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Determinants of the Tokyo Stock Price Index: Searching for Explanations of the Depression

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Abstract

This paper empirically analyzes the determinants of aggregated stock movements using the Tokyo Stock Price Index (Topix). While recognizing that determinants relevant in the long-run differ from those in the short-term, we confirm that some economic fundamentals such as the dividend-price ratio (DPR) are found to contain useful information for explaining stock prices and returns. Furthermore, we report evidence of nonlinearity in stock returns, and find that DPR is a significant factor in sliding stock prices.

JEL classification: G100
Keywords: Determinants of Topix, Structural breaks

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I. INTRODUCTION

Japanese stock prices have generally followed a declining trend since the financial bubble burst in the early 1990s. The Topix (Tokyo Stock Price Index), which is one of the most frequently cited Japanese aggregate stock price indices, recorded its highest ever level of 2,859.57 in December 1989, but thereafter started to decline reaching only 965.77 points in August 2003. The adverse effects of the bubble bursting have hit the financial sector directly, have spread nationwide, and have led the country into a lingering economic recession.

In addition to their direct relevance to making financial portfolio decisions, stock movements have had significant political and economic implications in the past. In particular, falling stock prices indicate a decline in the credibility of the economic policies implemented by the government and the Bank of Japan (BOJ). Furthermore, due to the forward-looking nature of stock prices, potential investors have viewed companies with stagnating stock prices as facing imminent financial constraints and thus as with a poor business prospects. In light of their political and economic significance, the government has frequently attempted to prevent stocks from declining further by taking direct measures, so-called price keeping operations (PKO). While the government has purchased Japanese stocks under these operations however[1], they seem to have had only marginal and temporary effects, if any, on stock prices (Nagayasu 2003). Therefore, a question often posed to policy-makers is how to improve stock price levels, but no one has yet come up with a proposal with solid empirical evidence.

Against this background, this paper revisits issues related to the determinants of the Topix from a "macroeconomic perspective" and attempts to identify outstanding problems preventing stock recovery. This study is important since although some research has been conducted on the Topix, we do not know the relevance of the explanatory variables previously identified when more recent data are included in the analysis. The explanatory power of some variables might have altered because of recent events such as deregulation and institutional restructuring in the financial sector, measures that were implemented in order to respond to the continuing economic downturn.

Our contribution to the existing literature is threefold. First, given recent questions about the reliability of determinants of Japanese stock prices, the stability of a stock equation is initially examined using the time-series method. This allows us to investigate determinants in the long-run, which may potentially differ from short-term ones. This is in contrast to a primary focus in previous research on short-term movements in stock returns. Second, this paper examines the possibility of nonlinearity in stock returns since their determinants may differ when they are increasing or decreasing. Third, this paper uses low frequency (quarterly) data because of the increased availability of explanatory variables.[2] While a few of these, such as interest rates, are available for an analysis of high frequency data, significantly more explanatory data, including the consumption-wealth ratio, recently reported to contain useful information for predicting U.S. aggregated stock data (Lettau and Ludvigson 2001), can be used for analysis of low frequency data. To our knowledge, no one has yet analyzed the relevance of this variable in the Japanese context.

This paper consists of four sections. Section II reviews previous empirical research focusing on stock return dynamics. Since literature on the Japanese market is rather limited, we also look into experiences in other countries, notably the U.S. Section III presents empirical results, and the paper concludes with Section IV. We conclude that the Topix is determined by conventional economic fundamentals such as the dividend-price ratio although the determinants for the long-term trend in the Topix are not necessarily identical to those for short-term dynamics. Furthermore, relevant explanatory variables when stock returns are increasing slightly differ from those when they are falling. Based on our findings, we argue that the origin of the stagnating Topix lies in the dividend policy of corporations listed on the Stock Exchange.[3]

II. LITERATURE REVIEW

The majority of research has been conducted for U.S. aggregated stock market data, and has focused on stock returns, which are the first difference of the stock price (index) in logarithmic form (i.e., $r_t = log(p_t/p_{t-1})$, where p_t is a stock price index at time t). This data transformation is conducted partly in order to make use of the stationarity of stock returns. Such research has identified a number of indicators that may help select a comprehensive set of determinants for stock returns.[4]

Typical examples of explanatory variables include the dividend-price ratio, book value-price ratio (or the price-book value ratio), the term spread between long- and short-term assets, and short-term interest rates. Campbell, Lo, and MacKinlay (1997) report that among indicators, the interest rate and dividend-price ratio seem to contain much information on U.S. stock returns. In particular, the dividend-price ratio is the most successful explanatory variable for long-horizon forecasts according to their review. More recently, Lettau and Ludvigson (2001) have proposed use of the consumption-wealth ratio. Like the dividend-price ratio, DPR, (e.g., Campbell and Shiller 1988), they derive the relationship between the consumption-wealth ratio ($c_t - w_t$) and the stock returns (r_t) as follows.

$$c_t - w_t = E_t \sum_{i=1}^{\infty} \rho^i (r_{t+i} - \Delta c_{t+i}) \tag{1}$$

where c_t and w_t are log consumption and wealth at time t respectively, and $\Delta c_{t+i} = c_{t+i} - c_{t+i-1}$. The E_t is an expectations operation, and ρ is the ratio of investment to wealth. Notably, like the dividend-price ratio, this equation indicates a positive relationship between the consumption-wealth ratio and stock returns. The empirical study of Lettau and Ludvigson using U.S. data shows that this ratio is a significant explanatory variable and is a better forecaster of stock returns over the short-time horizon than the dividend-price ratio.

