutmos (1998, 1999) offered an empirical new finding that the adjustment speed is faster when the stock price is over the intrinsic value. Motivated by his new finding of the asymmetric stock price adjustment, Pagan and Soydemir (2001), Bang and Shin (2003), and Nam et al. (2003, 2005) have got the same finding as Koutmos (1998, 1999). However, Koutmos's empirical framework derived from a partial price adjustment model is based on drastic approximation and then should be developed. Third, actual stock price after adjustment is still overvalued when it is over its value. The value is determined by the fundamental factors underlying the asset. Cheung and Ng (1998) and Gjerde and Satterm (1999) related its value to the macroeconomic variables, Hess and Lee (1993) and Lee (1999) related it to other financial variables such as rates of return, dividends, and earnings. Our approach is based on the idea that price approaches value in competitive markets, so that value can be estimated from price directly.

The organization of the paper is as follows. Section 2 sketches a partial adjustment price model by Amihud and Mendelson (1987) and Koutmos (1998, 1999) and defines the asymmetric price adjustment, the market efficiency, over(under)-evaluated price on the model, and link the model to an EGARCH. Section 3 provides the estimation results of the Tokyo Stock Market during 1980-2005. Section 4 gives concluding remarks. Appendix gives proofs of propositions.

## **2. The Model**

### **2.1 Partial Asymmetric Adjustment Model and Market Efficiency**

We follow a partial adjustment price model by Amihud and Mendelson (1987) and Koutmos (1998, 1999) with some modifications. The model distinguishes the unobserved intrinsic value of stock ( $V_t$ ) from the observed stock price ( $P_t$ ), both are

expressed in natural logarithms. The process of intrinsic value follows a random walk process with drift:

$$V_t = a + V_{t-1} + u_t, \quad u_t | I_{t-1} \sim N(0, \sigma_{ut}^2), \quad t=1, \dots, T, \quad (1)$$

where  $a$  is constant and  $I_{t-1}$  denotes the information set of the time  $t-1$ . We assume that the disturbance term ( $u_t$ ) has the EGARCH process proposed by Nelson (1991):

$$\begin{aligned} \log \sigma_{ut}^2 &= \alpha_0 + \alpha_1 z_{t-1} + \alpha_2 (|z_{t-1}| - E(|z_{t-1}|)) + \alpha_3 \log \sigma_{ut-1}^2 \\ u_t / \sigma_{ut} &\sim N(0, 1). \end{aligned} \quad (2)$$

The partial asymmetric adjustment price process of  $P_t$  represents that adjustment costs (like  $\theta^+$ ,  $\theta^-$ ) are asymmetric in up and down markets:

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

where  $(V_t - P_{t-1})^+ = \max\{V_t - P_{t-1}, 0\}$ , and  $(V_t - P_{t-1})^- = \min\{V_t - P_{t-1}, 0\}$ . If  $\theta^+ = \theta^- (= \theta)$ , equation (3) reverts to the basic partial adjustment price process proposed by Amihud and Mendelson (1987). 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 stock price is adjusted by (3) to  $P_t$ . None of Amihud and Mendelson (1987) and Koutmos (1998, 1999), however, investigated the theoretical relationship of partial adjustment price process to the market efficiency. The market efficiency and the asymmetric stock price adjustment based on the partial adjustment price model is defined as follows:

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

This definition of market efficiency indicates that the speeds  $(1 - \theta^+)$  and  $(1 - \theta^-)$  of price adjustment of both positive and negative discrepancy for the intrinsic value are equal to unity in (3), namely the stock price instantaneously and fully adjusts to the intrinsic value:

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

If  $0 < \theta^+, \theta^- < 1$ , the stock price partially adjusts for the intrinsic value. When  $\theta^+, \theta^- < 0$ , the stock price overshoots the intrinsic value.<sup>3</sup> We test the null hypothesis of market

