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Hiroshi Nakaota[†] and Yuichi Fukuta[‡]

Abstract

Many studies have observed the leading indicator property of the term spread (LIPTS), which indicates that the term spread —the difference between long- and short-term interest rates— has information on future economic conditions. We examine whether this property is related to monetary policy or not by using Japanese monthly data with consideration for structural changes. Results of structural change tests show that the term spread has predictive ability for the future economic activity from 1982:4 to 1997:8. Decomposing the term spread into three parts; one is explained by past monetary policy shocks, another is explained by expected future call rates and the other is the remaining part, we find that all three parts are significantly related to the future economic growth rate. Hence, we find that the monetary policy plays an important role for the LIPTS.

Keywords: leading indicator property of the term spread (LIPTS), term spread, future economic activity, monetary policy

JEL classification: E32, E43, E44

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1. Introduction

Information on future economic activity is helpful for various economic agents. If business entrepreneurs learn more about future economic activity, they can plan better business projects. If policymakers get to know more about future economic conditions, they can adopt better policies. Researchers have long examined the predictive ability of various economic variables for future business cycles. For example, Estrella and Mishkin (1998) make a comparison of the abilities for future recessions of some financial variables. Existing studies, such as Estrella and Hardouvelis (1991), Harvey (1991) and Hu (1993), find the leading indicator property of the term spread (LIPTS), which shows the term spread—the difference between long- and short-term interest rates— has information on future economic conditions. More concretely, the current term spread is positively correlated with future economic activity. If the current term spread broadens, future economic conditions tend to improve, and vice versa. Because many papers support this property, Benati and Goodhart (2008) describe it as having become a "stylized fact".[1]

Why does the term spread provide predictability for the future economic activity? What factors produce the LIPTS? To answer these questions, a theoretical model which is compatible with the LIPTS has to be proposed. However, in contrast to an enormous volume of empirical studies on the LIPTS, only a few papers have presented theoretical models. In terms of causes of the LIPTS, we can divide the existing theoretical studies into two streams. The first approach proposes models where real sectors, such as productivity, cause the LIPTS, applying the Consumption-based Capital Asset Pricing Model (C-CAPM) in Lucas (1978).[2] The second approach considers models where the monetary policy plays an important role in explaining the LIPTS.[3] However, because so far, both approaches explain the LIPTS only partially, further extensions are needed.

The comparison of the effectiveness of real sectors in the LIPTS with that of the monetary policy is useful in understanding the direction of the theoretical extensions. In the comparison, we have to extract a factor which is related to the monetary policy or real sectors from the term spread. If a monetary policy factor in the term spread has a significant correlation with the future economic activity, the second approach may give a convincing explanation. In the case where the factor does not affect the future economic condition, an extension using the first approach may be reasonable. Laurent

[1] Recent studies on the relationship between term spread and future economic activity are introduced in Wheelock and Wohar (2009) and the following website:
http://www.newyorkfed.org/research/capital_markets/biblio.pdf

[2] See Harvey (1988) and Rendu de Lint and Stolin (2003).

[3] Estrella (2005) shows that some parameters on the reaction function of the monetary authority affect the LIPTS.

(1988, 1989) discusses how the term spread reflects a monetary policy stance. In contrast, Plosser and Rouwenhorst (1994) show that the information on future economic growth in the term spread is independent of the information on the current and future monetary policy. Benati and Goodhart (2008) also obtain weak evidence for the relationship between the LIPTS and monetary policy. So far, empirical results for the effect of the monetary policy on the future economic activity through the term spread are not conclusive.

The purpose of this paper is to examine whether or not factors related to the monetary policy included in the term spread affect the future economic activity using Japanese data sets. As mentioned before, the evidence in this investigation may be useful in resolving the mechanism of the LIPTS. To extract the monetary policy factor from the term spread, we employ the following procedure. First, estimating a VAR model proposed by Miyao (2000) to describe the Japanese economy, we compute monetary policy shocks based on the estimated results. Because we assume that the central policy instrument of the Japanese monetary authority, the Bank of Japan, is a call rate, the VAR system includes a call rate.[4] We regard call rate shocks as exogenous monetary policy or monetary policy shocks.[5] Next, we calculate the forecast values of future call rates using the estimated VAR model. These values are a factor associated with the expected future monetary policy stance. Third, regressing the term spread on the estimated monetary policy shocks and the future monetary policy stance factor, we decompose the current term spread into a part related to the monetary policy shocks, a part concerned with future monetary policy stance and a remaining part. Finally, based on the regression of the future economic growth rate on these three parts, we investigate the explanatory power of the three factors. If we obtain a significant relationship between the two monetary policy parts and the growth rate, then the monetary policy plays an important role for the LIPTS.

Many existing empirical studies on the LIPTS in the US use spot rates computed from long-term bond data. Fama and Bliss (1987) present a method to calculate the spot rates. However, some studies on the LIPTS in Japan, such as Hirata and Ueda (1998) and Hasegawa and Fukuta (2011), use data on the yield-to-maturity of Japanese long-term government bonds. It is well-known that the yield-to-maturity is affected by the coupon rate. The coupon rates of Japanese government bonds have declined in recent decades. This may cause some problems with the empirical results about the LIPTS in Japan. To avoid this problem, we compute the spot rate data based on the

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[4] Miyao (2000) also uses this assumption.
[5] This interpretation is similar to Bernanke and Blinder (1992) and Miyao (2002).

method proposed by Fama and Bliss (1987). By using the spot rate data, we can compare the results with those for other countries in an unbiased way. This is one of the contributions of this paper.

To start the above examination, we have to confirm that the LIPTS is also observed in Japan.[6] Hence, we first examine whether the term spread has the leading indicator property of future economic growth using Japanese monthly data from 1982:4 to 2007:3. The results do not support the LIPTS for the whole data sample period. This evidence may be affected by structural changes in the Japanese economy as pointed out by Miyao (2000) and Nakashima (2007).[7] Applying the method proposed by Qu and Perron (2007) and Kurozumi and Tuvaandorj (2011), we investigate structural changes in the parameters of the VAR model in our sample period. The results show that structural changes happen at 1987:6, 1997:8 and 2002:10. Dividing our sample into four subsamples based on these points, we re-examine the LIPTS in each subsample. We find that the term spread has predictive ability for the future economic activity in the first subsample: from 1982:4 to 1987:6 and the second subsample: from 1987:7 to 1997:8. Hence, we investigate whether or not the monetary policy factors in the term spread affect the future economic activity between 1982:4 and 1997:8. Our results show that both monetary policy factors and other factors have explanatory power for future economic growth. This evidence indicates that the monetary policy plays an important role in causing the LIPTS in Japan.

This paper is organized as follows. In Section 2, we examine the LIPTS in our sample period and the effect of structural changes in the Japanese economy on the evidence for the LIPTS. Decomposing the term spread into parts related to the monetary policy and other parts, we investigate whether these parts affect the future economic activity or not in Section 3. Concluding remarks are provided in Section 4

[6] Some papers have investigated the LIPTS using Japanese data. Using the data between 1970 and 1989, Harvey (1991) obtains mixed results for the properties which depend on the sample periods. Hu (1993) finds the evidence for the LIPTS in the period from 1967 to 1991. Pointing out the existence of restrictions in the Japanese financial markets before the middle of the 1980s, Kim and Limpaphayon (1997) support the LIPTS between 1984 and 1991. Galbraith and Tkacz (2000) and Ikeno (2003) find the less evidence for the LIPTS in the sample period including the 1990s. Taking a structural change into account, Nakaota (2005) supports the LIPTS until the middle of the 1990s. Because Wheelock and Wohar (2009) mention that after the middle of the 1980s the LIPTS is not supported in the US, the Japanese results of the LIPTS may be similar to the US. Whereas Hirata and Ueda (1998) find the relationship between the yield spread and future recessions, Bernard and Gerlach (1998) and Ikeno (2003) observe the weak relationship. Hasegawa and Fukuta (2011) find the evidence for the relationship between the current yield spread and future recessions until the middle of the 1990s by taking the structural break into consideration.

[7] Structural breaks in the LIPTS are also observed by Nakaota (2005) and Hasegawa and Fukuta (2011).

2 The Leading Indicator Properties of the Term Spread (LIPTS) and Structural Changes in the Japanese Economy

In this section, we first examine the leading indicator properties of the term spread (LIPTS) using the Japanese data between 1982:4 and 2007:3. Next, we investigate the effects of structural changes in the Japanese economy on the evidence for the LIPTS.

2.1 An Examination of the Leading Indicator Properties of the Term Spread (LIPTS)

Based on the empirical studies by Estrella and Hardouvelis (1991), Estrella and Mishkin (1997), Hamilton and Kim (2002), Nakaota (2005) and other papers, we estimate the following equation by using OLS:

$$y_t^k = \alpha_0 + \alpha_1 \text{spread}_t + \varepsilon_t \ , \tag{1}$$

$$y_t^k \equiv \left({}^{1200}/_{k}\right) \times (\ln y_{t+k} - \ln y_t) \ ,$$

$$\text{spread}_t \equiv i_t^l - i_t^s,$$

where y_t is the industrial production based on 2005 at t, spread_t means the term spread which is given by the difference between the 9-year spot rate (i_t^l) and 1-month CD rate (i_t^s) at t, y_t^k indicates the growth rate of the industrial production between t and t+k, k denotes the forecast horizon, ε_t is the error term.[8] ε_t follows a distribution with $(k-1)$th order serial correlation because of the overlapping of the forecast horizon. We adjust the standard error by using the Newey and West (1987) method. We use monthly data between 1982:4 and 2007:3. In the case where we set k from 2 to 10, the estimated period is from 1982:4 to 2007:2. In the case wherek=11 to k=24, the period is from 1982:4 to 2007:12−k.[9]

Table 1 shows the estimated results. The spread coefficients, α_1, are significant in the case where the term spread forecasts the future economic growth rate from 2 to 4 months ahead. In other cases, we obtain no significant relationship between the current term spread and future growth. It seems that the LIPTS is not observed in Japan. Nakaota (2005) finds a structural change in the relationship between the Japanese term spread and future growth rate of the industrial production. Miyao (2000) and Nakashima (2007) show evidence for a structural change in the Japanese economy by using VAR analyses. Since the failure of the LIPTS in our sample period may result from structural breaks, we analyze structural changes in our sample period in subsection 2.3.

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8 We explain the data used in detail in the Appendix. The term spread is an annual percentage rate. To adjust the k-month growth rate to an annual rate, we multiply the log-difference by $(1200/k)$.

9 Industrial production data are available up to 2007:12.

2.2 A VAR Model for the Japanese Economy

We have to specify the equation to test for structural breaks. The purpose of this paper is to investigate the relationship between monetary policy factors included in the term spread and the future economic growth. To clarify the effect of the monetary policy, it is useful to describe the Japanese economy by a model that takes the monetary policy effects into account. Miyao (2000) uses a VAR model to examine the stability of the Japanese monetary policy. We use the same specification as Miyao (2000) to analyze the possibility of structural changes in our sample period.[10] Following Miyao (2000), we estimate the VAR model which contains four macroeconomic variables: the call rate (r), the industrial production based on 2005 (y), the monetary base (m) and a measure of nominal effective exchange rates (e). We take logarithms of all variables except for the call rate. To estimate the model, we employ monthly data from 1981:4 to 2007:12.[11]

First, we test the four macroeconomic variables series for a unit root using the Augmented Dickey-Fuller test. While we apply unit root tests including a constant term and a deterministic trend to the variables in levels, we use the tests including a constant term only for the variables in first differences. We select the optimal lag length based on the AIC. Table 2 shows the results of the unit root tests. The null hypotheses of a unit root against the alternative of trend-stationary process are not rejected for all variables in levels. The hypotheses for all variables in first differences are rejected. Figure 1 presents time series plots of the first differences of the call rate presented by a solid line and the industrial production indicated by a dotted line. Figure 2 also plots the first differences of the monetary base presented by a solid line and the nominal effective exchange rate indicated by a dotted line. From these figures, it seems that these variables do not have a unit root.

