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The term structure of interest rates in Japan: the predictability of economic activity

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Abstract

This paper examines whether the yield spread between long- and short-term interest rates contains information about future economic activity in Japan, and whether the nature of this relationship changes with time. The results firstly indicate a break point in the relationship between interest rates and economic activity. The yield spread is then split into two factors: expected future changes in short rates, and the term premium. Analysis is made concerning which of these factors contains information about future economic activity. The results indicate that the first factor contains information over time, even though the term premium has changed.

JEL classification: E43; E52

Keywords: Term structure of interest rates; Interest rates; Interest yield spread; Aggregate productivity; Monetary policy

1. Introduction

Market analysts and policymakers wish to have exact information about future economic activity. With accurate information, entrepreneurs can plan optimal investments and policymakers can make appropriate policy. Many interested parties have searched for the variables that indicate future economic conditions, and researchers have long searched for the variables that help to predict the business cycle.[1]

For this purpose, many researchers have investigated whether the yield spread—that is, the difference between long- and short-term interest rates—contains information for

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[1] See, for example, Honda et al. (1995), Honda and Matsuoka (2001).

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predicting future economic growth under the expectations hypothesis.[2] Intuitively, if people expect that they can increase future consumption above current levels, they come to feel that present consumer goods are expensive compared with future consumer goods. Interest rates rise. Conversely, if people expect that they will decrease future consumption below current levels, interest rates fall. If people can increase future consumption, economic growth will be faster in the future. Consequently, if they expect that future economic growth will be rapid, the yield spread extends. Alternatively, if they expect future economic growth will be slower, the yield spread narrows. On this basis, Harvey (1988) showed that the term structure of ex ante real rates of interest contains information about future real consumption and economic growth in the context of the Consumption Capital Asset Pricing model (C-CAPM).

In terms of economic forecasting, a number of studies have examined the yield spread of nominal interest rates as a predictor of future economic activity. Estrella and Hardouvelis (1991), for example, found that the yield spread between the 10-year Treasury Bond rate and the 3-month Treasury Bill rate contains information about future growth in output, consumption, and investment, and the probability of a recession in the United States. Plosser and Rouwenhorst (1994) also concluded that the term structure in the United States has significant predictive power for long-term economic growth, and showed that the term structure includes information about future real activity that is independent of information concerning current or future monetary policy. Lastly, Hamilton and Kim (2002) likewise investigated whether the yield spread between the 10-year US Treasury Bond rate and the 3-month US Treasury Bill rate included information about future real GDP, and showed that the spread's forecasting contribution can be decomposed into an effect related to expected changes in short-term rates and an effect related to the term premium. Hamilton and Kim (2002) concluded that both factors made statistically important contributions, although the effect of expected short-term rates was more important than the term premium for predicting GDP. Several other papers also have demonstrated the yield spread's predictive power regarding future economic activity.

Nevertheless, there is no such consensus that the yield spread between long- and short-term interest rates contains information about future economic activity in Japan. Harvey (1991) examined G-7 economies and concluded that the Japanese yield spread contained no information about future economic activity for the period 1970–1989. While Hu (1993) did find a positive correlation between future Japanese economic activity and the yield spread for the period from January 1957 to April 1991, he also found that lagged stock price change and lagged output growth have more explanatory power than the term structure. Kim and Limpaphayom (1997) likewise used Japanese data, in that case, quarterly observations for the period 1975–1991, to examine the yield spread between long- and short-term interest rates as a predictor of future GDP. They found that the yield spread contained no information about future GDP over the whole period, but the yield spread contained useful information for up to five quarters ahead in the period from 1984 to 1991. In justifying this finding, Kim and Limpaphayom (1997) argued that market expectations

[2] See Saito (2000), chapter 2, and Luenberger (1997), chapter 4, regarding the expectations hypothesis on the term structure of interest rates.

had not influenced interest rates before 1984 because of heavy regulation.[3] Kim and Limpaphayom (1997) concluded that financial deregulation had more fully brought market expectations into interest rates, and that the yield spread had then included information about future economic activity.

Later, Galbraith and Tkacz (2000) concluded that the Japanese yield spread contained no information about future economic activity for the period from 1966 to 1997. However, and in common with most studies in the Japanese context, Galbraith and Tkacz (2000) did not take into account the fact that published interest rate data in Japan only concern simple interest; thus, they frequently defined the yield spread as the difference between published long- and short-term interest rates. Importantly, Saito (2000) has argued that the yield spread of coupon bonds contains no accurate information about future economic activity under the expectations hypothesis, but the spot rate of zero-coupon bonds contains accurate information about future economic activity. As coupon effects should be removed from published long-term interest rates, an important methodological requirement is to convert published interest rates data into compound interest.

Another consideration is that the relationship between the yield spread and future economic activity may not be robust in all countries, and that such relationships, where they exist, can vary with time. For example, Estrella and Mishkin (1997) found that the relationship was broken in October 1979 in the United States. Moreover, Dotsey (1998) showed that the information content of the yield spread differed across sample periods, and that the spread did not appear to be statistically significant over some subperiods. Finally, Smets and Tsatsaronis (1997) found that the predictive content of the term spread is not time invariant. The present analysis considers these factors.

This analysis uses data examined by Nakashima (2003).[4] The results clearly show that the yield spread contains useful information about future economic conditions in Japan. Using an established statistical technique, break points in the relationship between the yield spread and future economic activity are also identified. This shows that the relationship between the yield spread and future economic activity changed with time. Moreover, the yield spread contains relatively more useful information about future economic activity when compared with other macroeconomic variables, including those evident in earlier work in this area. Finally, by splitting the yield spread into its component parts, comprising an expectation effect and a term premium effect, the results show that the expectation effect is relatively more important regarding the predictability of economic activity.