<sup>3</sup> Tsukuda, Miyakoshi and Shimada (2006) have shown the equivalence between our definition and Fama's random walk form of the market efficiency (i.e.,  $E\{R_t | I_{t-1}\} = \text{constant}$ ).

efficiency against the inefficiency of market as shown in (3):

$$H_0 : \theta^+ = \theta^- = 0 \text{ vs } H_1 : \theta^+ \neq 0 \text{ or } \theta^- \neq 0. \quad (5)$$

The symmetric adjustment speed can be tested as

$$H_0 : \theta^+ = \theta^- \text{ vs } H_1 : \theta^+ \neq \theta^-. \quad (6)$$

The stock price is over- (under-) evaluated is defined as follow.

**Definition 2:** The stock price is said to be over-evaluated if  $P_t > V_t$  in (1), under-evaluated if  $P_t < V_t$ , and normal otherwise.

This definition evaluates the stock price in logarithm (after adjustment in (3)). It indicates that the normal price is the intrinsic value, the over-evaluated price is over it, and the under-evaluated price is under it. Hess and Lee (1993) and Lee (1999) related its value to other financial variables such as rates of return, dividends, and earnings. Our approach is based on the idea that price approaches its value in competitive markets, so that the value can be estimated from price directly.

The digit of the partial adjustment price model can be understood by the following theorem.

**Proposition 1:** (i) When the previous stock price is under (over) the intrinsic value at the present period  $t$ , the stock price  $P_t$  at the present period is adjusted to increase (decrease):

$$V_t - P_{t-1} \leq 0 \Leftrightarrow R_t \leq 0 \quad (7)$$

(ii) Over (under)-evaluation is computed from the return and adjustment speeds:

$$P_t - V_t = R_t \left(1 - \frac{1}{\xi_t}\right) \quad (8)$$

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

$$\begin{aligned}
R_t &= (1-\theta^+)(V_t - P_{t-1})D_t^+ + (1-\theta^-)(V_t - P_{t-1})(1-D_t^+) \\
&= \left\{ (1-\theta^-) + (\theta^- - \theta^+)D_t^+ \right\} (V_t - P_{t-1}) \\
&= \xi_t (V_t - P_{t-1})
\end{aligned} \tag{9}$$

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

Then, the relation of (7) holds. On the other hand, (7) yields to  $P_{t-1} + R_t / \xi_t = V_t$ . By using

$$\text{this relation, we get the (8): } P_t - V_t = P_t - P_{t-1} - \frac{R_t}{\xi_t} = R_t \left(1 - \frac{1}{\xi_t}\right).$$

After the intrinsic value  $V_t$  is found at the beginning of period  $t$  and compared with the previous stock price  $P_{t-1}$  ( $V_t - P_{t-1}$ ), the stock price  $P_t$  at period  $t$  is adjusted to increase when  $V_t - P_{t-1} > 0$ , as shown in (7). However, the adjustment speed ( $0 < (1-\theta^+)$  or  $(1-\theta^-) < 1$ ) is less than one (i.e., partially), so that  $P_t$  is still  $P_t > V_t$  or  $P_t > V_t$  shown in (8) after adjustment.

If we can get the parameters  $\theta^+$  and  $\theta^-$  (i.e.,  $\xi_t$ ) in (5), (6), and (8), we can investigate whether the market is efficient, the stock price adjustment is asymmetric, the stock price is over(under)-evaluated.

Koutmos (1998, 1999) only incorporates the asymmetric effects to the partial price adjustment model of Amihud and Mendelson (1987), though he is silent for like market efficiency and over(under)-evaluation of stock prices based on the investor behavior.

## 2.2 The Reduced Model

We have an autoregressive process for the returns.