Based on the results of unit root tests, we characterize the Japanese economy by the following structural VAR model with the first differenced four macroeconomic variables:

$$\mathrm{B(L)}\Delta \mathrm{X_t} = \epsilon_\mathrm{t}, \quad (2)$$
$$\mathrm{B(L)} \equiv \mathrm{B_0} - \mathrm{B_1 L} - \mathrm{B_2 L^2} \cdots - \mathrm{B_{p_v} L^{p_v}},$$
$$\mathrm{X_t} \equiv (\mathrm{r_t}, \mathrm{y_t}, \mathrm{m_t}, \mathrm{e_t})',$$

where $\epsilon_\mathrm{t} = (\epsilon_\mathrm{rt}, \epsilon_\mathrm{yt}, \epsilon_\mathrm{mt}, \epsilon_\mathrm{et})'$ is pure structural shocks at t, ϵ_zt, $\mathrm{z} = \mathrm{r}, \mathrm{y}, \mathrm{m}$ and e, is

[10] The reason why we do not apply structural break tests to (1) directly is as follows. If the monetary policy affects the future economic activity and the current term spread, structural breaks in the Japanese monetary policy may also cause some changes in the LIPTS in Japan. Using a VAR model, Miyao (2000) detects a structural break in the Japanese monetary policy. This break may also explain the weak LIPTS in Japan. In this paper, after tests for structural changes in the VAR model proposed by Miyao (2000), we analyze the empirical implication of the changes on the stability of the LIPTS.

[11] We explain the data used in detail in the Appendix.

the i.i.d. shock of the first difference of a variable z, the covariance matrix of ϵ_t is Σ_ϵ (4×4 matrix), p_v is the number of the lag length of the VAR model, B_i, $i = 1,2, \dots, p_v$, is a (4×4) matrix and L is the lag operator.[12] To obtain the first differenced variables, we multiply the log-difference of these variables by 100.[13] We can rewrite the VAR model into the following reduced VAR model:

$$A(L)\Delta X_t = u_t, \tag{3}$$
$$A(L) \equiv I - A_1 L - A_2 L^2 \cdots - A_{p_v} L^{p_v},$$

where u_t is the residual vector of reduced VAR model and the covariance matrix is Σ_u (4×4 matrix).

2.3 Structural Changes for the Japanese Economy

We use the methodology proposed by Qu and Perron (2007), and Kurozumi and Tuvaandorj (2011) to examine structural changes.[14] Qu and Perron (2007) propose likelihood ratio type statistics to test for multiple unknown structural changes in linear multivariate regression models. Because this test is applicable to the structural changes in a subset of the coefficients, and the conditional mean and covariance matrix of the errors, it is potentially useful in our investigation. However, many estimated parameters in our model cause a little difficulty when using the test statistics proposed by Qu and Perron (2007) directly. In addition, Qu and Perron (2007) assume the number of the lag length of the VAR model a priori. In terms of this point, Kurozumi and Tuvaandorj (2011) propose modified Akaike information criterion (MAIC) to select the appropriate model in the case of multiple unknown structural changes in linear multivariate regression models. If we employ the MAIC for the selection of the model, we are able to estimate the VAR model parameters, the number of structural changes and their points, and the lag length of the VAR model simultaneously. More concretely, assuming the number of lag length of the VAR model, we first apply the method of Qu and Perron (2007) to estimate the VAR model which permits multiple unknown structural changes. Next, we employ the MAIC presented by Kurozumi and Tuvaandorj (2011) to determine the appropriate model.

We consider l structural changes ($l + 1$ regimes) in our data sample period. Then

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[12] The results of the unit root tests are similar to Miyao (2000). Miyao (2000) further examines whether there are cointegrating relations in the four-variable system and finds the evidence against cointegration. Following Miyao (2000), we characterize the Japanese economy by the VAR models with the first differences of four variables.

[13] Interest rates are measure in percent. We also measure the growth rate in percent.

[14] Miyao (2000) and Nakashima (2007) use the methods proposed by Christiano (1986) and Cecchetti and Karras (1994) to test for structural breaks. The test assumes a single known break point. Miyao (2000) and Nakashima (2007) find a structural change in the Japanese economy.

we can rewrite equation (3) as the following model:

$$A_j(L)\Delta X_{t_n} = u_{t_n} \quad (4)$$
$$A_j(L) \equiv I - A_{j1}L - A_{j2}L^2 \cdots - A_{jp_v}L^{p_v}$$
$$(j = 1, \dots, l+1 \text{ and } t_n = T_{j-1}+1, \dots, T_j)$$

where u_{t_n} has mean 0 and covariance matrix Σ_j for $T_{j-1}+1 \leq t \leq T_j$.[15] We set $T_0 = 0$ and $T_{l+1} = T$. We set T is the total number of observations. We denote the break points by $T_1, \dots, T_l$.

For given l and p_v, let us denote the quasi-log likelihood in (4) by $\log L_T(T_1, \dots, T_l | l, p_v)$. The maximum likelihood estimates (MLE) of $A_j(L)$ and break points, $T_1, \dots, T_l$, for given l and p_v, are obtained by maximizing $\log L_T(T_1, \dots, T_l | l, p_v)$ over all possible partitions $T_1, \dots, T_l = T\lambda_1, \dots, T\lambda_l$ in the set

$$\Lambda_\zeta = \{(\lambda_1, \dots, \lambda_l); |\lambda_{j+1} - \lambda_j| \geq \zeta,\ \lambda_1 > \zeta, \lambda_l \leq 1-\zeta\}, \quad (5)$$

where ζ is the minimum sample proportion between breaks and is referred to as the trimming parameter. $\hat{A}_j(L)$ and $\hat{T}_1, \dots, \hat{T}_l$ are the estimated parameters and break points. The estimated quasi-log likelihood is denoted by $\log \hat{L}_T(\hat{T}_1, \dots, \hat{T}_l | l, p_v)$. We regard $\hat{T}_1, \dots, \hat{T}_l$ as structural change point candidates for given l and p_v.[16] We assume that the maximum number of possible breaks, $\bar{l}$, is 4 and the minimum and maximum possible lag lengths are 3 and 8 respectively, and the trimming parameter, ζ, is 0.2.[17] We compute the modified Akaike information criterion (MAIC) proposed by Kurozumi and Tuvaandorj (2011) for each pair of l and p_v among $0 \leq l \leq \bar{l}$ and $3 \leq p_v \leq 8$. The MAIC is given by the following form:

$$\text{MAIC}(l, p_v) = -2\log \hat{L}_T(\hat{T}_1, \dots, \hat{T}_l) + 2(p_\Phi^{all} + p_\sigma^{all}) + 6l \quad (6)$$

where p_Φ^{all} is the total number of coefficients in the VAR model, p_σ^{all} is the number of unknown variance components in all regimes.

The model with $l = 3$ and p_v=3 minimizes the MAIC.[18] The selected model implies that the estimated structural change points are 1987:6. 1997:8 and 2002:10. Based on this result, we divide the sample period into four subsample periods; the first period is from 1982:4 to 1987:6, the second period is from 1987:7 to 1997:8, the third

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[15] t_n denotes the number of observations from the initial observation point. For example, when we use the sample period between 1981:4 and 2007:12, $t_n = 2$ implies the time period at 1981:5 in equation (4).

[16] We use the Gauss code provided by Qu and Perron (2007) to detect $\hat{T}_1, \dots, \hat{T}_l$ for given l and p_v.

[17] The reason we set the maximum number of possible breaks to 4 is the restriction of the total number of observations. If we set it larger than 4, the smallest subsample has 50 or 60 observations which may cause the small sample problem. The reason for $3 \leq p_v \leq 8$ is to obtain a reasonable VAR model with monthly observations. If we employ VAR models with 1 or 2 lags, it may be quite difficult to take the quarterly cycle effect into account. In the case of VAR models with longer lag lengths, we have to estimate many parameters, which may deteriorate the degree of freedom.

[18] Kurozumi and Tuvaandorj (2011) also propose a modified Bayesian information criterion (MBIC). We calculate MBIC for each pair of l and p_v. MBIC also supports the model with $l = 3$ and $p_v = 3$ and the same break points as MAIC.

period is from 1997:9 to 2002:10 and the fourth period is from 2002:11 to 2007:12.

2.4 A re-examination of the LIPTS in Each Subsample Period

To examine whether or not the term spread has predictive ability for the future economic activity in each subsample period, we estimate (1) for each subsample data. The first estimated period is from 1982:4 to 1987:6−k, where k indicates the forecast periods. The second period is from 1987:7 to 1997:8−k. The third period is from 1997:8 to 2002:10−k. The fourth period is from 2002:11 to 2007:2 in the case where k=2 to k=10 and from 2002:11 to 2007:3−k in the case where k=11 to k=24.

Table 3 presents the estimated results for each subsample. In the first subsample, the spread coefficients, α_1, are significantly positive for all forecast horizons, k, except for k=1. The second subsample results show that α_1 are also significantly positive in all forecast horizon cases except for the k=1 case. In the third subsample, α_1 are significantly positive only from k=1 to k=4. The fourth subsample results show that α_1 are not significantly positive in many forecast horizon cases. We also observe negative significant α_1 in both the third and fourth subsample. However, this evidence is not compatible with the LIPTS. From these results, we find that the term spread has a robust predictive ability for the future economic activity in the first and second subsample. In contrast, we cannot observe a significant relationship between the term spread and the future economic activity in other subsamples. In other words, the LIPTS is supported only in the first and second subsample. The results suggest the dwindling predictive power of the term spread in recent years.[19] As mentioned before, to analyze whether the monetary policy factors in the term spread are related to the LIPTS, the LIPTS needs to be satisfied with the data. Therefore, we henceforth concentrate our investigation on the first and second subsample.[20]

3 An Empirical Analysis of the Monetary Policy Factors and the LIPTS

In this section, we construct some monetary policy factors included in the term spread by using the structural VAR model in section 2.2. After that, we examine whether the factors are related to the future economic activity or not. As mentioned in the previous section, all empirical studies in this section use the data for the first subsample between 1982:4 and 1987:6 and the second subsample between 1987:7 and 1997:8. The

[19] Wheelock and Wohar (2009) indicate that the LIPTS may not be supported by the recent US data. Nakaota (2005) and Hasegawa and Fukuta (2011) also find the weak evidence for the LIPTS using recent Japanese data.

[20] Structural change tests indicate that a structural break occurred at 1987:7. This break may affect the relationship between monetary policy and the LIPTS. Hence, we examine the relationship for each subsample.

LIPTS is supported in these subsamples. Hence, if we observe a significant relationship between the monetary policy factors included in the term spread and future economic activity, the evidence may show that the monetary policy plays a role in the LIPTS.

3.1 A Decomposition of the Term Spread into Monetary Policy Shocks and Other Shocks

In this paper, we assume that the monetary authority controls the call rate to execute monetary policy. Estimating a structural VAR model including the call rate, Miyao (2000) identifies the shocks of the call rate as the exogenous monetary policy based on this assumption. Following his method, we also construct the exogenous monetary policy or monetary policy shock. The VMA (Vector Moving Average)(∞) representation for the structural VAR model (2) is the following form:

$$\Delta X_t = D(L)\epsilon_t, \tag{7}$$
$$D(L) \equiv D_0 + D_1 L + D_2 L^2 \cdots,$$

where D_i is a (4×4) matrix. This representation shows that the Japanese economy is described by current and past structural shocks. The first element of the ϵ_t matrix is the shock of the call rate at t, ϵ_{rt}. Hence, we can compute the time series of the call rate shocks . We regard a portion of the term spread correlated with the call rate shocks as a monetary policy factor in the term spread. In addition, we interpret the remaining part of the term spread as other factors.