There are also some research results for Japanese stock data. Such studies consider the DPR, the price book-value ratio (PBR), and the price-earnings ratio (PER). The positive relationship between the DPR and stock returns has already been mentioned briefly. A low PBR implies that a stock price is undervalued and is thus expected to increase in the future. Similarly, a low PER is often viewed as indicating an undervalued stock price and thus purchasing such stocks is regarded as a good investment. Empirical results seem to support the first two views. A positive relationship between Japanese stock returns and the DPR is reported by Rao, Aggarwal, and Hiraki (1992); a negative relationship between the PBR and stock returns by Chan, Hamao, and Lakonishok (1991) and Aggarwal, Hiraki, and Rao (1992). Somewhat mixed results for the PER have been documented by Aggarwal, Rao, and Hiraki (1990) and Chan, Hamao, and Lakonishok (1991). Among these economic fundamentals, previous research has pointed to the PBR as an important determinant of Japanese stock returns (Chan, Hamao, and Lakonishok 1991; Aggarwal, Hiraki, and Rao 1992). Therefore, these studies seem to suggest that as is the general conclusion of Campbell, Lo, and MacKinlay, Japanese stock returns can be predicted by some of these explanatory variables.[5] However, one concern arises when analyzing recent stock movements–that most of these findings are based on very old data (1960s to early or late 1980s). Thus, the relevance of these explanatory variables is highly questionable in the present context.

III. EMPIRICAL ANALYSIS

Data Description and Preliminary Analysis

Our dataset includes the stock return (r), the dividend-price ratio (DPR), the price-earning ratio (PER), the price-book value ratio (PBR), the term spread ($Term$), and the consumption-wealth ratio (CWR). All data are quarterly and are obtained from the Nikkei Needs database,[6] except "wealth" which is from the Flow of Funds Accounts data compiled by the Bank of Japan.[7] (See Appendix I for detailed information.) The sample period covers 1981Q1 to 1999Q1, and is determined by the availability of the data. Notably, PER and PBR are available from 1981Q1 in this database. Furthermore, wealth data based on the 1963 Systems of National Accounts (SNA) methodology are available until 1999Q1. While more recent wealth data are available, they are compiled using the 1993 SNA. Since reconciliation of these data is extremely complicated because of the different classification, measurement, and valuation methods employed in the data compilation, we shall not attempt to create a recent data set based on the 1963 SNA methodology. Because of this limited sample size and in order to maximize the number of observations for the in-sample analysis, we do not examine the out-of-sample forecasting performance of the stock equation.

Our endogenous variable, the stock, is the Topix, the most comprehensive stock aggregated data in Japan (Figure 1). The Tokyo Stock Exchange (TSE) consists of a first and second section, and the shares listed (about 1,500 companies) on the first section are included in the compilation of the Topix. The basic time-series properties of the log stock returns ($r_t = log(p_t/p_{t-1})$, where p_t is a stock price index at time t) are summarized in Table 1 where it is important to note that the stock return is normally distributed and contains no ARCH components. These results seem to reflect the fact that our stock return is based on low frequency data, and they are also not inconsistent with previous findings that high frequency stock returns frequently exhibit non-normal behavior and contain time-varying volatility.

In addition to the DPR, PER, and PBR that are often examined for Japanese stock data, the $Term$ is considered here as an explanatory variable. The $Term$ is calculated by subtracting the short-term interest rate from the long-term one, and, in this study, is based on the one-month call market rate and the yield on the 10 year government bond. The standard interpretation is that the stock returns will decline along with a rise in the term spread indicating increased inflationary pressure. Therefore, in normal circumstances, it is expected that a negative correlation exists between the term spread and stock returns. Indeed, Campbell, Lo, and MacKinlay (1997) report a negative relationship between the variables using U.S. data.

The standard unit root test, Augmented Dicky-Fuller, is employed to analyze the time-series properties of these data. The results are summarized in Table 2 and show that they are integrated of order one. Non-stationarity of explanatory variables may be a striking result since previous research (see Section II) analyzed the relationship between stock returns and non-transformed (i.e., the level of) explanatory variables, both of which are presumably stationary. This result may be attributable to the sample size considered, but allows us to investigate the stability of a stock equation in the long-run context.