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

$$R_t^* = a + \theta^+ R_{t-1}^{*+} + \theta^- R_{t-1}^{*-} + u_t, \tag{10}$$

where  $R_t^* = \xi_t^{-1} R_t$ ,  $R_{t-1}^{*+} = \xi_{t-1}^{-1} R_{t-1}^+$  ( $R_{t-1}^+ \equiv \text{Max}\{R_{t-1}, 0\}$ ),  $R_{t-1}^{*-} = \xi_{t-1}^{-1} R_{t-1}^-$  ( $R_{t-1}^- \equiv \text{Min}\{R_{t-1}, 0\}$ ),

and  $\xi_t = 1 - \theta^+$  ( $\equiv \xi^+$  for all  $t$ ) for  $R_t^+$ , and  $\xi_t = 1 - \theta^-$  ( $\equiv \xi^-$  for all  $t$ ) otherwise.

**Proof of Proposition 2:** Noting the facts  $V_t = \xi_t^{-1} R_t + P_{t-1}$  from (9),  $0 < \xi_t < 1$  from (3),

hence  $V_t - V_{t-1} = \xi_t^{-1} R_t - \xi_{t-1}^{-1} R_{t-1} + P_{t-1} - P_{t-2} = a + u_t$ . Considering the last equation, we have

$$\xi_t^{-1} R_t = a + (1 - \xi_{t-1}) \xi_{t-1}^{-1} (R_{t-1}^+ + R_{t-1}^-) + u_t \quad (11)$$

where  $P_{t-1} - P_{t-2} = R_{t-1} = R_{t-1}^+ + R_{t-1}^-$ . Considering (7),  $R_{t-1}^+ = R_{t-1} \geq 0$  in (11) corresponds

to  $V_{t-1} - P_{t-2} \geq 0$  which decide the  $\xi_{t-1} (\equiv (1 - \theta^-) + (\theta^- - \theta^+) D_{t-1}^+)$ . Then, the

$R_{t-1}^+ = R_{t-1} \geq 0$  can decide the  $\xi_{t-1}$ . As a symmetrical to this, the  $R_{t-1}^- = R_{t-1} \leq 0$  can decide the  $\xi_{t-1}$ . The return process has the expression in (10).

The model (10) with (2) is an EGARCH model. Equation (10) is alternatively expressed as

$$R_t = \xi_t (a + \beta^+ R_{t-1}^+ + \beta^- R_{t-1}^-) + \varepsilon_t, \quad (12)$$

where  $\beta^+ = (\xi^+)^{-1} \theta^+$ ,  $\beta^- = (\xi^-)^{-1} \theta^-$  and  $\varepsilon_t = \xi_t u_t$ . If  $\theta^+ = \theta^- (= \theta)$  and then  $\xi_t = 1 - \theta$ , equation (12) reduces to

$$R_t = a(1 - \theta) + \theta R_{t-1} + (1 - \theta) u_t. \quad (13)$$

The process of  $R_t$  in (12) is apparently similar to that of  $R_t^*$  in (10). However, except for the case of  $\theta^+ = \theta^-$ , the conditional expectation of  $\varepsilon_t$  is not zero and the process of  $\{\varepsilon_t\}$  is serially dependent: see Lemma 1 of Appendix in Tsukuda, Miyakoshi and Shimada (2006). The conditional variance of  $\varepsilon_t$  does not follow an EGARCH process unlike to that of  $u_t$ . Then, the joint density function based on equation (12) and (2) is expressed as follows.

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

$$\begin{aligned} \text{pdf}(R_1, \dots, R_T | \omega) = & \prod_{t \in T^+} \left\{ \frac{1}{\sqrt{2\pi\xi^+ \sigma_{ut}}} \exp\left\{-\frac{1}{2\xi^{+2} \sigma_{ut}^2} (R_t - \xi^+ \mu_t)^2\right\} \right\} \\ & \times \prod_{t \in T^-} \left\{ \frac{1}{\sqrt{2\pi\xi^- \sigma_{ut}}} \exp\left\{-\frac{1}{2\xi^{-2} \sigma_{ut}^2} (R_t - \xi^- \mu_t)^2\right\} \right\} \end{aligned} \quad (14)$$

where  $\mu_t = a + \beta^+ R_{t-1}^+ + \beta^- R_{t-1}^-$ ,  $T^+ = \{t | R_t \geq 0, t \in N\}$ ,  $T^- = \{t | R_t < 0, t \in N\}$ ,  $N = \{1, \dots, T\}$ , and  $\omega = \{a, \theta^+, \theta^-, \alpha_0, \alpha_1, \alpha_2, \alpha_3\}$  is a vector of unknown parameters.

