Structural Change in Japanese Business Fluctuations and Nikkei 225 Stock Index Futures Transactions *

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Abstract

Structural changes in business fluctuations have been gathering attention in Europe and the US in recent years. It has become clear that business fluctuations in the US began to stabilize from the middle of the 1980s, and similar structural changes have been observed in Europe. On the other hand, there have been only a few studies concerning structural changes in Japanese business fluctuations. With this background, this paper presents an analysis as to whether or not there has been a structural change in Japanese business fluctuations in recent years, and if so, when and what kind of change.

There are various econometric models for business fluctuations; a common one is the Markov switching model proposed by Hamilton (1989). In this model, it is understood that average growth rates differ between periods of expansion and periods of recession and the shifts between the period of expansion and the period of recession are formulated in accordance with the Markov process. Kim and Nelson (1999) expanded the Markov switching model of Hamilton (1989) considering structural changes and estimated the expanded model by using Bayesian estimation based on Markov chain Monte Carlo. In this paper, maximum likelihood estimation was performed by changing the points of structural change for each period in the model of Kim and Nelson (1999) and the period for which the likelihood becomes the highest is estimated as the point of structural change.

The variables for Japanese business fluctuations used in this paper are composite index (CI) and the index of industrial production (IIP) published by the Economic and Social Research Institute of the Cabinet Office

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of the government of Japan. To focus on structural change in recent years, the sample period was March 1980 to November 2003. It was estimated that the points in time of structural change in business fluctuations were April 1989, based on CI, and January 1992, based on IIP. The analysis also revealed that structural changes were statistically significant for both of the variables. In more detail, average growth rates showed significant reductions for the recession period and for the expansion period, and increases in the amplitudes of business fluctuations and dispersion of short-term deviation from business fluctuations.

The estimated points in time of the structural changes, April 1989 and January 1992, are almost the same as, or just after, the time of commencement of the Nikkei 225 futures transactions. Nikkei 225 futures transactions were blamed for lowering stock prices in Japan, thereby increasing stock price volatility, because stock prices started to drop significantly at the beginning of the 1990s. This paper also presents an analysis of the effect of Nikkei 225 futures transactions on stock price fluctuations and business fluctuations in Japan. More concretely, an analysis was performed to determine whether or not there are any Granger causalities between trading volume or open interest of Nikkei 225 futures transactions and the levels of the Nikkei 225 stock index, CI, IIP or their volatility. The analysis revealed no significant interactions. Therefore, Nikkei 225 futures transactions were not the cause of the instability of stock price fluctuations or business fluctuations in Japan.

I. Introduction

Structural changes in business fluctuations have been gathering attention in Europe and the US in recent years. It has become clear that business fluctuations in the US began to stabilize from the middle of the 1980s (Kim and Nelson 1999, McConnell and Perez-Quiros 2000, Blanchard and Simon 2001, Stock and Watson 2002, Kim, Nelson and Piger 2004), and similar structural changes have been observed in Europe (Artiz, Klolzig and Toro 2004). On the other hand, there have been only a few studies concerning structural changes in Japanese business fluctuations. With this background, this paper presents an analysis as to whether or not there has been a structural change in Japanese business fluctuations in recent years, and if so, when and what kind of change.

There are various econometric models for business fluctuations (Komaki 2001 and Watanabe 2002). A common one is the Markov switching model proposed by Hamilton (1989). In this model, it is understood that average growth rates differ between periods of expansion and periods of recession, and shifts between the period of expansion and the period of recession are formulated in accordance with the Markov process. The likelihood of this model can be evaluated using the filter proposed by Hamilton (1989), so that the parameters of this model can be estimated by the maximum likelihood method. With the maximum likelihood estimates of parameters, applying the filter proposed by Hamilton (1989) and the smoother proposed by Kim (1994) will yield the posterior probability, which is the probability conditional on all observations, of expansion (or recession) in each period. Kim and Nelson (1999) expanded the Markov switching model of Hamilton (1989) considering structural changes. They introduce a dummy variable that takes the value zero prior to the structural change and one after the structural change, and assume that this dummy variable follows a Markov process. Specifically, they assume that when the dummy variable is zero, the probability of switch to one in the next period is positive, but once the dummy variable switches to one, it continues to be one with probability one and never switch to zero. They estimate the expanded model using Bayesian estimation based on Markov chain Monte Carlo.[1] It is, however, possible to estimate the parameters in this model using the maximum likelihood method if the point in time of structural change is given. In this paper, we apply the maximum likelihood method by changing the point of structural change for each period, and estimating the point of structural change as the period for which the likelihood becomes the highest.