While all the above-mentioned variables are readily available, the CWR needs to be estimated in some way. For this purpose, Lettau and Ludvigson (2001) make the following operational suggestion. Assume that the total assets (W_t) consist of nonhuman (A_t) and human (H_t) assets ($W_t \equiv A_t + H_t$), and this identity could be approximated in logarithmic form as $w_t \approx \beta_1 a_t + (1-\beta_1)h_t$, where indicators with small letters are log variables. By approximating h_t by log labor income (y_t), the CWR can be expressed as:

$$CWR_t = c_t - \beta_a a_t - \beta_y y_t \tag{2}$$

where c_t is log consumption. This can be regarded as one type of consumption function where the consumption is determined by wealth and labor income, and the CWR_t is a residual term. According to this equation, a positive relationship exists between consumption, and both asset wealth and labor income. Furthermore, when these three data are non-stationary and co-integrated,[8] the term, CWR, must be stationary. Lettau and Ludvigson (2001) show that, like the well-known linearized formula for the DPR (Campbell and Shiller 1988), an increasing in the CWR implies a rise in the expected returns on the financial portfolio or a decline in the *expected* consumption growth ($E\Delta c_{t+i}$). The former positive relationship can be interpreted as an excessive (lack of) consumption being associated with an increase (decrease) in the demand for stocks and thus rising (reducing) stock returns. The negative relationship between the present CWR and expected consumption growth is consistent with the stationarity of the CWR, and signals that the excessive consumption will decline in the future. For predicting U.S. stock data, the CWR is found to contain very useful information since it reflects changes in the investors' expectations about future returns (Lettau and Ludvigson 2001).

In order to estimate the CWR, the time-series properties of equation (2) are initially evaluated by Johansen's multivariate co-integration method that is based on the vector auto-regressor (VAR).[9] The presence of co-integration provides evidence of a stationary CWR. As in Lettau and Ludvigson (2001), our specification includes the constant term in the co-integrating vector. Furthermore, the choice of lag lengths, 9, for the VAR is chosen on the basis of several statistical criteria (Table 3). Table 4 summarizes the main results from this method, and confirms that there is one stationary linear combination among our variables. Furthermore, this table presents statistics for the co-integrating vector, β, and the adjustment matrix, α. The β is a vector comprising parameters for our variables in the long-run context ($c_t + \beta_a a_t + \beta_y y_t + \beta_{Const} \sim I(0)$), and α measures adjustment speeds to the long-run paths. The parameter included in β for consumption is normalized and thus our estimates in Table 4 should be interpreted as follows:

$$c_t = 0.253a_t + 0.615y_t + 0.193 \qquad (3)$$

Consistent with standard economic theory and the results from the U.S. data, this suggests that an increase in financial assets and/or income will result in a rise in consumption. The CWR is thus obtained on the basis of equation (3): $CWR_t = c_t - 0.253a_t - 0.615y_t - 0.193$.

The Stability of Stock Price Equations

This section analyzes the stability of the stock price index equation using the time-series method developed by Hansen (1992a). While many other tests are available for the analysis of data instability (e.g., Andrews 1993, Andrews and Ploberger 1994, Bai and Perron 1998), these tests are often designed for stationary time-series and thus are not directly relevant to our analysis in this section. To our knowledge, it is only Hansen's method that considers this issue among a set of non-stationary data, and it has not been employed in a study on stock data. He proposes three test statistics, Lc, $MeanF$, and $SupF$, in order to investigate parameter instability for $I(1)$ variables based on the Fully-Modified OLS (Phillips and Hansen 1990). Details of his test statistics are explained in Appendix II.

Hansen's method is attractive in at least the following two areas. First, the possible endogeneity issue is dealt with in the context of the Fully-Modified OLS. Second, his approach, which analyzes the null hypothesis of parameter stability against the alternative of parameter instability, is also considered as equivalent to a co-integration test. Hansen (1992a, Section 5) argues that finding parameter consistency indicates the existence of co-integration. In this regard, our analysis in this section can be viewed as a study investigating the long-term trend in the stock price index.

Table 5 reports the results from Hansen's tests, and confirms the existence of stability in some form of the stock equation. In this table, several stock equations are considered. Initially, Eq A, which includes all explanatory variables discussed above except the stationary CWR, is estimated. Hansen's tests reveal that Eq A is instable, and furthermore its explanatory variables, PBR and PER, are statistically insignificant. Therefore, we consider other specifications: Eq B that excludes PBR from the original specification, and Eq C that excludes PER. Between these specifications, Eq C is of more interest because there is evidence in favor of parameter stability and also PBR is now marginally statistically significant (t=1.769). The importance of this variable for Japanese stocks is consistent with the findings of Chan, Hamao, and Lakonishok (1991) and Aggarwal, Hiraki and Rao (1992). Furthermore, the superior performance of an equation without PER seems to be consistent with the mixed results of previous studies on the significance of this variable (e.g., Aggarwal, Rao, and Hiraki 1990; Chan, Hamao, and Lakonishok 1991).

The parameter instability in Eq A seems to be caused by instability in the PER. The sequence of Hansen's statistics (F_{nt}, on which Lc, $MeanF$, and $SupF$ are based and that is defined in Appendix II) is plotted for these three specifications in Figures 2–4. Due to a truncation of observations needed to carry out his tests, results from 1983Q4 to 1996Q3 are reported in these figures. Figure 2 shows the sequence of statistics for Eq A and suggests that the parameter instability has existed since as early as 1983. In addition, the instability level is shown to decline and since 1993 has gone below the critical value for $SupF$ provided by Hansen (1992a). What is interesting is that this turning point is largely identical to one suggested by Eq B (Figure 3). Furthermore, Figure 4 indicates that the stock price model becomes stable throughout when PER is removed from Eq A (i.e., Eq C). Therefore, these figures suggest that the mixed results as regards the significance of PER in previous studies are due to the instability of the PER.