The proof is given in Appendix. The model of (12) is estimated by the maximum likelihood estimation method using the joint density of (14). Thus, we get the parameter set of  $\varpi$  including  $(\theta^+, \theta^-)$ , which provides the market efficiency, asymmetric price adjustment, and over(under)-evaluation.

Equation (7) in Koutmos (1998, pp. 280) takes rough approximation and should be developed as equation (12) in this paper. That is, since the conditional expectation of  $\varepsilon_t$  is not zero and  $\{\varepsilon_t\}$  is serially dependent, then  $\varepsilon_t$  can not follow the GARCH model. Though Koutmos (1998) finds empirically useful facts about the stock market movements, the partial asymmetric adjustment model does not logically induce the Threshold GARCH model which is used for his empirical studies. Extending Koutmos (1998), equation (4) of Koutmos (1999, pp. 86) introduces an error term in the asymmetric price adjustment process. However, the error term in equation (4) causes discrepancy of stochastic orders between  $u_t$  and  $\varepsilon_t$  in his equations (4) and (5) because  $\varepsilon_t$  is expressed as difference of  $u_t$  and  $u_{t-1}$ . In other words, if  $\varepsilon_t$  is an I(0) process, then  $u_t$  becomes an I(1) process.

### 3. An Illustrative Example

We investigate the Tokyo Stock Market for illustrating how our model works. The daily closing stock price data of the Tokyo Stock Exchange Price Index (TOPIX) are purchased from the Data Base of Nomura Research Institute, JAPAN. Figure 1 indicates the data of stock prices in natural logarithms and returns from January 4, 1980 to December 2, 2005. It shows the up-trend to the end of 80s, but the down-trend in 90s and 2000s. The returns move mildly in the former period, while they greatly fluctuate in the latter one. Based on these visual observations, the sample period is divided into the two sub-periods: the first is from January 4, 1980 to the end of 80s, the second is from the beginning of 1990 to December 2, 2005.

The results of the parameters in the model (12) with (2) are shown in Table 1. The estimates of the drift term in equation of (12) are positive in the first sub-sample but negative in the second, supporting the up-trend of stock prices in the 80s and the down-trend in the 90s and after. The estimates of  $\alpha_1$  and  $\alpha_3$  reveal asymmetric volatility and variance persistence, supporting the stylized facts for stock price movements.

The first main interests of this study are market efficiency and asymmetric price adjustment speeds to intrinsic values. The estimates of  $\theta^+$  and  $\theta^-$  are positive and significant at 5% level for each sub-sample period. Table 2 shows that the null hypothesis of market efficiency ( $H1: \theta^+ = \theta^- = 0$ ) is rejected in both sub-samples. Thus, the market is inefficient in the sense adjustment speed. The null hypothesis of symmetric adjustment speeds ( $H2: \theta^+ = \theta^-$ ) in equation (3) is rejected in the first sub-sample but not in the second.