The variables for Japanese business fluctuations used in this paper are the composite index (CI) and the index of industrial production (IIP) published by the Economic and Social Research Institute of the Cabinet Office of the Government of Japan. To focus on structural changes in recent years, the sample period is March 1980 to November 2003. It is estimated that the time of the structural change in business fluctuations is April 1989, based on CI, and January 1992, based on IIP. The analysis also reveals that structural changes are statistically significant for both variables. In more detail, the average growth rate of IIP decreases for the both of recession and expansion periods, and the amplitude of business fluctuations and the variance of short-term deviations from business fluctuations increase.

The estimated times of the structural changes, April 1989 and January 1992, are almost the same as, or just after, the time of commencement of the Nikkei 225 futures transactions. Nikkei 225 futures transactions are blamed for lowering stock prices in Japan, thereby, increasing stock price volatility, because stock prices started to drop significantly at the beginning of the 1990s (Miyazaki 1992). This paper also presents an analysis of the effect of Nikkei 225 futures transactions on stock price and business fluctuations in Japan. More concretely, an analysis is performed to examine whether or not there are any Granger causalities between trading volume or open interest of Nikkei 225 futures transactions and the level of the Nikkei 225 stock index, CI, IIP or their volatilities. The analysis reveals no significant causalities, providing no evidence that Nikkei 225 futures transactions are the cause of the instability of stock price and business fluctuations in Japan.

The rest of this paper is organized as follows. SectionII explains the Markov switching model and its extension to take account of structural changes. SectionIII applies the extended model to the analysis of structural changes in business fluctuations in Japan. Section IV analyzes the causalities between Nikkei 225 futures transactions and stock price or business fluctuations in

[1] Uchiyama and Watanabe (2004) analyze structural changes in business fluctuations in Japan using the same model and estimation method as those in Kim and Nelson (1999). The only difference is that while Kim and Nelson (1999) assume that the number of points of structural change is one, Uchiyama and Watanabe (2004) analyze the cases where it is more than one and choose the number of points of structural change based on marginal likelihood.

Japan. Conclusions are given in Section V.

II. Model

II. 1. Markov Switching Model

The analysis in this paper is based on the model proposed by Kim and Nelson (1999). Since this model is an extension of the Markov switching model proposed by Hamilton (1989) to consider structural changes, we start with a brief review of the Markov switching model of Hamilton (1989).

The Hamilton (1989) model assumes that the average growth rates of macroeconomic variables may differ between periods of expansion and periods of recession. This model introduces the following dummy variable to express whether the economy is in the expansion regime or in the recession regime.

$$S_t = \begin{cases} 0, & \text{Re}\,cession \\ 1, & Expansion \end{cases} \tag{1}$$

Let y_t denote the growth rate of a macroeconomic variable defined as the first difference of the log of the variable and specify it as a simple AR process:

$$y_t = \mu_{S_t} + \phi_1(y_{t-1} - \mu_{S_{t-1}}) + \cdots + \phi_p(y_{t-p} - \mu_{S_{t-p}}) + e_t, \quad e_t \sim i.i.d.N(0, \sigma^2), \tag{2}$$

where e_t is an error term, which is assumed to follow an identical and independent normal distribution, and it represents short-term deviations from business fluctuations. The parameter μ_{S_t} is the mean of , y_t that is, the average growth rate of the macroeconomic variable, which may differ depending on S_t, that is, whether the economy is in the expansion regime or in the recession regime. μ_{S_t} is specified as follows.

$$\mu_{S_t} = \mu_0(1 - S_t) + \mu_1 S_t, \qquad \mu_0 < \mu_1 \tag{3}$$

This specification means that the average growth rates are μ_0 in the recession regime ($S_t = 0$), and μ_1 in the expansion regime ($S_t = 1$). It is assumed that $\mu_0 < \mu_1$.

This model is called regime switching model because the mean of y_t may switch depending on the regime.[2] Hamilton (1989) assumes that S_t follows a Markov process with transition probabilities:

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[2] It is straightforward to allow for a switch in the variance of error term σ^2 or $\phi_1, \ldots, \phi_p$ as well as the mean.

$$\begin{aligned} &\Pr[S_t = 0 \mid S_t = 0] = \pi_{00}, \quad \Pr[S_t = 1 \mid S_t = 0] = 1 - \pi_{00} \\ &\Pr[S_t = 0 \mid S_t = 1] = 1 - \pi_{11}, \quad \Pr[S_t = 1 \mid S_t = 1] = \pi_{11} \end{aligned} \tag{4}$$

Hence, his model is called Markov switching model.