More concretely, we use the following steps to divide the term spread into the monetary policy factor and other factor. First, to identify structural monetary policy shocks, we assume the structural VAR model (2) and a recursive constraint proposed by Sims (1980).[21] This requires B_0 in (2) to be lower triangular. Concerning the order of variables, $X_t = (r_t, y_t, m_t, e_t)'$, we assume that the economic variables are determined in order of the call rate (r), the industrial production (y), the monetary base (m), and the measure of nominal effective exchange rates (e). This implies that, whereas the current values of the industrial production (y), the monetary base (m) and the nominal effective exchange rate (e) do not influence the current call rate (r), the current call rate (r) influences the other three variables. As mentioned before, we suppose that the call rate shock ϵ_r is the monetary policy shock. We estimate the structural VAR model using Choleski decomposition of the covariance matrix of the reduced VAR model (3), Σ_u. Using the estimated results, we obtain the series of monetary policy shocks, $\hat{\epsilon}_{rt}$. Next, we regress the current term spread on the estimated current and past structural monetary policy shocks by OLS:

[21] See Hamilton (1994) and Enders (2010) for the Sims's structural VAR. Miyao (2000) also identify the model using the Sims (1980) type of recursive constraint.

$$\text{spread}_t = \beta_0 + \beta_1\hat{\epsilon}_{rt} + \beta_2\hat{\epsilon}_{rt-1} + \cdots + \beta_{p+1}\hat{\epsilon}_{rt-p} + \eta_t, \quad (8)$$

where η_t is the residual. The lag length, p, is determined by the AIC.[22] We decompose the current term spread into a part explained by monetary policy shocks, $\hat{\beta}_1\hat{\epsilon}_{rt} + \hat{\beta}_2\hat{\epsilon}_{rt-1} + \cdots + \hat{\beta}_{p+1}\hat{\epsilon}_{rt-p}$ and a remaining part of the term spread ($\hat{\eta}_t$). We regard $\hat{\beta}_1\hat{\epsilon}_{rt} + \hat{\beta}_2\hat{\epsilon}_{rt-1} + \cdots + \hat{\beta}_{p+1}\hat{\epsilon}_{rt-p}$ as a monetary policy factor, which is denoted by "monetary_factor_t," and $\hat{\eta}_t$ as other factor indicated by "other_factor_t". Finally, to investigate whether each factor has information on the future economic growth rate or not, we apply the OLS method to regress the future economic growth rate on the computed monetary factor and other factor:

$$y_t^k = \gamma_0 + \gamma_1 \text{monetary\_factor}_t + \gamma_2 \text{other\_factor}_t + \nu_t, \quad (9)$$

where ν_t is the residual.[23]

Table 4-1 reports the estimated results for the first subsample from 1982:4 to 1987:6. Coefficients of the monetary policy factor γ_1 are significant in the case where the forecast horizon k is larger than 14. The coefficients of the other factor γ_2 are significantly positive in the case where the forecast horizon is from k=2 to 22. It seems that not only the monetary policy factor but also the other factor, which may be a combination of other factors excluding the monetary policy shock, plays an important role in causing the leading indicator properties of the term spread (LIPTS). We observe a negative relationship between the past monetary policy shocks and the current term spread.[24] This evidence indicates that a tight monetary policy, positive monetary policy shocks, causes a future decrease in the term spread. A positive coefficient of the monetary factor implies that the tight monetary policy results in the contraction of the economy 14 months or more later. This effect plays an important role for the LIPTS especially in the long forecast horizon. Table 4-2 presents the empirical results for the second subsample from 1987:7 to 1997:8. All coefficient of the monetary policy factor γ_1 are significantly positive. Many coefficients of other factors γ_2 are also significant. These results show that both the monetary policy factor and the other factor contribute to the LIPTS in the second subsample. This evidence is similar to that for the first

[22] First, we search the optimal lag length on the assumption that the lag length is 12 or less by AIC. If the AIC indicate that the optimal lag length is less than 12, we employ that as the lag length. Second, if the AIC support the 12 lag length, we search for the optimal lag length on the assumption that the lag length is between 12 and 24. If the AIC indicate that the optimal lag length is between 12 and 24, we employ that as the lag length. Third, if the AIC support the 24 lag length, we search for the optimal lag length between 24 and 36. We continue with similar searches until the maximum lag length becomes 48.

[23] To use the estimated values as explanatory variables causes a bias for the standard error of the estimates in equation (9). To overcome this problem, we adjust the standard errors by using the method proposed by Newey and West (1997).

[24] The estimated result of equation (8) shows that the estimated coefficients of past monetary policy shocks, β_2, …, β_{p+1}, are negative. We do not present the estimated results in this paper.

subsample. The empirical investigation in this subsection shows that the monetary policy plays an important role for the LIPTS in Japan.

The monetary policy factor computed in this subsection is, however, a part of the term spread explained by the current and past monetary policy shocks. In other words, the factor may not contain information on future expected interest rates. Hamilton and Kim (2002) find that the expected future interest rate and term spread are effective in the LIPTS by using US data. In addition, Rendu de Lint and Stolin (2003) mention that the term spread may reflect expectations of future interest rates. If the future interest rates are affected by the future monetary policy stance, it may be reasonable to examine whether or not the monetary policy factor in the term spread related to the future expected interest rates has information on the future economic activity.

3.2 A Decomposition of the Term Spread into Monetary Policy Shocks, Expectations of Future Monetary Policy and Other Shocks

If investors expected a future recession and a reaction to it by the monetary authority, they would forecast a decrease in short-term interest rates. The expectation hypothesis of the term structure of interest rates implies that the average of the expected future short-term interest rates determines the long-term interest rates. Hence, the expectation of a future recession may cause a decrease in the long-term interest rate and the term spread. In other words, the term spread may be affected by the expectations of future monetary policy. If we do not take this effect into account, we may underestimate the monetary policy effect on the LIPTS. In this section, we examine the relationship between the LIPTS and the monetary policy by considering not only the past monetary policy shocks but also future expectations about the monetary policy. On the assumption that the monetary authority controls the short-term interest rates, the future expected stance of the monetary policy is reflected by the future expected short-term interest rates.

We examine whether these two monetary policy factors have any effects on the LIPTS by the following method. First, computing the forecast values of call rates from next the period to future periods based on the estimated VAR model in section 2, we subtract a current call rate from the mean values of the current call rate and the forecast values of future call rates. We define this difference as the call spread. Second, we regress the current term spread on the estimated current and past structural monetary policy shocks, and the current call spread. Based on the regression results, we decompose the term spread into three parts; one is the part explained by current and past monetary policy shocks, another is that explained by the current call spread and the other is the remaining part of the term spread. Third, we regress the future economic growth rate on these three factors and examine their predictive power. Because we confirm that the LIPTS is satisfied by the data in this sample period, the significant relationship between the future economic growth and monetary policy factors indicates that monetary policy affects the LIPTS.

We first explain the procedures to compute the forecast values of call rates and call spread. We estimate future call rates using the estimated reduced VAR model in (3). We compute forecasts of call rates from one month ahead $(\hat{i}^s_{t+1})$ to 8 years and 11 months, 107 months, ahead $(\hat{i}^s_{t+107})$ in each month and take the simple average among the current call rate and the forecasts, $\left(\frac{1}{108}\left(\sum_{j=1}^{107}\hat{i}^s_{t+j} + i^s_t\right)\right)$.[25] Next, we subtract the current call rate from the simple average and define $\left(\frac{1}{108}\left(\sum_{j=1}^{107}\hat{i}^s_{t+j} + i^s_t\right) - i^s_t\right)$ as the call spread denoted by "$\mathrm{call\_spread}_t$". To obtain the monetary policy factor, the future monetary policy factor and other factor, we estimate the following formula by OLS:

$$\mathrm{spread}_t = \delta_0 + \delta_1\hat{\epsilon}_{rt} + \delta_2\hat{\epsilon}_{rt-1} + \cdots + \delta_{p+1}\hat{\epsilon}_{rt-p} + \delta_i \mathrm{call\_spread}_t + \xi_t, \qquad (10)$$

where $\hat{\epsilon}_{rt}$ is the monetary policy shock computed in subsection 3.1 and ξ_t is an error term. The lag length, p, is determined based on the AIC.[26] Using the estimated parameters, we regard the term given by $\hat{\delta}_1\hat{\epsilon}_{rt} + \hat{\delta}_2\hat{\epsilon}_{rt-1} + \cdots + \hat{\delta}_{p+1}\hat{\epsilon}_{rt-p}$ as the current and past monetary policy factor denoted by "$\mathrm{monetary\_factor} *_t$", the term given by $\hat{\delta}_i\mathrm{call\_spread}_t$ as the future monetary policy factor denoted by "$\mathrm{future\_monatery\_factor} *_t$" and the remaining errors, $\hat{\xi}_t$, as the other factor denoted by "$\mathrm{other\_factor} *_t$".[27] We, finally, apply the OLS method to estimate the following equation to investigate the relationship between the LIPTS and monetary policy:

$$y^k_t = \phi_0 + \phi_1 \mathrm{monetary\_factor} *_t$$
$$+\phi_2 \mathrm{future\_monetary\_factor} *_t + \phi_3 \mathrm{other\_factor} *_t + \upsilon_t, \qquad (11)$$

where υ_t is the residual.[28]

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[25] In this paper, the long-term interest rate is the 9-year spot rate. To match the maturity of the spot rate, we forecast the call rates 107 months ahead.

[26] First, we search the optimal lag length on the assumption that the lag length is 12 or less by AIC. If the AIC indicate an optimal lag length less than 12, we employ that as the lag length. Second, if the AIC support the 12 lag length, we search for the optimal lag length on the assumption that the lag length is between 12 and 24. If the AIC indicate an optimal lag length between 12 and 24, we employ that as the lag length. Third, if the AIC support the 24 lag length, we search for the optimal lag length between 24 and 36. We continue a similar search until the maximum lag length becomes 48.

[27] The method to obtain the monetary factor in this subsection is similar to that in section 3.1 with the exception that the estimated equation in this subsection includes the call spread. Hence, we also use the same "monetary factor" to this term.

[28] We also adjust standard errors by the method proposed by Newey and West (1997) to take the problem caused by using the estimated values as explanatory variables into account.

Table 5-1 presents the estimated results for the first subsample between 1982:4 and 1987:6.[29] Whereas the coefficients of the current and past monetary policy factor, ϕ_1, are insignificant in the cases where the forecast horizons are less than 13 months except for k=8, they are significantly positive in the case where they are 14 months or more. This evidence shows that the part in the term spread related to the past positive call rate shocks has information on the economic slowdown more than 14-months ahead. We find a negative association between the past monetary policy shock and the current term spread.[30] The positive coefficients of the monetary policy factor may be reflected by the evidence that the past tightness of the monetary policy, positive policy shocks, has negative impact on the real economy almost 14 months later. In other words, investors may expect that it will take more than a year until the monetary policy has an effect on the real economy. The coefficients of the future monetary policy factor, ϕ_2, are positive and significant for the forecast horizons from 2 months to 12 months. In contrast, they are not significant in the case of the 13 months or more horizons. Positive coefficients of the future monetary policy factor show that the increase in the yield spread caused by the rise in the future expected short-term interest rates is followed by future high economic growth. It seems that the increase in the future expected short-term interest rates raises the long-term interest rate and yield spread. Because, during a boom, the short-term interest rates are likely to be high, this result may be reasonable.[31] The coefficients of other factor, ϕ_3, are positive and significant in all cases except for the 1 month forecast horizon.[32] The term spread between the 9-year spot rate computed from the Japanese government bonds and 1-month CD rate is related to not only the monetary policy factors but also the other factor. This relation causes the predictive capability of the term spread for future economic growth. The contributions of these factors depend

[29] To compute the future call rates based on the VAR model in (3), we use the past four shocks in the VAR model including the monetary policy shocks. Hence, the monetary factor and future monetary factor in (11) may be correlated. To control this problem, we also estimate (11) by substituting the corrected call spread for the call spread in (10). The corrected call spread is the sum of the estimated constant term and error term based on the regression of the call spread on the current and past monetary shocks. The empirical results for both subsamples based on the above correction are similar to those in this paper in terms of the signs of the coefficients.