How do we interpret the findings? In our framework, the observed values of stock price (i.e., closing prices of the day) are adjusted towards the intrinsic values (security values). The adjustment speeds are  $(1-\theta^+)$  if  $V_t - P_{t-1} \geq 0$  (or equivalently  $R_t \geq 0$  from Proposition 1-(i)) and  $(1-\theta^-)$  if  $V_t - P_{t-1} < 0$  ( $R_t < 0$ ). In particular, in the first sub-sample the speed is  $(1-0.284)$  for the case of under-intrinsic value (positive return), and  $(1-0.199)$  for over-intrinsic value (negative return). The adjustment speeds are significantly different in this period. Koutmos (1998, pp. 285) finds the asymmetric adjustment speeds in many stock markets and argues as “One possibility is that investors have a higher aversion to downside risk, so they react faster to bad news. The use of stop-loss orders is an example of such aversion. Also, portfolio managers feel they are penalized more if they under-perform in a falling market than in a rising market.”

**[ INSERT Figure 1, 2 3 and Tables 1, 2]**

The second main interest of this study is whether the stock prices (i.e., closing price of the day) are over (under)-evaluated. Based on the Definition 2, the intrinsic value and the stock price in natural logarithms are illustrated in Figure 2. The adjustment speed is high in both sub-sample, then the stock prices approach the intrinsic values and the over (under) evaluation of the stock prices are not observed explicitly in Figure 2. However, as shown in Figure 3 with the simulation of low speed ( $\theta^+ = \theta^- = 0.2$ , that is  $1-\theta = 0.8$ ) during 1980-1989, the over (under)-evaluation is explicitly observed, since the stock prices do not approach quickly. Moreover, we simulate the case that  $\theta^+ < 0$  ( $1-\theta^+ > 1$ ) the

stock price overshoots the intrinsic value. As shown in Figure 3, all stock prices are over-evaluated.

#### **4. Concluding Remarks**

We have defined and analyzed three propositions such as the market efficiency in the framework of an asymmetrical partial price adjustment model of Koutmos (1998, 1999) for investor behavior, the asymmetric stock price adjustment, the over (under)-evaluation of stock price, and finally linked the partial adjustment price model for investor behavior to an EGARCH model to test these propositions. We add new view points of market efficiency and over(under)-evaluation to his model. Second, as an operational example of the model, we examine whether the Tokyo Stock Market is efficient, the asymmetric stock price adjustment works in its market, and the Tokyo stock price is still over (under)-evaluated after adjustment. Moreover, Koutmos (1998, pp. 280) took rough approximation to linkage with EGARCH and was developed in this paper. As an illustrative example, we find that the Tokyo stock market is inefficient during 1980-2005 in the sense that the adjustment speeds to the intrinsic values are less than 1. In the 80s, the stock price adjustment is faster when the price is above the intrinsic value than when the price is below it. In both sub-periods, the under (over) –evaluation of stock prices are observed since the adjustment speed to the intrinsic value is slow.

There has never been trial to investigate the market efficiency and over (under)-evaluation of stock prices by using the ARCH-type model with individual actions hypothesis.

## Appendix

*Proof of Proposition 2:* From (11), the return process is rewritten as

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

The conditional density of  $R_t$  given  $I_{t-1}$  is written by

$$\text{pdf}(R_t; \omega | I_{t-1}) = \begin{cases} \frac{1}{\sqrt{2\pi\xi^+ \sigma_{ut}}} \exp\left\{-\frac{1}{2\xi^{+2} \sigma_{ut}^2} (R_t - \xi^+ \mu_t)^2\right\} & \text{for } R_t \geq 0 \\ \frac{1}{\sqrt{2\pi\xi^- \sigma_{ut}}} \exp\left\{-\frac{1}{2\xi^{-2} \sigma_{ut}^2} (R_t - \xi^- \mu_t)^2\right\} & \text{for } R_t < 0 \end{cases} \quad (\text{A.2})$$