Parameter signs reported in Eq C are also consistent with our expectations based on Japanese experience although some are different from the standard theoretical predictions. First, consistent with economic theory, PBR is negatively correlated with the stock price. Second, $Term$ is positively correlated with the stock price. While this sign is inconsistent with theoretical predictions, this result is consistent particularly with the unique situation of Japan that has experienced a recession since the early 1990s and where increased inflation, which raises the term spread through long-term interest rates, is indicative of economic recovery and thus represents encouraging news for the stock market.

Similarly, DPR has a negative sign, which is in contrast to theoretical predictions and previous empirical findings (e.g., Aggarwal, Hiraki, and Rao 1992). However, our findings can be justified on two grounds. First, the results of Aggarwal, Hiraki, and Rao (1992) is based on sample observations from 1966 to 1983, and thus may not be directly comparable with our result. Second and more importantly, our result is consistent with the dividend policy of corporations listed on the TES. In Japan, the provision of dividends is very stable despite stock price movements since it is, in practice, a way to maintain close relations with shareholders. Traditionally, corporations have often provided to shareholders, say, 10 percent of the face value of stocks as dividends. This practice supports the fact that when stock prices were increasing, as in the 1980s, the DPR exhibited a declining trend. By the same token, the DPR has increased along with a decline in the stock price in the 1990s. This trend in dividends remains valid during our sample period, and as a result, there were cases in 1999 and 2002 where payout ratios became negative. Since the payout ratio measures the percentage of earnings paid out in dividends, negative payout ratios confirm that traditional dividend policies were practiced and dividends were indeed paid to shareholders despite poor business performance.

Estimation of Dynamic Stock Return Equation

The existence of stability (co-integration) in the stock price equation allows us to construct an error correction model that helps capture the dynamics of the stock return. In order to obtain a meaningful statistical model, we follow the standard general-to-specific approach. Our general model consists of a maximum of one lagged endogenous and exogenous variables with the constant term. All variables are transformed into stationary data by taking their first difference, and now the variables' names are prefaced by "D" e.g., $D.Topix$. The one exception is a stationary CWR that is included in the stock return equation without any transformation. In addition, consistent with the result of Eq C in Table 5, the error correction term (ECM_{t-1}), specified as $ECM_{t-1} = log(p_{t-1}) + 0.590DPR_{t-1} - 0.019Term_{t-1} + 0.023PBR_{t-1} - 3.721$, is included in this analysis. The specific or parsimonious model is obtained by removing statistically insignificant data.

The intermediate and final results obtained by the OLS are reported in Table 6. The intermediate results (Eq D), which do not include insignificant current (i.e., $t = 0$) variables, show that ECM and $Const$ are significant at the five percent level, and $D.DPR$ at a 10 percent level. Series of diagnostic tests indicate that the residual is white noise, and support the reliability of our estimates. This model is reduced in order to obtain a specific model (Eq E). In Eq E, all remaining variables, $D.DPR$, ECM, and $Const$, are statistically significant and have expected signs. As in our long-run analysis, $D.PER$ is insignificant, and $D.PBR$, which is reported to be significant in the past, is also irrelevant in the short-run context. In addition, unlike results using U.S. data, the CWR does not seem to contain useful information about the dynamics of Japanese stock returns. Put another way, excessive or lack of consumption ($CWR \neq 0$) are not associated with any significant changes in stock returns. Thus, it follows that future stock returns cannot be inferred in Japan from observable consumption behavior, and unlike in the U.S., a consumption boom does not coincide with a stock boom. This result may be attributed to the Japanese preference for safe assets (e.g., Nakagawa and Shimizu 2000). Finally, we have observed fewer economic fundamentals relevant in the short-term. This result is consistent with the conventional understanding that non-fundamentals such as investors' expectations take on more importance in determining short-term movements.

Asymmetry in Stock Returns?

In the previous subsection, we analyzed stock returns assuming that they behave homogenously regardless of the direction of their movements. However, it is quite possible, at least empirically, that stock returns may be affected by different fundamentals depending upon whether they are increasing or decreasing. If this is the case, the estimates reported in the previous section may not reflect accurately the true behaviors of stock returns. Therefore, we extend the analysis by modelling stock returns using a nonlinear model.

In order to investigate this possibility, the following threshold autoregressive model with two regimes is employed.

$$\begin{aligned} y_t = (\phi_{01} + \phi_{11} y_{t-1} + \cdots + \phi_{p1} y_{t-p} + \pi_{11} x_t + \cdots + \pi_{p1} x_{t-p})(1 - (I[y_{t-1} > 0])) \\ +(\phi_{02} + \phi_{12} y_{t-1} + \cdots + \phi_{p2} y_{t-p} + \pi_{12} x_t + \cdots + \pi_{p2} x_{t-p})(I[y_{t-1} > 0]) + \varepsilon_t \end{aligned} \tag{4}$$

where y_t represents stock returns, and x_t is a vector of explanatory variables. $I(k)$ is the indicator function, and equals one if event k occurs and zero otherwise. The threshold point is set as zero, and thus this equation estimates the parameters of explanatory variables for positive and negative stock returns. Initially, all the explanatory variables considered in the previous section are included, and then the model is reduced using the general-to-specific approach (with a maximum p of one).