[30] The estimated result of equation (10) shows that the estimated coefficients of past monetary policy shocks, $\delta_2, \ldots, \delta_{p+1}$, are negative. We do not present the estimated results in this paper.

[31] Hamilton and Kim (2002) find that the expected future interest rate and term premium play a role in the LIPTS using US data. Our results based on Japanese data may be similar to their results.

[32] Singleton (2006) presents the relationship between the three factors related to the level, slope and curvature, and maturity of bonds in terms of the expected future interest rates and the premium using the US data. He shows that the slope factor is affected by the expected future interest rates and the curvature factor is related to the premium. Because both slope and curvature factors have some effect on the yield spread, our evidence that the yield spread is influenced by not only the expected future interest rate, the future monetary policy factor, but also monetary policy and other factors may be compatible with his US evidence.

on the forecast horizon. In short horizons, the future monetary policy factor and other factor play a crucial role in causing the LIPTS. The current and past monetary policy factor and the other factor have some effects on the prediction ability of the term spreads for future economic activity in the long horizon. Table 5-2 reports the results for the second subsample from 1982:7 to 1997:8. The coefficients of the current and past monetary policy factor are significantly positive in many cases. The future monetary policy factor also has a significant positive effect on the future economic growth. The other factor coefficients are positive and significant especially in the case of the long forecast horizons. These results indicate that not only monetary policy factor but also the other factor play an important role for the LIPTS in Japan in this subsample.[33]

Comparing the results in the previous subsection with those in this subsection, we confirm that the analysis which does not take future monetary policy expectations into account in section 3.1 underestimates the effects of monetary policy on the LIPTS, especially in the first subsample. Taking not only the current and past monetary policy but also the future monetary policy into account, we observe differences in the effects of the monetary policy factors among forecast horizons in the first subsample. In the short horizon, a factor in the term spread related to the future expectations of the monetary policy contains information on future economic growth rate. A factor in the term spread concerned with the past monetary policy shocks causes the predictive ability in the long forecast horizons.

3.3 Robustness: Other Maturities Analysis

We use the 9-year spot rate as the long-term interest rate in section 3.1 and 3.2. To examine the robustness of our empirical results, we conduct empirical studies similar to section 3.2 using other spot rates whose maturities range from two years to eight years.

Table 6-1 shows the estimated results for the first subsample. The coefficients of the current and past monetary policy factor, ϕ_1, are significantly positive only in the case of the long forecast horizons. The results are similar to those for the 9-year government spot rate. This may indicate that the effect of the current and past monetary policy on term spread is common to all maturities. The coefficients of the future

[33] In the first subsample, while the current and past monetary policy factor has a significant effect on the future economic growth in the long forecast horizon, the future monetary policy factor affects the future growth in the short horizon. In contrast, we do not observe such difference in the second subsample. It might be possible to interpret this difference to mean that monetary policy effects depend on the sample period. However, the AIC show that, whereas the lag length of equation (10) is set at 45 in the second subsample, it is 10 in the first subsample. Hence, the current and past monetary policy factors in the second subsample may be more informative than that in the first subsample. Actually, if we set the lag length of equation (10) at 10 in the second subsample, we obtain empirical results similar to the first subsample.

monetary policy factor, ϕ_2, are positively significant in the case of the 9 months or less forecast horizons for 6-year, 7-year and 8-year spot rates This evidence may be interpreted to mean that the short maturity spot rates, such as 2-year and 3-year spot rates, do not include information on the future monetary policy factor. The coefficients of the other factor are significantly positive in the case of forecast horizons between 9 and 24 for all spot rates. On the other hand, for short term economic growth rates, the coefficients are positive and not necessarily significant. This evidence may be a little different from the 9-year spot rate. Table 6-2 shows similar empirical results to Table 5-2 for the second subsample except for the other factor effect in the short maturity spot rates.[34]

From these results, we find that information on future economic growth in the term spread results from the current and past monetary policy factor and the other factors in many cases. The term spread also has information on the future monetary policy factor in the case of the relatively long maturity and the short forecast horizon. Empirical studies on the LIPTS use long-term interest rates not 2 or 3 years maturity interest rates. Hence, it may be reasonable to conclude that monetary policy plays an important role in the LIPTS.

4. Conclusion

Many empirical studies have shown that the term spread—the difference between long- and short-term interest rates— has information on future economic conditions. This property of the term spread is called the "leading indicator property of the term spread (LIPTS)." However, the reasons why we observe the LIPTS have not been clarified. Taking structural changes in the Japanese economy into account, this paper examines the reasons in terms of monetary policy. Tests for structural breaks in a VAR model to characterize the Japanese economy between 1982:4 and 2007:3 showed the occurrences of breaks at 1987:6, 1997:8 and 2002:10. Empirical analyses on the LIPTS for the four subsamples indicated the property was supported between 1982:4 and 1997:8. Using this sample period, we investigated whether the monetary policy caused the LIPTS or not by using the following methods. First, on the assumption that the central policy instrument of the Japanese monetary authority is the call rate, we regarded the call rate shocks as monetary policy shocks. Based on the estimation results of a structural VAR model including the call rate, we obtained the series of the monetary

[34] As mentioned in footnote 33, in the second subsample, the current and past monetary policy factor may be informative because of the long lag length in the estimation of equation (10). Short maturity spot rates are less volatile than the long maturity spot rates. Hence, the current and past monetary policy factor may have explanatory power for the short maturity yield spreads.

policy shocks. Next, we computed the series of call spreads by subtracting the current call rate from the average of the expected values of future call rates. The call spread is regarded as the future monetary policy factor. Third, regressing the term spread on the estimated monetary policy shocks and the call spread, we decomposed the current term spread into three parts; one explained by monetary policy shocks, another explained by call spreads and the remaining part. Finally, we examined whether these three factors were related to future economic growth or not. From the results, we found that the monetary policy shocks, future monetary policy and the other factor are all important for the LIPTS. This evidence shows that, for a theoretical explanation of the LIPTS, we need to consider a model which includes monetary policy aspects. In addition, if the other factors are related to real shocks, such as production shocks, we also need to propose a model that takes real economy aspects into consideration. Theoretical studies on the LIPTS mechanism have proposed models with real sectors and those with monetary sectors separately. Our results may indicate that a model with both sectors is needed to resolve the LIPTS.

Finally, we mention some restrictions of this paper and some directions for further research. First, our empirically results depend on the VAR model proposed by Miyao (2000). Because Miyao (2000) analyzes the Japanese monetary policy by his VAR specification, his motivation coincides with ours. However, we should examine whether the other specifications of VAR models produce similar results or not. Second, we do not specify the source of other factors in this paper. In other words, they may include various kinds of information, such as real shocks or specification errors. We need to decompose the other factors into more detailed factors. Third, we should provide theoretical explanations for the reasons why we obtained our results. Based on our results, we may need to consider a model taking both monetary sectors and real sectors into account. Finally, we should consider the reasons for the three structural changes.

Appendix

In this appendix, we explain the data used in the paper. The sample period of the paper is from 1981:4 to 2007:12.[35]

1. Variables in VAR Model

The Call Rate (r)

We construct a series of overnight call rates from 1978:1 to 2007:12 using the collateralized overnight call rate (monthly average) and the uncollateralized overnight call rate (monthly

[35] In cases where we obtain the data for the period from 1981:4 to 2007:12, we do not mention the data period explicitly in the explanation that follows.

average). The uncollateralized overnight call rate is viewed as the target rate for the Bank of Japan. However, the series is not available before 1985:6. We use the collateralized overnight rate until 1985:6 as a proxy for the uncollateralized overnight rate by adjusting the risk premium, and use the uncollateralized overnight rate itself after 1985:7. To adjust the risk premium, we first compute the ratio of the mean of the uncollateralized overnight call rate to the mean of the collateralized overnight call rate from 1985:7 to 2009:12. We then produce the quasi uncollateralized overnight rate by multiplying the mean ratio by the collateralized overnight rate until 1985:6.[36]

$$\begin{aligned}\text{the quasi uncollateralized overnight rate} \\ &= \text{the collateralized overnight rate} \\ &\times \left(\frac{\text{the mean of the uncollateralized overnight rate}}{\text{the mean of the collateralized overnight rate}}\right). \qquad (A.1)\end{aligned}$$

The call rate series are obtained from the Bank of Japan's web site.

Industrial Production based on 2005 (y)

The industrial production series is an index of industrial production whose base year is 2005. A seasonally adjusted series is available from the Ministry of Economy, Trade and Industry's web site.

The Monetary Base (m)

The monetary base series is monthly average and a seasonally adjusted series. This data is obtained from the Bank of Japan's web site.

A Measure of Nominal Effective Exchange Rate (e)

A measure of nominal effective exchange rate is the Nominal Effective Exchange Rate. This series is available from the Bank of Japan's web site.

2. Spot Rates of Long-term Government Bonds

We compute the spot rate data by a method similar to the one proposed by Fama and Bliss (1987). To compute spot rates for a month, we use the data on coupon rates, bond prices at the end of that month, maturity dates and coupon payment dates for the 10-year Japanese government bonds. Because the Japanese government bonds pay a coupon semi-annually, bonds with a 10-year maturity have 20 coupon payments before redemption. We compute spot rates whose maturities are 0.5-year, 1.0-year, 1.5-year, 2.0-year, …, 10.0-year on the assumption that the spot rates are constant for half a year. First, we use the data on bonds with less than 0.5-year maturities. Because these bonds have only one cash payment, we can compute the discount rates for each bond on the assumption that the rates for maturities between 0 year and 0.5 year are constant. This assumption means that we adjust the differences in maturities by changing the interval for the discount. The average discount rate is regarded as the 0.5-year spot rate.

[36] Kitaoka et al. (2008) also produce the quasi uncollateralized overnight rate in the same way.

Next, we use the data on bonds with maturities between 0.5 year and 1.0 year. These bonds have two cash payments. Applying the computed 0.5-year spot rate as a discount rate for first coupon payment, we can compute the discount rates for the second cash payments of each bond on the assumption that the rates for maturities between 0.5 year and 1.0 year are constant. The average discount rate is regarded as the 1.0-year spot rate. Third, the data on bonds with maturities between 1.0 year and 1.5 year are used to compute the 1.5-year spot rate. There are three cash payments in these bonds. Using the computed 0.5-year spot rate as a discount rate for first coupon payment and the 1.0-year spot rate as a discount rate for the second coupon payment, we can compute the discount rates for the third cash payments for each bond on the assumption that the rates for maturities between 1.0 year and 1.5 year are constant. Repeating this procedure, we can calculate spot rates from 0.5-year to 10-year at the 0.5 year interval for that month. The application of this method to the every month from 1981:4 to 2007:12 produces the spot rate data for these periods.[37] Bond prices are collected from the Nikkei Newspaper and Nikkei NEEDS FinancialQUEST. The data on coupon rates, coupon payment and maturity dates are collected from the Tokyo Stock Exchange Monthly Statistics Report and Nikkei NEEDS FinancialQUEST.

3. Short-term Interest Rate

The short-term interest rate series is the new issue, 1 month CD rate. This data is available from the Nikkei NEEDS FinancialQUEST.

[37] Our data set includes the bonds whose maturities are less than 9.5 year until 1986:6. Hence, we can compute spot rates from 0.5-year to 9.5-year until 1986:6. From 1986:7, we can calculate the 10-year spot rate.