Substituting equation (A1) into the following relation

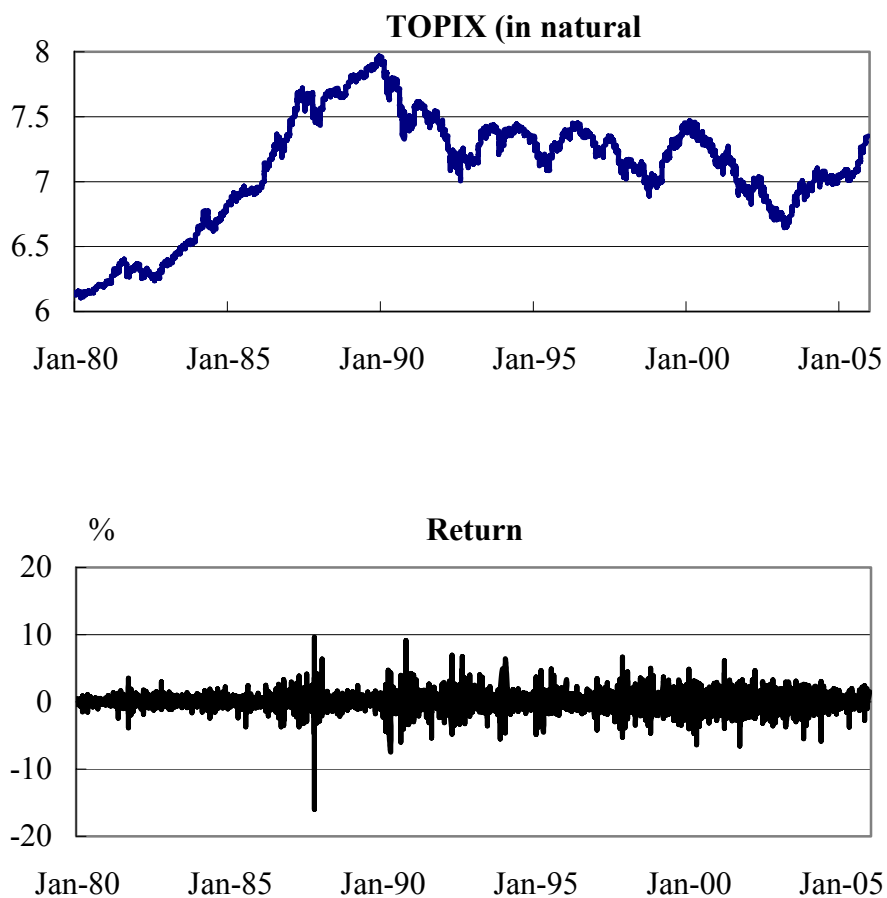
$$\text{pdf}(R_1, \dots, R_T | \omega) = \prod_{t \in T} \text{pdf}(R_t; \omega | I_{t-1}), \quad (\text{A.3})$$

the required joint density in (13) is obtained.