The likelihood of this model can be evaluated using the filter proposed by Hamilton (1989), so that the parameters in this model can be estimated by the maximum likelihood method. Applying the Hamilton (1989) filter and the smoother proposed by Kim (1994) will yield the posterior probability of recession (expansion) $\Pr[S_t = 0 \mid y_1,\ldots,y_T]$ $(\Pr[S_t = 1 \mid y_1,\ldots,y_T])$ for each period.

II. 2. Extended Markov Switching Model

Some researchers document that business fluctuations in the US began to stabilize from the middle of the 1980s. Considering such structural changes, Kim and Nelson (1999) extend the Hamilton (1989) model as follows. Let τ denote the time of a structural change. Then, they define a dummy variable that represents whether it is before or after the point of structural change as follows.

$$D_t = \begin{cases} 0, & 1 \le t < \tau \\ 1, & \tau \le t \le T \end{cases} \tag{5}$$

Assuming that the average growth rates in the recession regime, μ_0, and in the expansion regime, μ_1, may differ depending on whether it is before or after τ, they modify equation (3) in the Hamilton (1989) model as follows.

$$\mu_{S_t} = \mu_{0t}(1 - S_t) + \mu_{1t} S_t, \quad \mu_{0t} = \mu_0 + \mu_{00} D_t, \quad \mu_{1t} = \mu_1 + \mu_{11} D_t \tag{6}$$

For example, suppose that the average growth rate in the recession regime increases and that in the expansion regime decreases. Then, $\mu_{00} > 0$ and $\mu_{11} < 0$. To take account of structural changes in σ^2, which is the variance of the error term e_t in equation (2), they specify σ^2 as follows.

$$\sigma_t^2 = \sigma_0^2 + \sigma_1^2 D_t, \quad \sigma_0^2 > 0, \quad \sigma_0^2 + \sigma_1^2 > 0 \tag{7}$$

Then, the variance of e_t, σ_t^2 is σ_0^2 up to $\tau - 1$ and $\sigma_0^2 + \sigma_1^2$ from τ. Since the both of these must be positive, it must be assumed that $\sigma_0^2 > 0$ and $\sigma_0^2 + \sigma_1^2 > 0$. If σ_t^2 decreases from τ, $\sigma_1^2 < 0$.

If τ is given, parameters in this model can also be estimated using the maximum likelihood method. In this paper, we use maximum likelihood estimation by changing τ for each period, and estimate τ as the period for which the likelihood becomes the highest.

III. Data and Estimation Results

The variables for Japanese business fluctuations used in this paper are composite index (CI) and the index of industrial production (IIP) published by the Economic and Social Research Institute of the Cabinet Office of the Government of Japan. The sample period is March 1980 to November 2003, and the sample size is 285.[3)] Figures 1 and 2 plot the time series of these data. We use the growth rate of these variables (the first difference of their log) for y_t, and estimate the extended Markov switching model that allows for structural changes in business fluctuations. We assume that the number of the points of structural change is one and perform the maximum likelihood estimation by changing τ for each period from March 1984 to October 1999. Uchiyama and Watanabe (2004) also analyze the case where the number of the points of structural change is more than two and choose two as the number of the points of structural change based on marginal likelihood. Their sample period is May 1974 to January 2004, and one of the points of structural change they estimate is prior to our sample period. Therefore, assuming that the number of points of strucutural change is one in our sample period will not cause any problem.

Estimation results are summarized in Table 1 and 2. In Table 1, which is the result when CI is used for y_t, the point in time of structural change is estimated as April 1989. This estimate is almost the same as that in Watanabe and Uchiyama (2004), which is March 1989. In this paper, we use the likelihood ratio test to examine whether the structural change is statistically significant. The null hypothesis is:

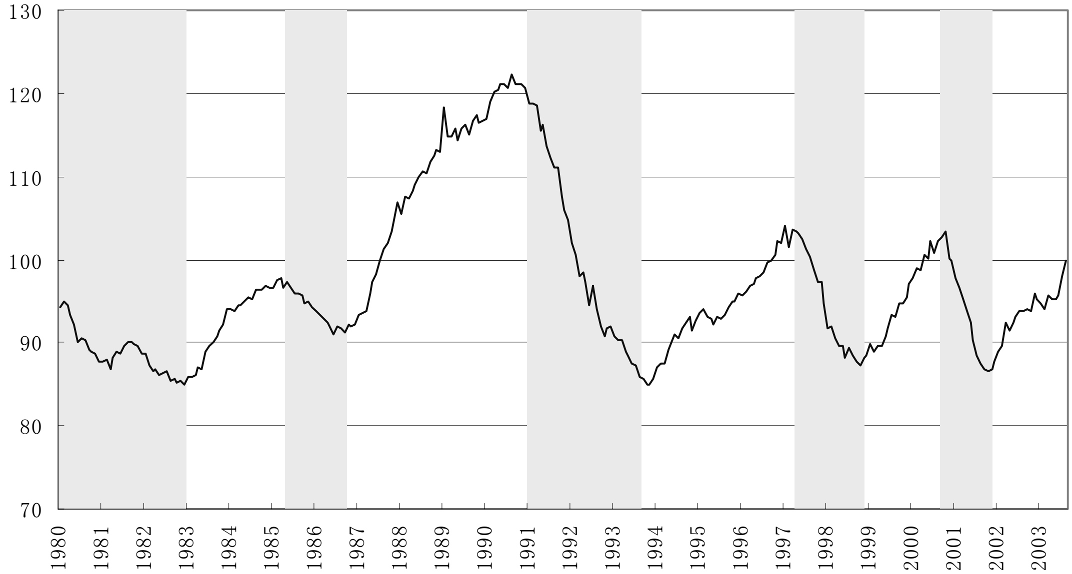
$$H_0 : \mu_{00} = \mu_{11} = \sigma_1^2 = 0 .$$

Hence, the likelihood ratio statistic follows a χ^2 distribution with three degrees of freedom. The value of likelihood ratio statistics is 31.76, so that the structural change is statistically significant at the 1% significance level. Next, look at the parameter estimates to examine what kind of structural changes occurred. The estimates of μ_{00} and μ_{11} are negative and statistically significant at the 1% significance level and the 5% significance level respectively. These results show that average growth rates of CI decrease significantly for both of the recession period and the expansion period. The estimate of μ_{11} is smaller than that of μ_{00}, indicating that the difference in average growth rate of CI between the expansion period and recession period, that is, the amplitude of business fluctuations, increases since April 1989. The estimate of σ_1^2 is positive and statistically significant at the 1% significance level, implying that not only the amplitude of

3) These data are obtained from the web-site of the Economic and Social Research Institute of the Cabinet Office of the government of Japan.

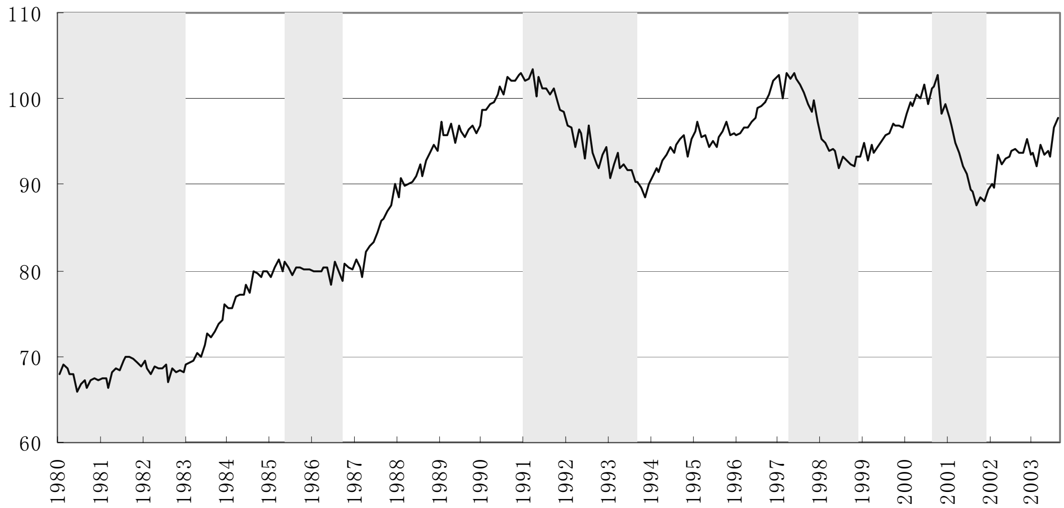
business fluctuations but also the variance of the short-term deviation from business fluctuations increases. Similar results are obtained in Uchiyama and Watanabe (2004).

Figure 1. Compsite Index (CI)



Note: The shaded areas represent the periods of Economic and Social Research Institute (ESRI) recessions.

Figure 2. Index of Industrial Production (IIP)



Note: The shaded areas represent the periods of Economic and Social Research Institute (ESRI) recessions.