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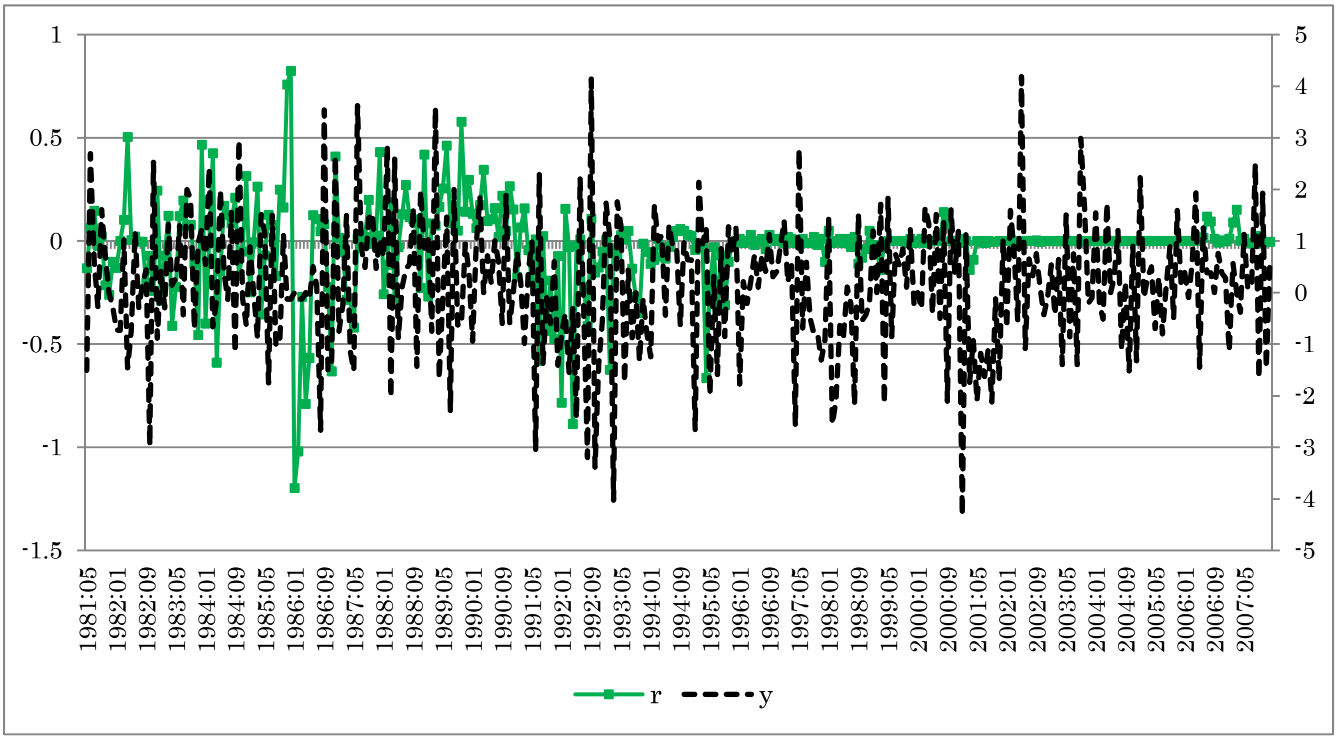
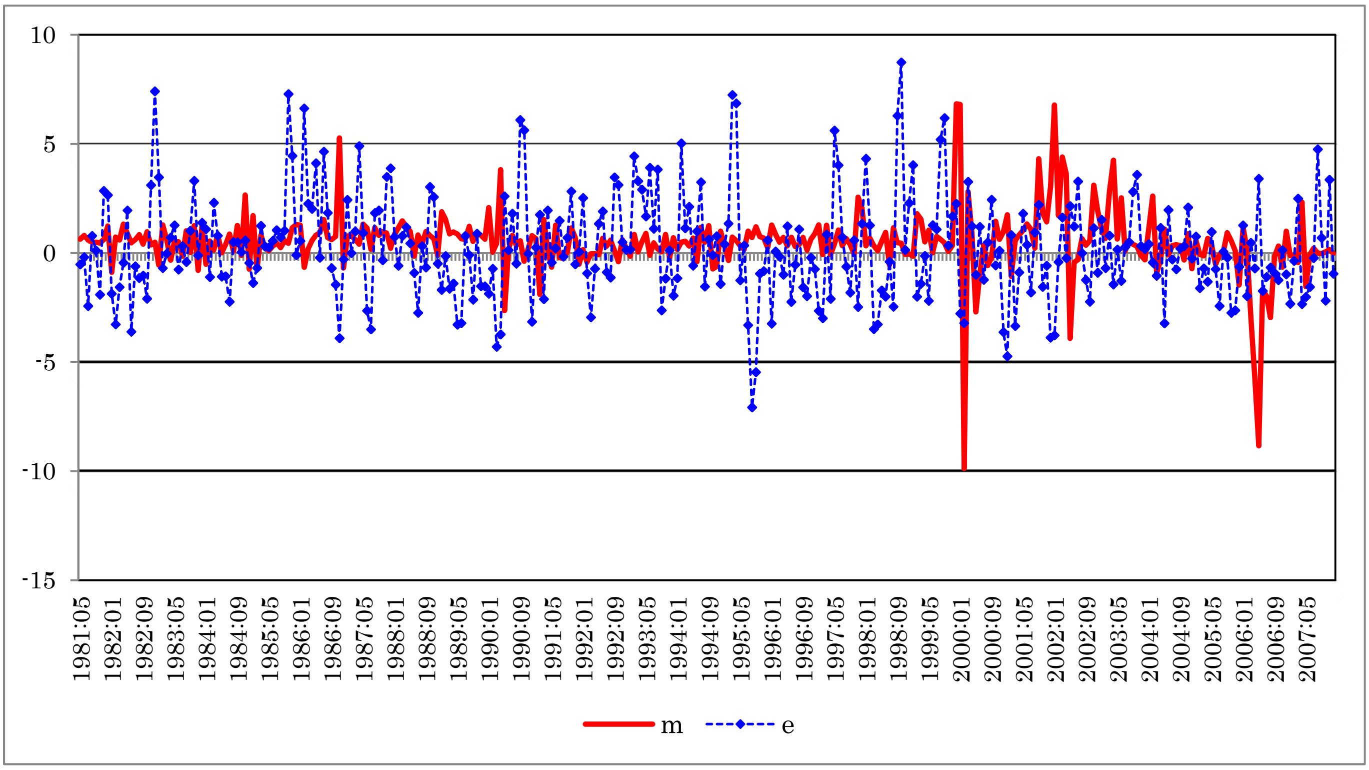
Figure 1: Plots of the First Differences of Call Rate (r) and the Industrial Production (y)



Notes:

The left vertical axis measures the first difference of the call rate indicated by the solid line. The right vertical axis measures the first difference of the industrial production indicated by the dotted line. These variables are measured in percent.

Figure 2: Plots of the First Differences of the Monetary Base (m) and Nominal Effective Exchange Rate (e)



Notes:

The first difference of the monetary base is indicated by the solid line. The difference of the nominal effective exchange rate is indicated by the dotted line. These variables are measured in percent.

Table 1: Examination of the Leading Indicator Properties of the Term Spread

Full sample Analysis 1982:4 – 2007:3

k	α_0	SE	α_1	SE	R^2
1	0.3998	(1.4614)	1.2839	(1.0422)	0.0017
2	0.6653	(0.7961)	1.0439**	(0.5038)	0.0069
3	0.7992	(0.8024)	0.9211*	(0.4841)	0.0087
4	0.8951	(0.8794)	0.8365*	(0.5083)	0.0086
5	0.8857	(0.9677)	0.8475	(0.5599)	0.0105
6	1.0138	(1.0253)	0.7427	(0.5932)	0.0084
7	1.0222	(1.0683)	0.7478	(0.6287)	0.0097
8	1.0196	(1.1364)	0.7646	(0.6755)	0.0113
9	1.0826	(1.1677)	0.7072	(0.7038)	0.0100
10	1.1156	(1.2126)	0.6859	(0.7427)	0.0100
11	1.1777	(1.2544)	0.6283	(0.7775)	0.0086
12	1.2130	(1.2879)	0.5934	(0.8080)	0.0080
13	1.2124	(1.3046)	0.5890	(0.8239)	0.0086
14	1.2427	(1.3228)	0.5521	(0.8408)	0.0080
15	1.2650	(1.3570)	0.5424	(0.8701)	0.0080
16	1.2776	(1.3650)	0.5276	(0.8752)	0.0081
17	1.2971	(1.3751)	0.4887	(0.8833)	0.0072
18	1.3237	(1.3880)	0.4519	(0.8945)	0.0062
19	1.3807	(1.4277)	0.4044	(0.9241)	0.0046
20	1.4110	(1.4540)	0.3702	(0.9433)	0.0036
21	1.4215	(1.4635)	0.3480	(0.9544)	0.0031
22	1.4342	(1.4872)	0.3119	(0.9742)	0.0021
23	1.4511	(1.5151)	0.2918	(0.9957)	0.0016
24	1.4591	(1.5364)	0.2773	(1.0147)	0.0013

Notes:

1. We estimate the following equation for the monthly data from 1982:4 and 2007:3:

$$y_t^k = \alpha_0 + \alpha_1 \text{spread}_t + \varepsilon_t,$$
$$y_t^k = \left({}^{1200}/_{k}\right) \times (\ln y_{t+k} - \ln y_t),$$
$$\text{spread}_t = i_t^l - i_t^s,$$

where y_t is the index of industrial production based on 2005 at t, spread_t is the difference between the 9-year spot rate computed from the Japanese government bond data and 1-month CD rate at t, y_t^k indicates the growth rate of industrial production between t and t+k, k denotes the forecast horizon, ε_t is the error term.

2. Standard errors corrected by the Newey and West (1987) method are in parentheses in column SE.
   ***, **, and * denote the statistical significance at the 1 %, 5%, and 10% levels, respectively.
3. *R* squared statistics adjusted for degrees of freedom are presented in column R^2.

4. In the case where the forecast horizon k is from 2 to 10, the estimated period is from 1982:4 to 2007:2. In the case from k=11 to k=24, the estimated period is from 1982:4 to 2007:3−k.

Table 2: Augmented Dickey-Fuller Tests

Variables in the Level			Variables in the First Differences		
Variables	Statistics	Lags	Variables	Statistics	Lags
r	-2.9205	(16)	Δr	-3.6344***	(24)
y	-2.1241	(24)	Δy	-4.5424***	(24)
m	-1.9488	(3)	Δm	-6.9527***	(2)
e	-2.1595	(11)	Δe	-3.9832***	(10)

Notes:

1. ***, **, and * denote the statistical significance at the 1 %, 5%, and 10% levels, respectively.
2. The optimal lag lengths chosen based on the AIC are in parentheses in columns Lags.
3. While the unit root tests for variables in levels includes a constant term and a deterministic trend, the tests for variables in the first differences include a constant term only.
4. The four variables are the call rate (r), industrial production (y), the monetary base (m) and a measure of nominal effective exchange rates (e).