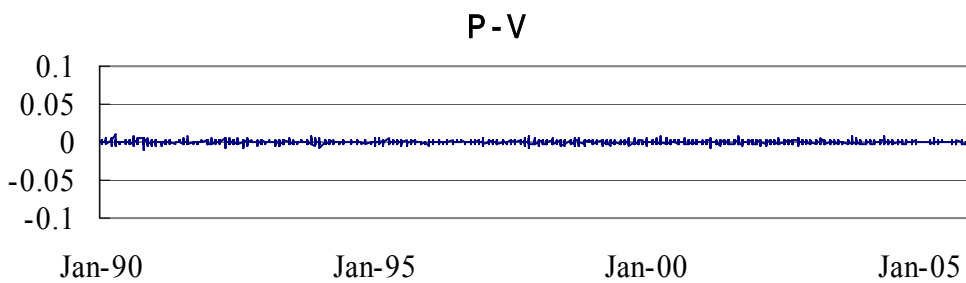
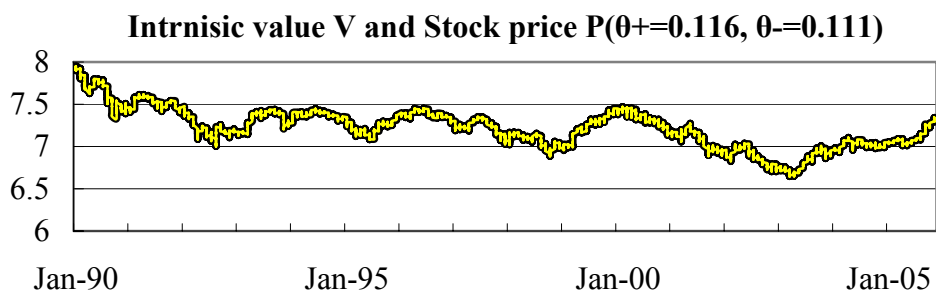
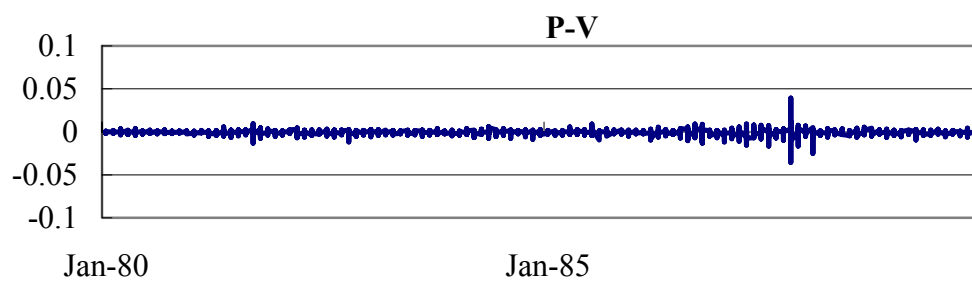
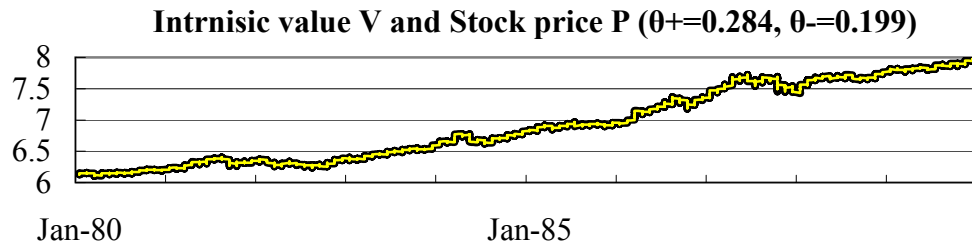
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**Figure 1. TOPIX and Its Returns**