Table 1. Estimation Result for Composite Index (CI)

Estimate of τ = April, 1989

Likelihood ratio statistic = 31.76

	ϕ_1	ϕ_2	μ_0	μ_{00}	μ_1	μ_{11}	σ^2_0	σ^2_{00}	p_{11}	p_{00}
Estimate	−0.323	−0.026	−0.412	−0.718	0.682	−0.194	0.543	0.553	0.961	0.933
Standard Error	0.065	0.066	0.097	0.154	0.085	0.117	0.079	0.147	0.016	0.026
t-value	−4.956	−0.390	−4.229	−4.669	8.054	−1.665	6.903	3.770	59.705	35.514

Table 2. Estimation Result for Index of Industrial Production (IIP)

Estimate of τ = January, 1992

Likelihood ratio statistic = 21.24

	ϕ_1	ϕ_2	μ_0	μ_{00}	μ_1	μ_{11}	σ^2_0	σ^2_{00}	p_{11}	p_{00}
Estimate	−0.689	−0.319	−0.066	−0.768	0.736	−0.343	0.963	0.447	0.924	0.901
Standard Error	0.067	0.066	0.067	0.150	0.092	0.121	0.135	0.239	0.031	0.037
t-value	−10.356	−4.848	−0.979	−5.121	8.006	−2.832	7.115	1.867	29.889	24.600

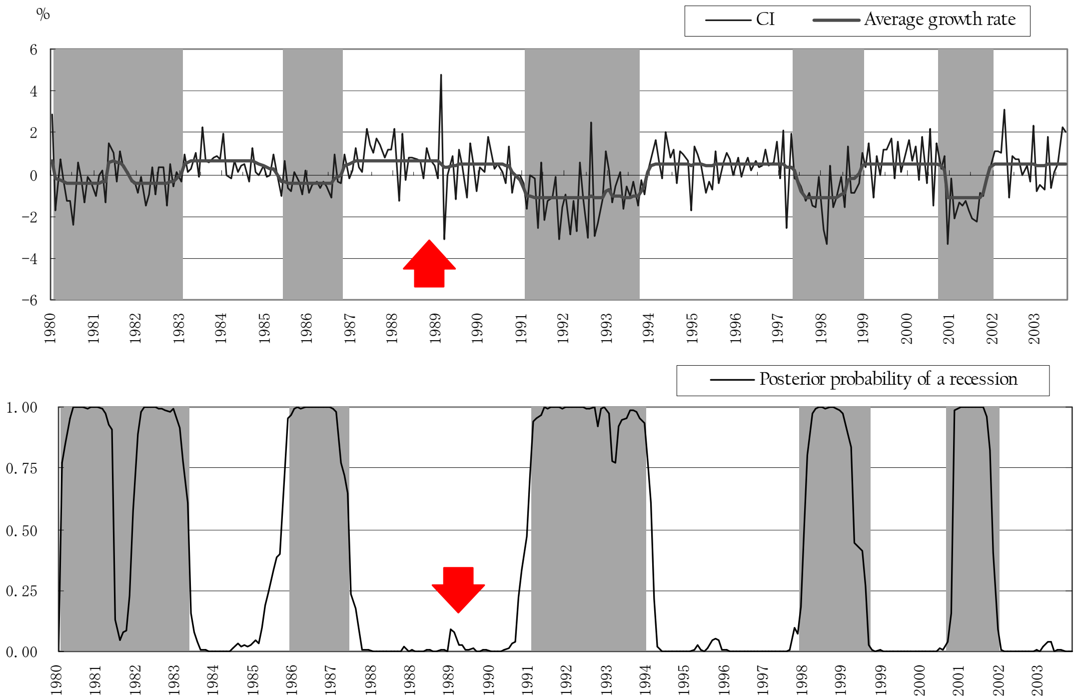
Table 2 contains the estimation result for IIP. The time of the structural change is estimated as January 1992. The value of likelihood ratio statistic is 21.24, so that the structural change is statistically significant at the 1% significance level. The estimation results are qualitatively the same as those for CI. The average growth rate of IIP decreases for the both of recession and expansion periods, and the amplitude of business fluctuations and the variance of short-term deviations from business fluctuations increase since January 1992.

Applying the Hamilton (1989) filter and the Kim (1994) smoother with the maximum likelihood estimates of parameters shown in Tables 1 and 2 will yield the posterior probability of recession $\Pr[S_t = 0 \mid y_1,\ldots,y_T]$ for each period. They are plotted in Figures 3 and 4. The shaded areas represent the periods of recessions (from peak to trough) published by Economic and Social Research Institute of the Cabinet office of the government of Japan. Once the posterior probability of recession $\Pr[S_t = 0 \mid y_1,\ldots,y_T]$ and that of expansion $\Pr[S_t = 1 \mid y_1,\ldots,y_T]$ are obtained, the posterior mean of average growth rate can be calculated as follows.