Table 3: Re-examination of the Leading Indicator Properties of the Term Spread (LIPTS) –Subsample Analyses—

	First subsample: 1982:4-1987:6			Second subsample: 1987:7-1997:8			Third subsample: 1997:9-2002:10			Fourth subsample: 2002:11-2007:12		
k	α_1	SE	R^2	α_1	SE	R^2	α_1	SE	R^2	α_1	SE	R^2
1	3.2723	(3.1213)	0.0016	0.9752	(1.2476)	-0.0033	13.5772*	(7.0022)	0.0440	6.5959	(5.1322)	0.0126
2	3.1410***	(1.1150)	0.0486	0.9763*	(0.5590)	0.0086	12.8747***	(4.5282)	0.1176	3.2436*	(1.8956)	0.0084
3	3.0895***	(0.9849)	0.1323	0.9575*	(0.5426)	0.0183	12.1670**	(5.3987)	0.1264	2.0700	(2.1167)	-0.0021
4	3.1893***	(1.1023)	0.1339	0.9922*	(0.5591)	0.0285	10.5989*	(6.2065)	0.1150	0.7667	(2.2146)	-0.0163
5	3.1758***	(1.0043)	0.1838	1.0890*	(0.6180)	0.0428	9.6505	(6.4213)	0.0980	-0.2543	(2.2659)	-0.0195
6	2.9236***	(1.0167)	0.1893	1.0888*	(0.6376)	0.0489	8.2196	(6.3465)	0.0738	-0.9222	(1.9704)	-0.0111
7	3.2325***	(1.0304)	0.2370	1.1402*	(0.6673)	0.0647	7.4299	(5.9388)	0.0654	-1.1706	(1.6299)	-0.0004
8	3.3811***	(0.9085)	0.2937	1.2136*	(0.7027)	0.0811	6.8130	(5.7515)	0.0605	-1.6050	(1.2703)	0.0246
9	3.2086***	(0.9638)	0.3019	1.2565*	(0.7051)	0.0936	5.5436	(5.2939)	0.0386	-1.9735*	(1.0005)	0.0598
10	3.1735***	(0.8797)	0.2889	1.3168*	(0.7217)	0.1122	3.8745	(4.8776)	0.0119	-2.3804***	(0.7614)	0.1268
11	3.2792***	(0.7685)	0.3448	1.3288*	(0.7312)	0.1218	2.1929	(4.2441)	-0.0089	-2.6153***	(0.7407)	0.1687
12	3.0783***	(0.8382)	0.3176	1.3939*	(0.7382)	0.1404	0.9844	(3.9100)	-0.0181	-2.8386***	(0.8012)	0.2416
13	3.0825***	(0.7637)	0.3375	1.4324*	(0.7332)	0.1562	0.0741	(3.5382)	-0.0213	-2.6054***	(0.8743)	0.2292
14	3.0591***	(0.6318)	0.3696	1.4529**	(0.7306)	0.1694	-0.9327	(3.1287)	-0.0186	-2.5435***	(0.9048)	0.2865
15	2.9630***	(0.7024)	0.3453	1.5115**	(0.7330)	0.1831	-1.8137	(2.7658)	-0.0090	-2.1772**	(0.8607)	0.2342
16	3.0245***	(0.6798)	0.3563	1.5427**	(0.7151)	0.1958	-2.1431	(2.4552)	-0.0019	-1.8098**	(0.8015)	0.2128
17	2.9804***	(0.5879)	0.3604	1.5509**	(0.6989)	0.2070	-3.0496	(2.1095)	0.0246	-1.3844**	(0.6231)	0.1289
18	2.9214***	(0.7050)	0.3144	1.5912**	(0.6727)	0.2254	-3.6328**	(1.7405)	0.0518	-1.1535**	(0.5834)	0.1045
19	3.6814***	(0.5183)	0.3466	1.6474**	(0.6644)	0.2440	-4.5727***	(1.4240)	0.1080	-0.9594*	(0.5719)	0.0652
20	4.2486***	(0.3960)	0.3753	1.6898***	(0.6461)	0.2589	-4.9629***	(1.2098)	0.1467	-0.8789*	(0.4913)	0.0596
21	4.1653***	(0.4073)	0.3533	1.7522***	(0.6092)	0.2908	-5.5853***	(1.0501)	0.2192	-0.6566	(0.5585)	0.0261
22	4.3929***	(0.7213)	0.3293	1.8022***	(0.5877)	0.3192	-5.8219***	(0.9837)	0.2724	-0.6050	(0.5500)	0.0193
23	4.4037***	(0.9120)	0.3226	1.8733***	(0.5671)	0.3473	-6.2833***	(1.0746)	0.3727	-0.6220	(0.4648)	0.0342
24	4.4197***	(0.7598)	0.3083	1.9049***	(0.5516)	0.3647	-6.3441***	(1.0354)	0.4392	-0.4603	(0.3794)	0.0071

Notes:

1. See the notes 1, 2 and 3 in Table 1.

2. The first, second and third estimated periods are from 1982:4 to 1987:6−k, from 1987:7 to 1997:8−k and from 1987:8 to 2002:10−k, respectively, where k indicates the forecast horizon. The fourth estimated period is from 2002:11 to 2007:2 in the case where k is between 2 to 10, and from 2000:3 to 2007:3−k in the case k=11 to k=24.

Table 4-1: Regression Results of the Monetary Factor and Other Factor

First subsample: 1982:4-1987:6

k	γ_0	SE	γ_1	SE	γ_2	SE	R^2
1	3.7990*	(2.2594)	-0.8168	(5.7576)	5.4845	(3.9062)	-0.0002
2	3.5793***	(0.9619)	0.0985	(2.4249)	5.8294***	(1.4999)	0.1164
3	3.6053***	(0.6466)	0.4766	(1.5810)	5.6583***	(1.0310)	0.3341
4	3.7353***	(0.6721)	0.9340	(1.4526)	5.7437***	(1.1088)	0.3111
5	3.7843***	(0.6968)	1.7098	(1.3446)	5.2184***	(1.0027)	0.3628
6	3.7154***	(0.7770)	1.0402	(1.5467)	5.0310***	(1.0525)	0.4067
7	3.8382***	(0.8551)	1.9338	(1.6190)	5.0058***	(1.0649)	0.3936
8	3.8591***	(0.9250)	2.5166	(1.6741)	4.7778***	(0.9296)	0.4331
9	3.8369***	(1.0620)	2.3928	(2.2040)	4.5223***	(1.0277)	0.4263
10	3.8699***	(1.1319)	2.4034	(2.2563)	4.2615***	(1.0004)	0.3742
11	3.7762***	(1.2062)	2.6062	(2.3373)	4.1282***	(0.9321)	0.4051
12	3.8182***	(1.3455)	2.6603	(2.6520)	3.7264***	(1.0019)	0.3494
13	4.0705***	(1.4280)	3.6275	(2.6317)	3.1428***	(0.8690)	0.3481
14	4.4309***	(1.4864)	4.8316**	(2.4051)	2.4780***	(0.8164)	0.3825
15	4.6632***	(1.6919)	5.3807*	(2.7854)	1.9578**	(0.8262)	0.3568
16	4.6853***	(1.5715)	5.8982**	(2.4428)	1.6476**	(0.6855)	0.3709
17	4.5809***	(1.5324)	5.8923***	(2.2525)	1.5195**	(0.6625)	0.3779
18	4.4264***	(1.5938)	5.6704**	(2.4345)	1.4533**	(0.6054)	0.3197
19	4.3417***	(1.3643)	7.0985***	(1.8765)	1.9378***	(0.5495)	0.3767
20	4.1231***	(1.2439)	8.0574***	(1.2597)	2.5086***	(0.8742)	0.4282
21	3.9469***	(1.2581)	7.7451***	(1.5580)	2.5452***	(0.6882)	0.3938
22	3.8090***	(1.3793)	7.9397***	(1.1600)	2.4388*	(1.4084)	0.3884
23	4.1405***	(1.3947)	8.1980***	(1.0380)	1.6947	(1.5397)	0.4283
24	4.3351***	(1.2818)	7.8570***	(1.0481)	1.0275	(1.2532)	0.4141

Notes:

1. We estimate the following equation for the first sub-sample, from 1982:4 to 1987:6:

$$y_t^k = \gamma_0 + \gamma_1 \text{monetary\_factor}_t + \gamma_2 \text{other\_factor}_t + \nu_t,$$

where ν_t is the residual. To obtain the monetary policy factor and other factor, we estimate the following equation:

$$\text{spread}_t = \beta_0 + \beta_1 \hat{\epsilon}_{rt} + \beta_2 \hat{\epsilon}_{rt-1} + \cdots + \beta_{p+1} \hat{\epsilon}_{rt-p} + \eta_t,$$

where η_t is the error tem and $\hat{\epsilon}_{rt}$, $\hat{\epsilon}_{rt-1}$, $\hat{\epsilon}_{rt-2}$, $\hat{\epsilon}_{rt-3}$, … $\hat{\epsilon}_{rt-p}$ are obtained by the estimation of the structural VAR model using Choleski decomposition of the covariance matrix of the reduced VAR model (3). Based on the AIC, we set the lag length p at 10. We define $\hat{\beta}_1 \hat{\epsilon}_{rt} + \hat{\beta}_2 \hat{\epsilon}_{rt-1} + \cdots + \hat{\beta}_{p+1} \hat{\epsilon}_{rt-p}$ as monetary policy factor and the remaining part of the term spread $\hat{\eta}_t$ as the other factor using the estimated values of the above equation. The former is denoted by "monetary_factor_t" and the latter is denoted by "other_factor_t" in the first equation.

2. Standard errors corrected by the Newey and West (1987) method are in parentheses in column SE.

***, **, and * denote the statistical significance at the 1 %, 5% and 10% levels, respectively.

3. *R* squared statistics adjusted for degrees of freedom are presented in column R^2.

Table 4-2: Regression Results of the Monetary Factor and Other Factor

Second subsample: 1987:7-1997:8

k	γ_0	SE	γ_1	SE	γ_2	SE	R^2
1	-7.8451*	(4.4076)	4.4246*	(2.2269)	6.0474	(6.7123)	0.0372
2	-7.1834***	(2.1267)	4.1323***	(1.0869)	6.4969*	(3.5488)	0.1572
3	-6.7319***	(1.7401)	3.9045***	(0.9035)	6.1926**	(2.5206)	0.2572
4	-6.3942***	(1.4053)	3.7709***	(0.6858)	6.5918***	(2.1827)	0.3591
5	-6.7791***	(1.1843)	3.9659***	(0.5886)	6.6006***	(2.0040)	0.4602
6	-6.3912***	(0.8871)	3.7940***	(0.4354)	6.4247***	(1.7905)	0.4708
7	-6.0391***	(0.6918)	3.6346***	(0.3289)	6.2529***	(1.4985)	0.5317
8	-6.1527***	(0.6751)	3.7448***	(0.3150)	6.3293***	(1.2016)	0.6116
9	-5.7715***	(0.6744)	3.5783***	(0.2960)	6.3768***	(1.0734)	0.6012
10	-5.6429***	(0.6469)	3.5385***	(0.2552)	6.3659***	(1.0470)	0.6671
11	-5.0791***	(0.7005)	3.2698***	(0.2239)	6.4737***	(1.1094)	0.6476
12	-5.0186***	(0.7740)	3.2775***	(0.2419)	6.2123***	(1.0719)	0.6859
13	-4.9656***	(0.7618)	3.2821***	(0.2418)	5.7297***	(1.0422)	0.6960
14	-4.5119***	(0.7520)	3.0910***	(0.2256)	5.6350***	(1.2012)	0.6839
15	-4.6208***	(0.7810)	3.1918***	(0.2595)	5.4371***	(1.2894)	0.7008
16	-4.3663***	(0.8030)	3.0891***	(0.2566)	5.0847***	(1.2494)	0.6672
17	-4.0501***	(0.7772)	2.9611***	(0.2496)	4.8276***	(1.1080)	0.6647
18	-3.7701***	(0.7933)	2.8481***	(0.2668)	4.6483***	(1.1684)	0.6590
19	-3.6828***	(0.7791)	2.8693***	(0.2907)	4.6872***	(1.1014)	0.6638
20	-3.6751***	(0.7796)	2.8781***	(0.2988)	4.0971***	(0.9350)	0.6561
21	-3.4851***	(0.6910)	2.8216***	(0.2841)	3.7695***	(1.0052)	0.6761
22	-3.4179***	(0.6342)	2.8084***	(0.2928)	3.4617***	(1.0992)	0.7127
23	-3.4655***	(0.5774)	2.8406***	(0.2962)	2.8426**	(1.1930)	0.7361
24	-3.3366***	(0.5663)	2.7868***	(0.3074)	2.6340**	(1.2309)	0.7389

Notes:

We use the sample period from 1987:7 to 1997:8. The estimated equation and method are explained in note 1 in Table 4-1. Based on the AIC, we set the lag length p at 48. Standard errors and *R* squared are also presented in note 2 and 3 in Table 4-1.