The results from this model are reported in Table 7 and the probabilities for each regime are plotted in Figure 5. According to our estimates, about 40 percent of stock returns are included in regime 1 ($y_{t-1} \leq 0$), and the rest 60 percent in regime 2 ($y_{t-1} > 0$). Furthermore, the linearity test strongly suggests the nonlinear behavior of stock returns, and thus supports implementation of the nonlinear model.

Among several results, a common finding across regimes is that $D.DPR$ is statistically significant, and those significant parameters are negative. This result is consistent with the outcome from the linear model in our previous section, and thus we conclude the dividend-price ratio is one important element in the depression of the Topix.

In contrast, a notable discrepancy is the convergence speed indicated by the parameter for ECM. Indeed, when the stock returns are negative (and thus in regime 1), strong evidence is obtained for convergence to the long-run path. However, when the stock returns are positive, ECM has a negative, but insignificant parameter. Therefore, strong evidence of convergence reported in the previous section seems attributable to a strong force to move back to the steady state in regime 1.

IV. Summary and Discussion

This paper analyzes the determinants of the Topix using quarterly data. As Japanese stock prices have exhibited a declining trend since the financial bubble burst in the early 1990s and stock prices have attracted the attention of many investors and policy-makers, this paper has revisited this important topic.

Our results suggest that some economic fundamentals are still relevant for explaining stock movements. Unlike previous studies, we differentiate the long-term trend of the stock prices from the stock return movements. Then, we have pointed to indicators such as the term spread, and the price-book value and dividend-price ratios, as key explanatory variables to explain long-term trend in stock prices. In the short-term and stock return contexts, only the dividend-price ratio is found to be significant in addition to the error correction term. Thus, the significance of determinants is sensitive to the focus of the analysis (i.e., on stock prices or returns) of stock movements considered in our research. The fact that more economic fundamentals can explain the long-term trend in stock returns is not particularly surprising since their short-term movements are generally believe to reflect more non-economic fundamentals such as expectations of investors. Finally, using a nonlinear regression method, the dividend-price ratio is found always to be important regardless of the direction of stock returns.

These findings seem to have policy implications for the Japanese stock market. First, we have confirmed that economic fundamentals are still important determinants for explaining stock dynamics, indicating that it is important to improve economic fundamentals in order for strong stock performance. For example, given monetary policies that maintain nominal short-term interest rates at zero percent, higher long-term interest rates seem to play an important role to boost the Topix in the long-run by affecting the term spreads. In this regard, long-term interest rates are worthy of close monitoring. Second, our study shows that the dividend-price ratio is negatively correlated with the Topix both in the long- and short-terms. Traditional dividend policies, which provide a fixed proportion of the face value of stocks, may have worked to establish and maintain close relationships with shareholders, and as a result have facilitated in the strong stock performance in the 1980s. However, this policy has been providing downward pressure during the post-bubble period. In this regard, a more appropriate dividend policy is called for in order to reflect the overall business performance (e.g., profits/losses) of corporations. Obviously, many other factors which could affect the Topix yet are not covered in this study, may well exist. But, according to our estimates, modifying dividend policies should at least ease the declining stock price index. In this connection, it would be interesting to conduct an analysis of Japanese dividend policies in an attempt to understand why these policies have not changed significantly despite many companies experiencing sizable profit losses.

Appendix I.

The consumption data are non-durable consumption and services, and exclude shoes and clothing. The labor earnings are based on wages and incomes. These two types of data are obtained from the Nikkei Needs dataset. Wealth data are stocks of "personal" financial assets based on the Flow of Funds Accounts compiled by the Bank of Japan. Furthermore, in order to obtain as long time series data as possible, this paper uses data compiled following the old SNA (System of National Accounts) methodology. The BOJ disseminates the Flow of Funds Accounts data using two SNA standards (1968 and 1993 System of National Accounts). The international standard for national accounts statistics is the 1993 SNA. These two datasets are very difficult to reconcile because of the different statistical methodologies (i.e., classification and valuation) used in their compilation.

Appendix II

This appendix provides a brief explanation of Hansen (1992a) who proposes several tests in order to analyze the stability of the model. This appendix explains the three tests; namely, the $SupF$, $MeanF$, and Lc statistics. While the null hypotheses are identical for all, the alternatives differ according to the test.

Consider the following linear equation where the stability of parameter Γ is of interest to us and thus allows for a possible change in Γ over time.

$$y_t = \Gamma_t x_t + u_t$$

where u_t is the residual term. The tests examine the null hypothesis of no structural breaks existing in the data. In other words, using the above equation, the null hypothesis can be expressed as: $H_0 : \Gamma_1 = \Gamma_2$. The alternative hypothesis of the first test is $H_1 : \Gamma_1 \neq \Gamma_2$ where t is known. The alternative of the second test is $H_1 : \Gamma_1 \neq \Gamma_2, [t/n] \in T$, i.e., the timing of the structural break is unknown. Hansen (1992a) derives the following statistic:

$$F_{nt} = vec(Z_{nt})'(\widehat{\Omega}_{1,2} \otimes V_{nt})^{-1} vec(Z_{nt})$$

where $Z_{nt} = \sum_{i=1}^{t} \widehat{s}_i$, and $V_{nt} = M_{nt} - M_{nt} M_{nn}^{-1} M_{nt}$ where $M_{nt} = \sum_{i=1}^{t} x_i x_i'$. Based on F_{nt} obtained above, the null hypothesis of the $SupF$ test will be analyzed using the following statistic:

$$SupF = \sup_{t/n} F_{nt}$$

The second and third tests examine the null hypothesis that parameter Γ is a martingale process: $\Gamma_t = \Gamma_{t-1} + \varepsilon_t$ where $E(\varepsilon_t | T_{t-1}) = 0$ and $E(\varepsilon_t \varepsilon_t') = \delta^2 K_t$, where $G_t = (\Omega_{1,2} \otimes V_{nn})^{-1}$. In this regard, the null can be written as: $H_0 : \delta^2 = 0$ against the alternative of $\varepsilon^2 > 0$. The second statistic of $MeanF$ can be expressed as:

$$MeanF = (1/n^*) \sum_{t/n} F_{nt}$$

where $n^* = \sum_{t/n} 1$. Finally, the alternative hypothesis of the Lc test is $H_1 : \delta^2 > 0$, where

$K_t = (\Omega_{1,2} \otimes M_{nn})^{-1}$ and is based on the following calculation.

$$L_c = tr \left\{ M_{nn}^{-1} \sum_{t=1}^{n} Z_t \Omega_{1,2}^{-1} Z_t' \right\}$$

These three tests are used in this paper in order to analyze the stability of the exchange rate equation. These statistics are obtained by making an adjustment for autocorrelation using the vector autocorrelation (AR(1), $u_t = \phi u_{t-1} + e_t$). Furthermore, Bertlett kernel is employed to obtain positive semi-definite estimates for the covariance matrix.

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Footnotes

1. Due to confidentiality concerns, the size and frequency of PKO are not disclosed.
2. High frequency Topix data is analyzed, for instance, by Nagayasu (2004).
3. The terminology, "long-term" and "short-term", used throughout this paper is consistent with that frequently used in co-integration study. In other words, here the long-term analysis involves examination of the stock price, while the short-term study focuses on stock return dynamics.
4. A comprehensive review is provided by Campbell, Lo, and MacKinlay (1997) and Cochrane (2001).
5. Fama (1991) discusses that the presence of explanatory variables could represent market inefficiency since the fundamental determinants may indicate the existence of risk factors.
6. The Nikkei Needs database contains Japanese financial and economic indicators, and is one of the most comprehensive databases in Japan.
7. The definition of data for the derivation of the CWR is largely consistent with Lettau and Ludvigson (2001).
8. While results of the unit root tests are not reported here, each data (c_t, a_t, y_t) is found to follow the unit root.
9. Lettau and Ludvigson (2001) also use this statistical method to obtain the CWR along with the Stock-Watson method. See footnote 8 in their paper.

Table 1: **The Time-Series Properties of Topix**

	Topix
Mean	0.016
Std. Dev	0.077
Skewness	-0.037
Excess Kurtosis	-0.003
Min	-0.165
Max	0.197
Normality test χ^2 (2)=	0.027 (0.874)
ARCH (5) test F(5, 106)=	1.657 (0.151)
ARCH (10) test F(10, 96)=	1.314 (0.234)
ARCH (15) test F(15, 86)=	0.823 (0.650)

Note: Full sample (1981Q1-1999Q1). The statistics in parentheses are p-values. The ARCH test is based on Engle (1982).

Table 2: **Unit Root Tests**

	Level		Difference	
$Topix$	-1.869 (0.345)	[1]	-5.731 (0.000)	[0]
DPR	-1.827 (0.365)	[1]	-5.893 (0.000)	[0]
$Term$	-2.367 (0.155)	[1]	-6.296 (0.000)	[0]
PBR	-1.091 (0.715)	[1]	-6.185 (0.000)	[0]
PER	-2.243 (0.193)	[1]	-6.317 (0.000)	[0]

Note: Full sample (1981Q1-1999Q1). Based on the augmented Dicky-Fuller test. The numbers in parenthesis indicate p-values and those in brackets the lag length used in the test. With the maximum of four lags, the appropriate lag lengths are determined using the Schwarz information criterion.

Table 3: **Lag Selection for VAR**

Lag	LR	EPE	AIC	SC	HQ
0	–	1.73e-05	-2.452	-2.377	-2.421
1	1059.817	6.95e-10	-12.573	-12.273	-12.452
2	302.912	3.98e-11	-15.434	-14.909	-15.221
3	70.912	2.27-11	-15.997	-15.247	-15.693
4	211.203	2.84e-12	-18.075	-17.101	-17.681
5	66.915	1.62e-12	-18.643	-17.444	-18.157
6	45.090	1.15e-12	-18.987	**-17.563**	**-18.410**
7	11.169	1.20e-12	-18.950	-17.301	-18.282
8	16.079	1.18e-12	-18.978	-17.104	-18.218
9	**29.914**	**9.67e-13**	**-19.188**	-17.090	-18.338
10	9.447	1.02e-12	-19.144	-16.821	-18.203

Note: Full sample. LR, EPE, AIC, SC, and HQ refer to sequential modified LR test statistics, Final Prediction Error, and Akaike, Schwarz, and Hannan-Quinn information criteria. The bold items indicate the appropriate lag length implied by the criterion.