$$E[\mu_{S_t} \mid y_1,\ldots,y_T] = \mu_{0t} \Pr[S_t = 0 \mid y_1,\ldots,y_T] + \mu_{1t} \Pr[S_t = 1 \mid y_1,\ldots,y_T] \tag{8}$$

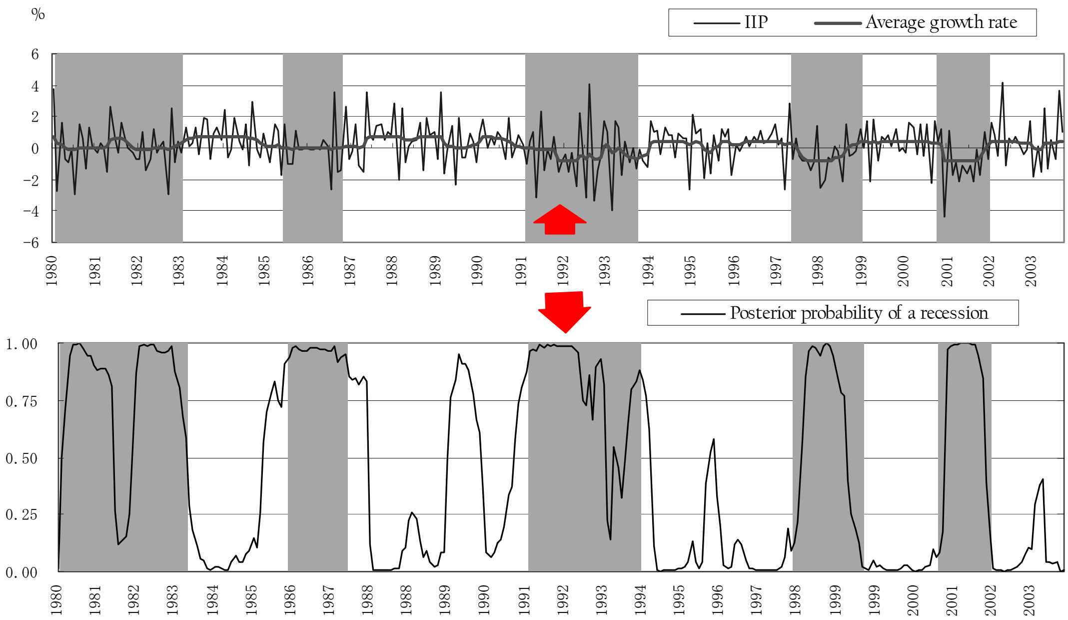
They are plotted with the growth rate of CI or IIP in Figures 3 and 4.

Figure 3. Average growth rates and posterior probabilities of a recession for CI



Note1: The shaded areas represent the periods of Economic and Social Research Institute (ESRI) recessions.
Note2: Arrows represent the time of structural change

Figure 4. Average growth rates and posterior probabilities of a recession for IIP



Note1: The shaded areas represent the periods of Economic and Social Research Institute (ESRI) recessions.
Note2: Arrows represent the time of structural change

IV. The Influence of Nikkei 225 Stock Index Futures Transactions

IV. 1. Method

In the previous section, the time of the structural change is estimated as April 1989 for CI and January1992 for IIP. They are almost the same as, or just after the time of commencement of the Nikkei 225 futures transactions. Precisely, the transaction of the Nikkei 225 futures started at SIMEX (currently, SGX–DT) in September 3, 1986 at Osaka Securities Exchange in September 3, 1989 at CME in September 25, 1990. Only because stock prices started to drop dramatically at the beginning of 1990 just after the commencement of the Nikkei 225 future transactions, Nikkei 225 future transactions were blamed for lowering stock prices and increasing stock price volatility in Japan. For example, Miyazaki (1992) attributes the cause of stock market crash to investors' behavior of "buying in the futures market and selling in the spot market" to cancel arbitrage transactions. We cannot, however, conclude whether Nikkei 225 futures transactions influence stock prices and business fluctuations negatively only because of the coincidence of the time of commencement of the Nikkei 225 future transactions, the stock market crash, and structural change in business fluctuations in Japan

In this section, we examine whether Nikkei 225 futures transactions may influence stock prices and business fluctuation in Japan. Specifically, we analyze how Nikkei 225 stock index, CI and IIP are influenced by the trading activity of Nikkei 225 futures. The variables for the trading activity of Nikkei 225 futures used in this paper are trading volume and open interest, which are the sum of those in Osaka Securities Exchange and in SGX–DT.[4)] Because the unit of trading is 1,000 yen×index in Osaka Securities Exchange while it is 500yen×index in SGX–DT, we add 1/2×trading volume (open interest) in SGX–DT to trading volume (open interest) in Osaka Securities Exchange. These data are plotted in Figures 5 and 6.