Table 5-1: Regression Results of the Monetary Factor, Future Monetary Factor and Other Factor

First subsample: 1982:4-1987:6

k	ϕ_0	SE	ϕ_1	SE	ϕ_2	SE	ϕ_3	SE	R^2
1	9.7142**	(4.5389)	-0.6240	(5.2684)	7.6136	(5.4223)	6.0120	(5.0339)	0.0100
2	6.3350***	(1.4666)	0.3522	(1.6975)	3.7351**	(1.5964)	7.3991***	(2.1088)	0.1252
3	6.8828***	(1.0058)	-0.0209	(1.0264)	4.6711***	(0.9715)	7.0296***	(1.4326)	0.4097
4	6.8837***	(1.0280)	0.2613	(0.8994)	4.5981***	(1.0624)	7.0352***	(1.4933)	0.3646
5	6.3740***	(0.9787)	1.3347	(0.8311)	3.6923***	(0.8339)	6.7150***	(1.2208)	0.4207
6	6.1070***	(1.1703)	0.7240	(0.9085)	3.4005***	(1.0324)	6.5108***	(1.1072)	0.4821
7	5.6899***	(1.0594)	1.1945	(0.8850)	2.7226***	(0.9459)	7.2397***	(1.1021)	0.5187
8	5.6559***	(1.0675)	1.9845**	(0.8689)	2.5549***	(0.8920)	6.9326***	(0.9709)	0.5567
9	5.6116***	(1.1330)	1.5757	(1.1745)	2.6950***	(0.8781)	6.5045***	(1.0359)	0.5223
10	5.6927***	(1.2606)	1.6712	(1.2104)	2.7233***	(0.8543)	6.1766***	(0.9913)	0.4615
11	5.1789***	(1.2471)	1.8301	(1.2561)	2.1714***	(0.7890)	6.5882***	(0.7156)	0.5454
12	4.8668***	(1.2080)	1.8709	(1.6425)	1.6876*	(0.9559)	6.0961***	(0.9559)	0.4807
13	4.5155***	(1.2444)	2.3795	(1.5612)	1.0076	(0.9605)	5.9654***	(0.8361)	0.5108
14	4.3395***	(1.2857)	3.4013***	(1.2683)	0.3250	(0.7730)	5.4360***	(0.5716)	0.5550
15	4.3471***	(1.3855)	3.9559***	(1.4443)	-0.0181	(0.6591)	4.6957***	(0.6192)	0.4879
16	4.1927***	(1.4075)	4.4685***	(1.2258)	-0.3423	(0.6915)	4.4037***	(0.4960)	0.5091
17	3.9388***	(1.3079)	4.5607***	(0.9759)	-0.6470	(0.6664)	4.0489***	(0.4622)	0.5277
18	3.7907***	(1.3485)	4.3287***	(1.3593)	-0.7019	(0.6027)	3.7150***	(0.4801)	0.4521
19	4.1343***	(1.2875)	5.6060***	(1.1322)	-0.1631	(0.7240)	3.8968***	(0.4355)	0.4928
20	4.4037***	(1.1626)	6.4356***	(1.1077)	0.3691	(0.7948)	3.8502***	(0.3671)	0.5216
21	4.2227***	(1.2439)	6.0101***	(1.4018)	0.2183	(0.8916)	3.6213***	(0.4483)	0.4858
22	3.9477***	(1.0594)	6.2679***	(1.1403)	0.2138	(0.7982)	4.1072***	(0.5530)	0.5116
23	4.1547***	(0.9329)	6.7217***	(0.9612)	0.5269	(0.7415)	3.6977***	(0.8882)	0.5099
24	4.2635***	(1.1967)	6.4956***	(1.2987)	0.9275	(0.7921)	3.7439***	(0.9691)	0.4510

Notes:

1. We estimate the following equation for the first sub-sample, from 1982:4 to 1987:6:

$$y_t^k = \phi_0 + \phi_1 \text{monetary\_factor*}_t + \phi_2 \text{future\_monetary\_factor*}_t + \phi_3 \text{other\_factor*}_t + \nu_t,$$

where ν_t is the residual. To obtain the monetary policy factor, future monetary policy factor and other factor, we estimate the following equation:

$$\text{spread}_t = \delta_0 + \delta_1 \hat{\epsilon}_{rt} + \delta_2 \hat{\epsilon}_{rt-1} + \cdots + \delta_{p+1} \hat{\epsilon}_{rt-p} + \delta_i \text{call\_spread}_t + \xi_t,$$

where ξ_t is the error term and $\hat{\epsilon}_{rt}$, $\hat{\epsilon}_{rt-1}$, $\hat{\epsilon}_{rt-2}$, $\hat{\epsilon}_{rt-3}$, … $\hat{\epsilon}_{rt-p}$ are obtained by the estimation of the structural VAR model using Choleski decomposition of the covariance matrix of the reduced VAR model (3) and call_spread_t is the expected future call rates for the 9-year period based on the estimated structural VAR model minus current call rate. Based on the AIC, we set the lag length p at 10. We define $\hat{\delta}_1 \hat{\epsilon}_{rt} + \hat{\delta}_2 \hat{\epsilon}_{rt-1} + \cdots + \hat{\delta}_{p+1} \hat{\epsilon}_{rt-p}$ as the monetary policy factor, $\hat{\delta}_i \text{call\_spread}_t$ as the future monetary policy factor and the remaining part of the term spread $\hat{\xi}_t$ as the other factor using the estimated values of the above equation. The first term is denoted by "$\text{monetary\_factor*}_t$," the second term is indicated by "$\text{future\_monetary\_factor*}_t$" and the third term is denoted by "other_factor*_t" in the first equation.

2. Standard errors corrected by the Newey and West (1987) method are in parentheses in column SE.

   ***, **, and * denote the statistical significance at the 1 %, 5% and 10% levels, respectively.

3. *R* squared statistics adjusted for degrees of freedom are presented in column R^2.

Table 5-2: Regression Results of the Monetary Factor, Future Monetary Factor and Other Factor

Second subsample: 1982:7-1997:8

k	ϕ_0	SE	ϕ_1	SE	ϕ_2	SE	ϕ_3	SE	R^2
1	-4.4675	(5.1949)	2.5128	(2.4140)	5.2523	(6.1052)	8.9114	(9.0977)	0.0093
2	-4.5295**	(2.1964)	2.6092**	(1.0510)	7.1932**	(3.0436)	3.9454	(4.6285)	0.1405
3	-2.5947*	(1.5540)	1.7128**	(0.7078)	8.5621***	(2.0222)	4.1288	(3.8366)	0.2516
4	-3.3026**	(1.3654)	2.0456***	(0.5801)	7.4692***	(1.8242)	5.4115*	(3.0671)	0.3562
5	-4.4382**	(1.8099)	2.5517***	(0.7816)	5.6391***	(1.2724)	6.2473**	(3.0297)	0.3956
6	-3.8442***	(1.3113)	2.3153***	(0.5646)	6.4362***	(1.2525)	5.1192*	(2.8726)	0.4363
7	-3.5144***	(0.9779)	2.2104***	(0.4195)	6.8101***	(1.2936)	4.1140	(2.5694)	0.5164
8	-4.3512***	(0.9901)	2.6209***	(0.4324)	5.8486***	(0.9468)	4.8794**	(2.2147)	0.5797
9	-4.2089***	(0.6766)	2.5512***	(0.3136)	5.7053***	(0.9134)	5.7051***	(1.7802)	0.5968
10	-4.0902***	(0.4263)	2.5234***	(0.2598)	5.9301***	(1.0194)	5.6798***	(1.3635)	0.6755
11	-4.0541***	(0.4046)	2.4885***	(0.1788)	5.4966***	(0.9156)	6.3542***	(1.1582)	0.6830
12	-4.4117***	(0.4747)	2.6232***	(0.1852)	4.3273***	(0.6396)	7.5580***	(0.9717)	0.7132
13	-4.2574***	(0.3994)	2.5937***	(0.1672)	4.3177***	(0.7809)	7.1161***	(0.9734)	0.7272
14	-3.6567***	(0.2752)	2.3608***	(0.1568)	4.6215***	(1.0845)	6.8965***	(1.2307)	0.7369
15	-3.7985***	(0.3477)	2.4554***	(0.1182)	4.2583***	(0.9194)	7.4148***	(1.1759)	0.7406
16	-3.9396***	(0.2951)	2.5275***	(0.1264)	3.6365***	(1.0198)	7.0869***	(1.4052)	0.7172
17	-3.5550***	(0.2794)	2.3910***	(0.1309)	3.6909***	(1.2174)	6.8701***	(1.0844)	0.7230
18	-3.8812***	(0.2099)	2.5501***	(0.1300)	3.0877**	(1.3314)	6.4613***	(1.0276)	0.7330
19	-3.7079***	(0.2450)	2.5396***	(0.1236)	3.2410**	(1.3798)	6.2850***	(0.6905)	0.7339
20	-3.5278***	(0.2856)	2.4989***	(0.1368)	3.1927**	(1.5780)	5.5214***	(0.6465)	0.7066
21	-3.0946***	(0.3169)	2.3851***	(0.1230)	3.7128**	(1.5643)	5.1124***	(0.6595)	0.7356
22	-3.1464***	(0.2800)	2.4421***	(0.1077)	3.4750**	(1.4570)	5.2397***	(0.5017)	0.7658
23	-3.1598***	(0.2511)	2.5025***	(0.0932)	3.5666**	(1.4092)	4.5189***	(0.3989)	0.7799
24	-3.0465***	(0.2819)	2.4533***	(0.1201)	3.3242**	(1.4991)	3.8956***	(0.4142)	0.7700

Notes:

We use the sample period from 1987:7 to 1997:8. The estimated equation and method are explained in note 1 in Table 5-1. Based on the AIC, we set the lag length p at 45. Standard errors and R squared are also presented in note 2 and 3 in Table 5-1.