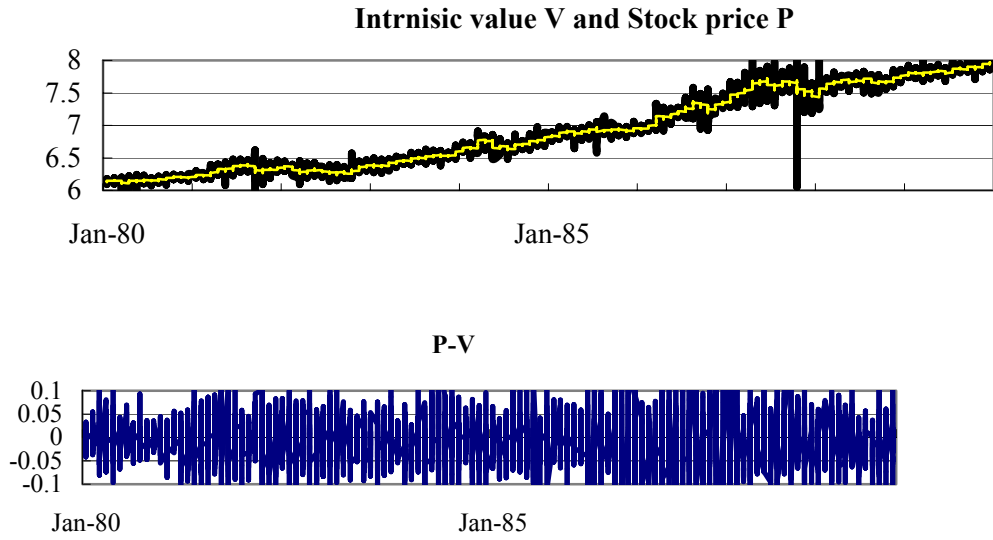


**Figure 2. Actual over(under)-evaluation**

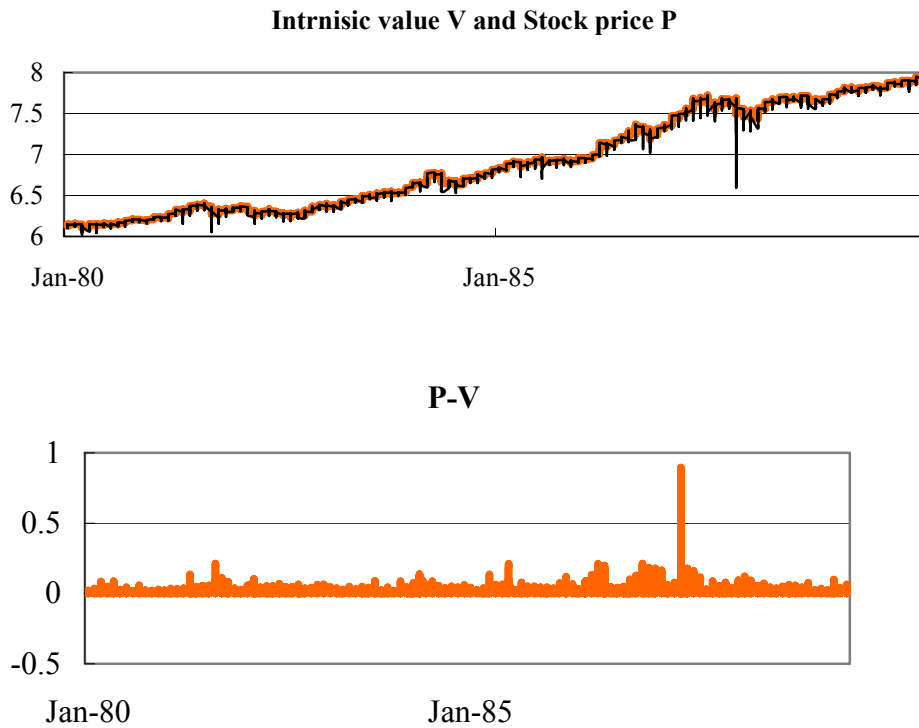


**Figure 3. Simulated over(under)-evaluation: 1980-1989**

$$(\theta^+ = \theta^- = 0.2)$$



$$(\theta^+ = -0.005, \theta^- = 0.85)$$



**Table 1. Estimates of Parameters**

Periods	1/4/80 – 12/ 28/89	1/4/90 – 12/2/05
<b>a</b>	0.00043** (3.93)	-0.00026 (-1.73)
$\theta^+$	0.284* (15.86)	0.111* (5.96)
$\theta^-$	0.199* (7.50)	0.116* (6.27)
$\alpha_1$	-0.151* (-9.80)	-0.098* (-11.46)
$\alpha_3$	0.933* (94.00)	0.964* (180.87)

Notes: The numbers in parentheses denote t-statistics. The asterisk "\*" is significant at 1% level.

**Table 2. Testing Results**

Null Hypothesis	Distribution	1/4/80 – 12/ 28/89	1/4/90 – 12/2/05
H1: $\theta^+ = \theta^- = 0$	$\chi^2(2)$	260.80*	51.00*
H2 : $\theta^+ = \theta^-$	$\chi^2(1)$	16.43*	0.07

Note : The asterisk "\*" is significant at 1% level. The critical values of  $\chi^2(2)$  and  $\chi^2(1)$  distributions are respectively 9.21 and 6.34 at 1% level.