We use the following two–stage estimation to analyze the effect on the volatility of Nikkei 225, CI and IIP as well as their levels. Define x_t =the growth rate of CI, IIP or Nikkei225 and y_t =the growth rate of the trading volume or open interest of Nikkei 225 futures. First, we estimate the following VAR model to analyze the effect on the level of Nikkei 225, CI and IIP.

$$x_t = \omega_1 + \sum_{k=1}^{p} a_k x_{t-k} + \sum_{k=1}^{p} b_k y_{t-k} + u_{1t} \tag{9}$$

$$y_t = \omega_2 + \sum_{k=1}^{p} c_k x_{t-k} + \sum_{k=1}^{p} d_k y_{t-k} + u_{2t} \tag{10}$$

The reason growth rates (the first log difference) are used for x_t and y_t is that the presence

4) These data arte obtained from Futures & Options Reports published by Osaka Securities Exchange.

of unit root is not rejected using an ADF test.

Next, we estimate the following VAR model to analyze the effect on the volatility of Nikkei 225, CI and IIP.

$$|u_{1t}| = \omega_3 + \sum_{k=1}^{p} e_k |u_{1t-k}| + \sum_{k=1}^{p} f_k y_{t-k} + u_{3t} \tag{11}$$

$$y_t = \omega_4 + \sum_{k=1}^{p} g_k |u_{1t-k}| + \sum_{k=1}^{p} h_k y_{t-k} + u_{4t} \tag{12}$$

where $|u_{1t}|$ is the absolute value of the residual in equation (9).

The sample period used for these estimations is June 1992 to January 2003.

Figure 5. Trading volume of Nikkei 225 futures

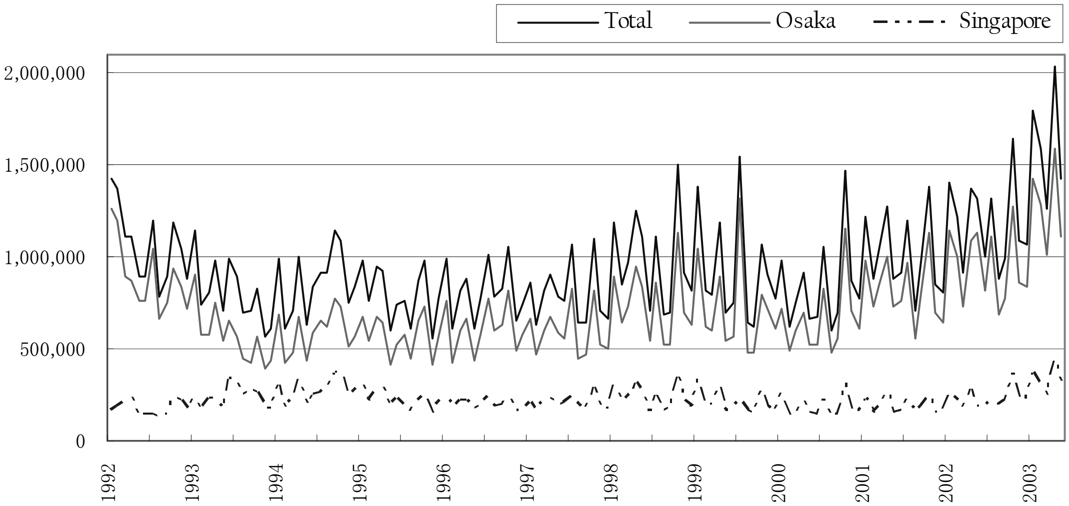
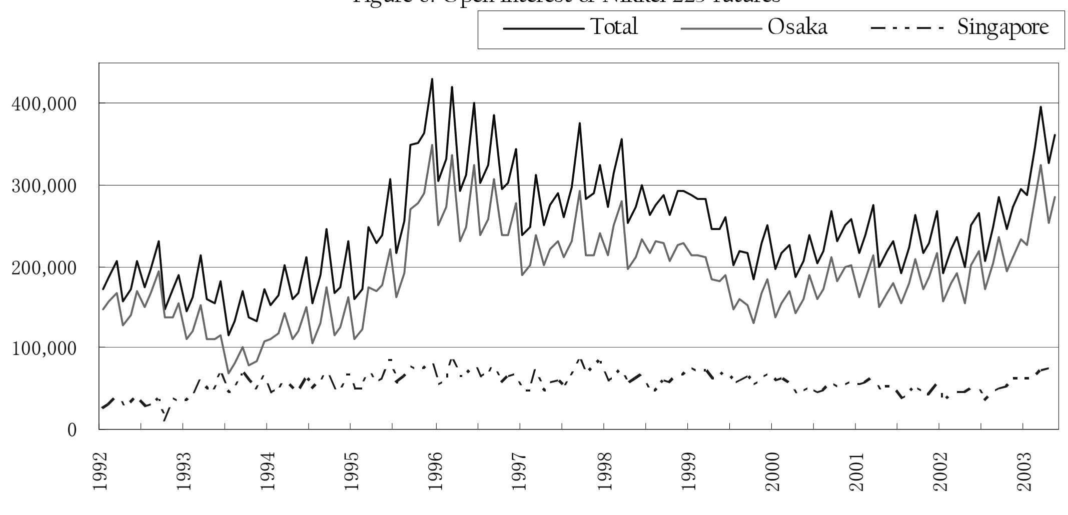