Table 4: **Johansen Test**

	Trace statistics	
H_0: Rank		
0	42.822 (0.005)	
1	14.251 (0.279)	
2	4.270 (0.385)	
	β	α
c_t	1.000	-0.494 [0.126]
y_t	-0.615	-0.123 [0.112]
a_t	-0.253	-0.192 [0.068]
$Const$	-0.193	

Note: Full sample. The statistics in parentheses are p-values, and those in brackets are standard errors.

Table 5: **Parameter Stability in Stock Return Equations**

Variable	Eq A	Eq B	Eq C
DPR_t	-0.541 [0.047]	-0.527 [0.029]	-0.590 [0.040]
$Term_t$	0.013 [0.006]	0.012 [0.006]	0.019 [0.006]
PBR_t	-0.004 [0.014]	–	-0.023 [0.013]
PER_t	0.001 [0.001]	0.001 [0.000]	–
$Const$	3.589 [0.009]	3.547 [0.044]	3.721 [0.066]
Lc	0.478 (0.200)	0.586 (0.069)	0.345 (0.200)
$MeanF$	33.726 (0.010)	38.342 (0.010)	4.781 (0.200)
$SupF$	80.320 (0.010)	81.395 (0.010)	0.067 (0.200)
$Bandwidth$	0.992	0.461	0.839

Note: Full sample. The statistics in parentheses are p-values (Hansen 1997).

Table 6: **The Dynamic Stock Return Equation**

Explanatory variable	Eq D	Eq E
$D.DPR_{t-1}$	-0.388 [0.229]	-0.364 [0.103]
$D.Term_{t-1}$	0.019 [0.014]	–
$D.PBR_{t-1}$	0.030 [0.074]	–
$D.PER_{t-1}$	-0.001 [0.001]	–
CWR_{t-1}	0.082 [0.263]	–
ECM_{t-1}	-0.071 [0.033]	-0.364 [0.103]
$Const$	0.298 [0.135]	0.335 [0.133]
Dygnostic test		
AR	F(5, 59)=1.683	F(5, 63)=1.358
ARCH	F(4, 56)=0.269	F(4, 56)=0.406
Normality	$\chi^2(2)$=2.094	$\chi^2(2)$=3.442
Heterogeneity	F(12, 51)=0.821	F(12, 51)=1.476

Note: Full sample. The statistics in brackets are standard errors. Instability tests are based on Hansen (1992b). "D." indicates the first difference of the variable.

Table 7: **Asymmetric Movements in Stock Returns**

	Regime 1	Regime 2
$D.Topix_{t-1}$	-0.241 [0.119]	0.091 [0.132]
$D.DPR_t$	-0.474 [0.092]	-0.543 [0.098]
$D.DPR_{t-1}$	-0.229 [0.153]	0.059 [0.217]
$D.Term_{t-1}$	-0.007 [0.009]	0.008 [0.008]
$D.PBR_{t-1}$	0.041 [0.036]	0.050 [0.060]
ECM_{t-1}	-0.061 [0.022]	-0.006 [0.021]
$Const$	0.221 [0.091]	0.056 [0.085]
Nonlinearity test	33.787	χ^2 (8)=[0.000]
Probability	0.394	0.606

Note: Full sample. For estimating the nonlinear model, the threshold point is set as zero, and the statistics in brackets are p-values. "D." indicates the first difference of the variable. The nonlinearity test is based on Krolzig (1997).

Figure 1: **Topix, 1981Q1–1999Q1** (Measured in yen)