Table 6-1: Results of Other Maturities: First subsample 1982:4-1987:6

M	k	ϕ_1	SE	ϕ_2	SE	ϕ_3	SE	R^2	M	k	ϕ_1	SE	ϕ_2	SE	ϕ_3	SE	R^2
2	3	0.2235	(2.1290)	3.2908	(2.3717)	1.3304	(2.5818)	-0.0057	6	3	0.0652	(1.0860)	5.2898***	(1.3002)	5.7067***	(1.2425)	0.3773
	6	0.5711	(1.8685)	2.4318	(2.2723)	2.7009	(2.2175)	0.0221		6	0.8697	(0.7741)	3.9023***	(1.0938)	6.0774***	(1.0690)	0.5297
	9	1.5726	(1.8122)	2.3374	(2.0076)	3.5443*	(2.0708)	0.0764		9	1.3479**	(0.6662)	3.1258***	(0.8513)	6.6059***	(0.8159)	0.6351
	12	2.5154	(2.0257)	1.6613	(1.7119)	4.2977***	(1.5374)	0.1404		12	1.4128	(1.0230)	2.2015***	(0.7407)	6.5912***	(0.7811)	0.6365
	15	5.5272***	(1.9621)	0.2037	(0.7972)	4.0075***	(1.1410)	0.2430		15	2.8413***	(1.0002)	0.8557*	(0.4517)	5.5741***	(0.6144)	0.6375
	18	4.8898***	(1.5644)	-0.0623	(0.8279)	4.0765***	(0.8638)	0.2482		18	3.3104***	(1.0388)	0.3636	(0.3823)	4.9175***	(0.5669)	0.6233
	21	3.4335**	(1.5936)	-1.1017	(0.8403)	5.5629***	(1.0170)	0.4017		21	4.7300***	(0.8647)	0.8787	(0.6185)	4.6457***	(0.4166)	0.6811
	24	4.3160**	(1.7147)	-0.1675	(0.8367)	4.9135***	(1.0203)	0.3515		24	4.8546***	(1.1252)	1.6189**	(0.6442)	4.9559***	(0.6812)	0.6726
3	3	-0.1298	(2.3941)	3.0494	(2.1735)	2.4386	(2.2172)	0.0163	7	3	0.0265	(1.1555)	5.2406***	(1.3698)	5.9965***	(1.6495)	0.2864
	6	0.4341	(1.9853)	2.3099	(2.0454)	3.3741*	(1.9926)	0.0521		6	0.7933	(0.9318)	3.8582**	(1.5089)	5.8461***	(1.2621)	0.3250
	9	1.5430	(1.8079)	2.1896	(1.7856)	4.2477**	(1.9324)	0.1154		9	1.5280	(0.9418)	3.1291**	(1.3311)	6.2823***	(1.0798)	0.3884
	12	2.3503	(1.8688)	1.6133	(1.5031)	4.8333***	(1.4999)	0.1667		12	1.8236	(1.3310)	2.0502	(1.3268)	6.1684***	(0.9261)	0.3808
	15	5.4558***	(1.9718)	0.3685	(0.8099)	4.2520***	(1.0578)	0.2404		15	4.1812***	(1.1008)	0.0348	(0.9159)	4.4766***	(0.7802)	0.4098
	18	4.8527***	(1.5403)	0.0568	(0.8294)	4.2106***	(0.8247)	0.2399		18	4.4088***	(1.0025)	-0.6574	(0.8008)	3.7511***	(0.5261)	0.4031
	21	3.0737*	(1.6649)	-0.8835	(0.9478)	5.5885***	(0.7880)	0.3746		21	5.3901***	(0.9877)	-0.4117	(1.0086)	3.5513***	(0.5819)	0.4455
	24	3.9636**	(1.9743)	-0.0797	(0.9295)	5.1861***	(1.2142)	0.3146		24	5.8580***	(1.1002)	0.2971	(0.9980)	3.2702**	(1.3827)	0.4246
4	3	-0.1382	(1.5655)	2.6161*	(1.5703)	4.6399***	(1.6091)	0.1342	8	3	0.0308	(1.1687)	5.2197***	(1.0491)	7.0214***	(1.5805)	0.3823
	6	0.3025	(1.1374)	2.0319	(1.2678)	5.5426***	(1.3923)	0.2809		6	0.9514	(1.0688)	3.8443***	(1.2060)	6.6373***	(1.2756)	0.4487
	9	1.1053	(1.1408)	1.8520*	(1.0117)	5.7744***	(1.3099)	0.3663		9	1.7372	(1.4434)	3.0716***	(1.0537)	6.6084***	(1.3031)	0.4769
	12	1.6795	(1.6036)	1.4017*	(0.8216)	5.6364***	(1.0787)	0.3863		12	2.2140	(2.0369)	1.8142	(1.2204)	5.9770***	(1.1820)	0.4187
	15	4.0225**	(1.8282)	0.4354	(0.5398)	4.6423***	(0.7646)	0.3947		15	4.7848***	(1.5503)	-0.3387	(0.8511)	4.2444***	(0.9012)	0.4368
	18	3.8168**	(1.7147)	0.3548	(0.6255)	4.2569***	(0.4836)	0.3529		18	5.0678***	(1.4423)	-1.0287	(0.8218)	3.3024***	(0.6010)	0.4102
	21	5.2800***	(1.6982)	0.6111	(1.0791)	4.1818***	(0.6033)	0.3737		21	6.6175***	(1.5045)	-0.1160	(1.1969)	3.1465***	(0.4812)	0.4257
	24	5.9129***	(1.7445)	1.1779	(1.0518)	3.8939***	(1.1007)	0.2938		24	7.0047***	(1.3130)	0.4221	(1.0855)	2.5947*	(1.4120)	0.3846
5	3	-0.1278	(1.3202)	2.7302	(1.7156)	4.1831***	(1.3322)	0.1673									
	6	0.3284	(0.8598)	2.1564	(1.3706)	5.0934***	(1.0802)	0.3842									
	9	0.9750	(0.6910)	1.9717*	(1.1062)	5.5031***	(0.8798)	0.5403									
	12	1.2107	(0.9697)	1.6108**	(0.8049)	5.5803***	(0.6799)	0.6066									
	15	2.7682**	(1.2211)	0.8596*	(0.4955)	4.9364***	(0.4462)	0.6242									
	18	2.5056**	(1.2014)	0.9383**	(0.4340)	4.8109***	(0.2968)	0.6340									
	21	3.8752***	(1.1355)	1.1695*	(0.6932)	4.5104***	(0.3228)	0.6530									
	24	4.4249***	(1.2516)	1.7734**	(0.7179)	4.4833***	(0.3167)	0.6094									

Notes:

Maturity years are indicated in column M. With respect to the estimate equation, see note 1 in Table 5-1. The AIC indicate that the lag numbers are 6 for M=2, M=3, M=4 and M=5, and 9 for M=6, M=7 and M=8. Standard errors and *R* squared are explained in note 2 and 3 in Table 5-1.

Table 6-2: Results of Other Maturities: Second subsample 1987:7-1997:8

M	k	ϕ_1	SE	ϕ_2	SE	ϕ_3	SE	R^2
2	3	5.2502**	(2.4167)	18.7682***	(4.5836)	5.1324	(5.8555)	0.2840
	6	5.7342***	(1.3314)	14.6609***	(2.9225)	4.5993	(4.0287)	0.4167
	9	4.3007***	(1.6144)	15.4796***	(2.6240)	1.2878	(4.8127)	0.4567
	12	3.8949**	(1.6886)	13.2378***	(2.4917)	4.0107	(3.9228)	0.4852
	15	3.5088*	(1.8947)	12.0880***	(2.2723)	5.8457	(4.1187)	0.4931
	18	3.2636**	(1.5751)	9.1853***	(2.8298)	5.9317*	(3.0496)	0.4205
	21	3.2972**	(1.3055)	9.0371**	(3.7654)	3.0247	(2.1858)	0.4382
	24	4.1322***	(1.1341)	5.8424	(3.6146)	1.7027	(2.2495)	0.4992
3	3	4.1116**	(1.9979)	14.8335***	(3.8505)	4.3142	(4.8023)	0.2733
	6	4.3318***	(1.1584)	11.7181***	(2.3175)	4.4684	(3.2420)	0.3979
	9	3.3119**	(1.4593)	12.2526***	(1.8399)	2.2506	(3.4339)	0.4464
	12	3.0066*	(1.6031)	10.4451***	(1.6623)	4.5019*	(2.6617)	0.4855
	15	2.6829	(1.7152)	9.8607***	(1.6144)	5.6193*	(2.9966)	0.4961
	18	2.5374*	(1.3722)	7.5922***	(2.2001)	5.1385**	(2.3216)	0.4181
	21	2.6053**	(1.1646)	7.5167**	(2.9972)	2.8036*	(1.5939)	0.4349
	24	3.2919***	(1.0239)	4.9733*	(2.8747)	1.6103	(1.5082)	0.4876
4	3	2.9070*	(1.6249)	12.3539***	(3.3098)	4.0303	(4.1165)	0.2570
	6	3.3913***	(0.8821)	9.5302***	(1.9199)	4.3095	(2.9262)	0.3925
	9	3.0143***	(1.0526)	9.5995***	(1.4295)	2.6484	(2.9561)	0.4657
	12	2.8070**	(1.1270)	8.1013***	(1.2485)	4.3282*	(2.2366)	0.5148
	15	2.4773**	(1.1956)	7.8086***	(1.2757)	5.0395*	(2.6364)	0.5248
	18	2.7186***	(1.0327)	5.5720***	(1.7868)	4.3722**	(1.8822)	0.4686
	21	2.7681***	(0.8808)	5.4429**	(2.4212)	2.3255*	(1.3454)	0.4942
	24	3.1179***	(0.7028)	3.6346	(2.4019)	1.4248	(1.3208)	0.5493
5	3	2.2813**	(0.9309)	11.8341***	(2.7838)	5.1162	(3.4493)	0.2643
	6	2.7273***	(0.5100)	9.1403***	(1.8357)	4.6330*	(2.4197)	0.4044
	9	2.8393***	(0.5217)	8.4837***	(1.3876)	3.5189	(2.4335)	0.4968
	12	3.0165***	(0.6069)	6.5085***	(1.1770)	4.9552***	(1.8631)	0.5686
	15	2.8005***	(0.6668)	6.2371***	(1.4042)	5.0281**	(1.9705)	0.5808
	18	2.9371***	(0.5715)	4.3051**	(2.0257)	4.4131***	(1.4158)	0.5542
	21	2.7646***	(0.4883)	4.7046*	(2.5516)	2.6948***	(0.9739)	0.5657
	24	2.8991***	(0.3724)	3.5941	(2.5135)	1.8634*	(1.1265)	0.6156

M	k	ϕ_1	SE	ϕ_2	SE	ϕ_3	SE	R^2
6	3	2.0565**	(0.8311)	12.2919***	(2.9835)	4.9111	(3.4142)	0.2618
	6	2.4429***	(0.4649)	9.4375***	(1.9918)	4.8532**	(2.2961)	0.4075
	9	2.5940***	(0.3914)	8.5889***	(1.5150)	4.2230**	(2.0623)	0.5131
	12	2.7231***	(0.4720)	6.5113***	(1.2850)	5.6837***	(1.4271)	0.5894
	15	2.5471***	(0.5185)	6.2903***	(1.5432)	5.7866***	(1.4887)	0.6081
	18	2.6565***	(0.4448)	4.3450**	(2.2012)	5.1107***	(1.0389)	0.5795
	21	2.4680***	(0.3947)	4.8606*	(2.6651)	3.2700***	(0.6325)	0.5766
	24	2.5810***	(0.2946)	3.7540	(2.6477)	2.1851***	(0.6879)	0.6182
7	3	2.1077**	(0.8362)	10.5894***	(2.6729)	4.2926	(3.4369)	0.2636
	6	2.5370***	(0.5458)	7.9864***	(1.7167)	4.7572**	(2.4145)	0.4291
	9	2.7138***	(0.3065)	7.1149***	(1.3283)	4.7636**	(1.9086)	0.5603
	12	2.8065***	(0.2554)	5.1998***	(0.9830)	6.6250***	(1.0767)	0.6608
	15	2.6359***	(0.2583)	5.0677***	(1.2830)	6.6284***	(1.0600)	0.6885
	18	2.7117***	(0.2115)	3.4654*	(1.8803)	5.9475***	(0.8117)	0.6712
	21	2.5015***	(0.2145)	4.1411*	(2.2276)	4.1860***	(0.7889)	0.6585
	24	2.5895***	(0.1473)	3.3015	(2.2164)	2.9161***	(0.4684)	0.6979
8	3	1.9153**	(0.7653)	9.2315***	(2.2536)	3.9436	(3.6479)	0.2566
	6	2.4393***	(0.5526)	6.9206***	(1.3900)	4.7430*	(2.7776)	0.4334
	9	2.6413***	(0.2996)	6.1785***	(1.0730)	4.9221**	(2.1041)	0.5777
	12	2.7214***	(0.1839)	4.5292***	(0.6535)	7.1313***	(1.1553)	0.6920
	15	2.5523***	(0.1512)	4.4206***	(0.9581)	7.0047***	(1.1416)	0.7202
	18	2.6349***	(0.1271)	3.0441**	(1.4707)	6.1575***	(0.8438)	0.7134
	21	2.4432***	(0.1293)	3.6898**	(1.7743)	4.6259***	(0.7154)	0.7095
	24	2.5210***	(0.1023)	3.1393*	(1.7258)	3.4501***	(0.5163)	0.7505

Notes:

Maturity years are indicated in columns M. With respect to the estimate equation, see note 1 in Table 5-1. The AIC indicate that the lag numbers are 48 for M=2 and M=3, 47 for M=4, and 45 for M=5, M=6, M=7 and M=8. Standard errors and *R* squared are explained in note 2 and 3 in Table 5-1.