Figure 6. Open interest of Nikkei 225 futures



IV. 2. Results

Estimation results for equations (9) and (10) are summarized in Table 3. This table reports the lag–length, p , selected based on SIC, and χ^2 statistics for Granger causality tests, which follow χ^2 distribution with the degree of freedom of p under the null of no Granger causality. Table 3 shows that there are no significant causalities. Next, estimation results for equations (11) and (12) are summarized in Table 4. There are no significant causalities except for the causality from the volatility of Nikkei 225 to the trading volume of Nikkei 225 futures. We do not find any evidence that Nikkei 225 futures transactions influence the level or the volatility of Nikkei 225, CI and IIP.

While CI and IIP are available only monthly, daily data are available for Nikkei 225 and its futures. Watanabe and Oga (1996) perform the same analysis using daily data and obtain similar results.

Table 3. Granger Causalities between Trading Volume or Open Interest of Nikkei 225 Futures and the Level of Macroeconomic Variables

	χ^2 Statistic	p (degree of freedom)
Trading Volume→CI	3. 68	3
Trading Volume→IIP	1. 98	2
Trading Volume→Nikkei 225	0. 56	2
Open Interest→CI	3. 16	4
Open Interest→IIP	2. 32	4
Open Interest→Nikkei 225	1. 73	3
CI→Trading Volume	5. 98	3
CI→Open Interest	1. 30	4
IIP→Trading Volume	1. 12	2
IIP→Open Interest	0. 73	4
Nikkei 225→Trading Volume	1. 43	2
Nikkei 225→Open Interest	5. 36	3

Table 4. Granger Causalities between Trading Volume or Open Interest of Nikkei 225 Futures and the Volatility of Macroeconomic Variables

	χ^2 statistic	p (degree of freedom)
Trading Volume→CI	0. 71	2
Trading Volume→IIP	0. 54	2
Trading Volume→Nikkei 225	0. 76	3
Open Interest→CI	1. 12	3
Open Interest→IIP	1. 75	3
Open Interest→Nikkei 225	4. 54	3
CI→Trading Volume	2. 91	2
CI→Open Interest	3. 68	3
IIP→Trading Volume	0. 81	2
IIP→Open Interest	1. 89	3
Nikkei 225→Trading Volume	15. 65***	3
Nikkei 225→Open Interest	1. 50	3

Note: *** indicates 1% level of significance.

V. Conclusions

In this paper, we analyze structural changes in business fluctuations in Japan using the extended Markov switching model. We use composite index (IIP) and the index of industrial production (IIP) as the variables for Japanese business fluctuations. The points in time of structural change are estimated as April 1989 for CI and January 1992 for IIP. For the both variables, there are significant reductions in average growth rates for the both of recession and expansion periods and significant increases in the variance of the both business fluctuations and dispersion of short-term deviation from business fluctuations. This paper is important in the sense that it estimates when and what kind of structural changes occur in business fluctuations in Japan.

We also perform Granger causality tests between trading volume or open interest of Nikkei 225 futures transactions and the level of the Nikkei 225 stock index, CI, IIP or their volatility to examine whether or not Nikkei 225 index futures transactions are the cause of the instability of stock price and business fluctuations in Japan. The analysis reveals no significant causalities.

The remaining problem is to find the cause of the instability of stock price and business fluctuations in Japan. Some researchers have analyzed the cause of the stability of business fluctuations in the US from the middle of the 1989s. McConnell and Perez-Quiros (2000) attribute to the stability of inventory, while Stock and Watson (2002) report that the contribution of monetary policy is 20-30%、that of shocks to productivity and commodity prices is 20-30% and the remaining 40-60% is unclear. Kim, Nelson and Piger (2004) conclude that the cause cannot be specified because many variables are stabilized.

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