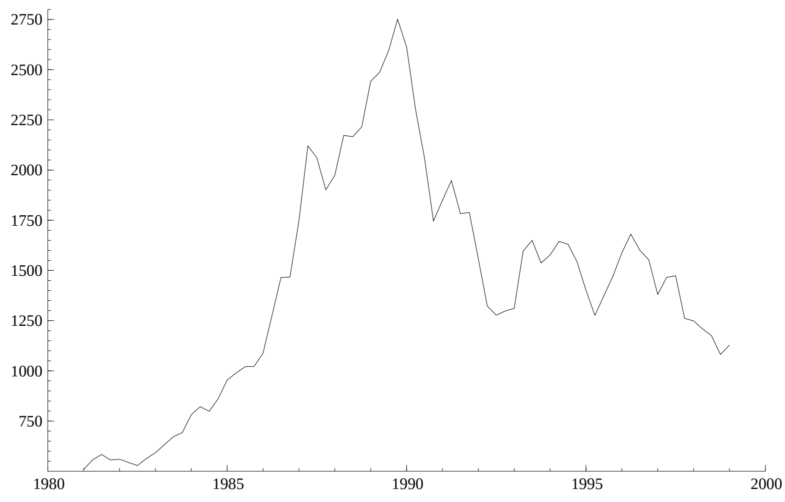
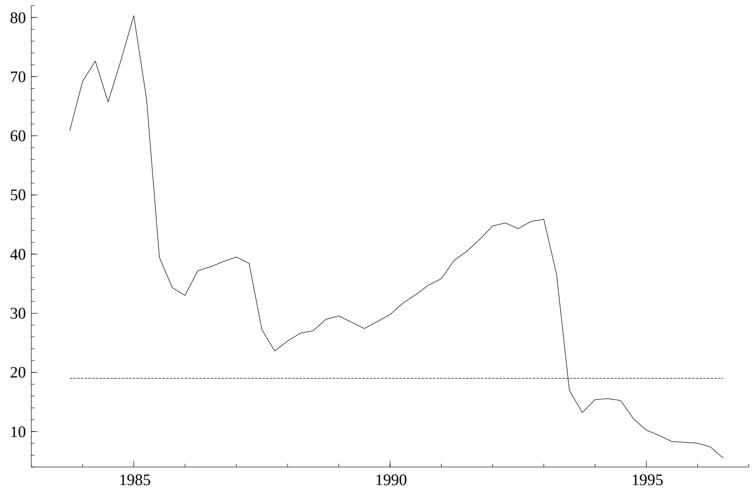
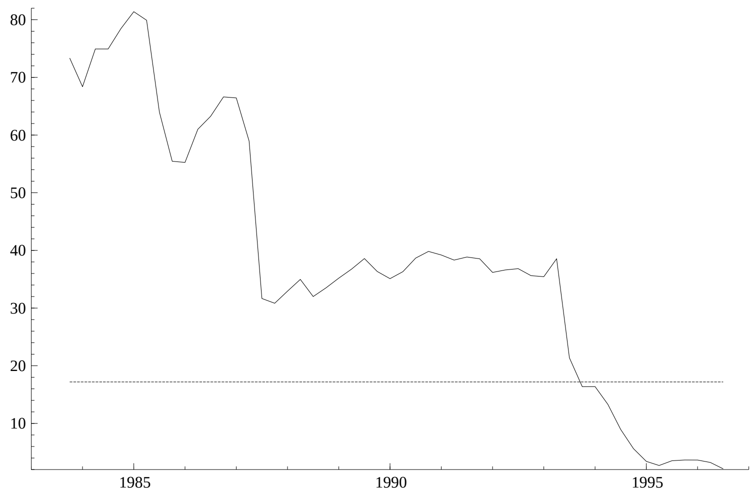


Figure 2: **Parameter Instability Tests for Eq A**



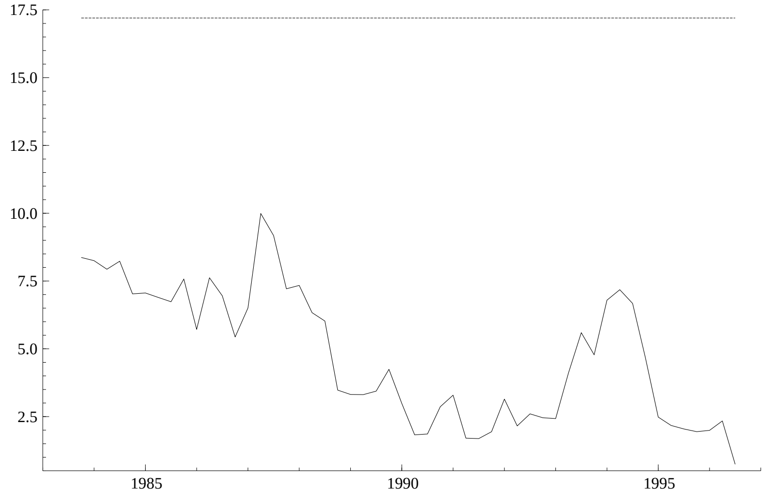
Note: Figures plots the sequence of F_{nt}, and a critical value (a vertical line) for $SupF$ is provided by Hansen (1992a).

Figure 3: **Parameter Instability Tests for Eq B**



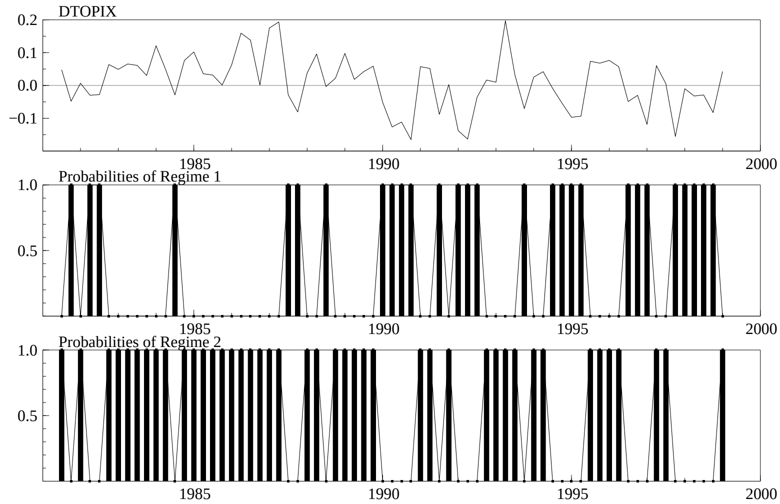
Note: Figures plots the sequence of F_{nt}, and a critical value (a vertical line) for $SupF$ is provided by Hansen (1992a).

Figure 4: **Parameter Instability Tests for Eq C**



Note: Figures plots the sequence of F_{nt}, and a critical value (a vertical line) for $SupF$ is provided by Hansen (1992a).

Figure 5: **The Nonlinear (Switching) Model for Stock Returns**



Note: Regime 1 (2) indicates that the transition variable is negative (positive).