The paper itself is as follows. Section 2 discusses whether the yield spread between long- and short-term interest rates has information about future economic activity in Japan following financial deregulation, and whether the nature of the relation changes with time. Section 3 examines whether the yield spread contains relatively more useful information about future economic activity when compared with other variables. In Section 4, and following Hamilton and Kim (2002), the yield spread is decomposed into two factors, and examination is made into which particular factor the information about future economic

[3] See Kuroda (1997) and Hoshi (2001) for a discussion of financial deregulation circumstances in Japan.

[4] Nakashima (2003) removed coupon effects from published long-term bond interest rates in order to render accurate interest rates. He adjusted the interest rate data by calculating compound interest.

activity should be included. The final section summarizes the results and makes some suggestions for future research in this area.

2. A reexamination of the predictability of the yield spread

2.1. The predictability of the yield spread for real economic activity

Quarterly data predominate in most research concerning yield spreads, but in order to increase sampling frequency the present analysis uses monthly data: the 5-year government bond rate, 1-month bond and debenture rates, and the index of industrial production. This follows the work of Plosser and Rouwenhorst (1994), amongst others. Many previous studies, including Estrella and Hardouvelis (1991), Estrella and Mishkin (1997), Haubrich and Dombrosky (1996), Bonser and Morley (1997), Dotsey (1998), and Hamilton and Kim (2002), use the following regression to examine the predictability of the yield spread for real activity:

$$y_t^k = \alpha_0 + \alpha_1 \mathrm{spread}_t + \varepsilon_t, \tag{1}$$
$$y_t^k = (1200/k)(\ln Y_{t+k} - \ln Y_t), \quad \text{where spread}_t = i_t^n - i_t^1,$$

where Y_{t+k} is the index of industrial production in month $t+k$, y_t^k the annualized industrial production growth over the next k months, i_t^n the 5-year government bond rate, i_t^1 the 1-month bond and debenture rate, and ε_t the disturbance term.[5,6] There are 144 observations in the sample period.

The estimated coefficients and standard errors of Eq. (1) are shown in Table 1. None of the spread coefficients is significant from 1 month to 4 years ahead. This means that the yield spread does not have predictability about future economic growth. However, Dotsey (1998) showed that the information content of the yield spread differed across sample periods, and that the spread did not appear to be statistically significant over some subperiods, while Smets and Tsatsaronis (1997) argued that the predictive content of the term spread is not time invariant. A necessary requirement is then to take into consideration the possibility that a structural change has taken place in the sample period. Following Andrews (1993), tests are made for an unknown structural change point in Eq. (1) of $k = 1$ under the null hypothesis of no structural change.[7] Fig. 1 shows the test statistics at each point of time. Since the critical value at the 5% level of significance is

[5] In the regression analysis of this paper, in order to control the influence of the series correlation on the disturbance term, I am utilizing the correction standard variation based on Newey and West (1987).

[6] Rate of economic growth is an index of industrial production based on 1995 data. It is a seasonally adjusted series from the Ministry of Economy, Trade and Industry. The short-term rate of interest is the 1-month bonds and debentures rate (*kousyasai-gensaki-yokugetumono*) from the Japan Securities Dealers Association. The period of data is from February 1985 to December 2001. The long-term rate of interest is the 5-year government bond rate from Nakashima (2003). He processed published interest rates data following Fama and Bliss (1987). The period of data is from February 1985 to January 1997.

[7] See Stock (1994) and Maddla and Kim (1998), chapter 13, regarding the technique of Andrews (1993).

Table 1
The predictability of economic activity using the yield spread

k (months ahead)	α_0	α_1	R^2
1	1.473 (1.719)	0.905 (0.667)	−0.004
2	1.559 (1.687)	0.869 (0.561)	−0.0005
3	1.5 (1.754)	0.813 (0.587)	0.003
4	1.519 (1.724)	0.765 (0.602)	0.003
5	1.488 (1.753)	0.83 (0.614)	0.007
6	1.445 (1.765)	0.889 (0.625)	0.012
7	1.436 (1.799)	0.897 (0.667)	0.015
8	1.415 (1.806)	0.945 (0.665)	0.019
9	1.366 (1.834)	0.991 (0.698)	0.023
10	1.338 (1.856)	1.008 (0.730)	0.026
11	1.295 (1.861)	1.035 (0.745)	0.03
12	1.246 (1.877)	1.105 (0.776)	0.038
13	1.216 (1.869)	1.101 (0.793)	0.04
14	1.205 (1.866)	1.05 (0.840)	0.038
15	1.227 (1.874)	0.972 (0.840)	0.03
16	1.23 (1.875)	0.916 (0.865)	0.027
17	1.221 (1.861)	0.855 (0.889)	0.025
18	1.24 (1.869)	0.775 (0.926)	0.02
19	1.297 (1.901)	0.682 (0.984)	0.014
20	1.311 (1.922)	0.626 (1.034)	0.011
21	1.337 (1.947)	0.541 (1.095)	0.007
22	1.346 (1.939)	0.481 (1.114)	0.004
23	1.391 (1.969)	0.387 (1.167)	0.0007
24	1.413 (1.987)	0.334 (1.205)	−0.001
36	1.455 (1.811)	−0.015 (1.179)	−0.007
48	1.387 (1.468)	−0.152 (0.888)	−0.004

In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors corrected.

11.79, the null hypothesis for July 1991 is rejected and we may conclude that significant structural change took place in July 1991.[8]

2.2. *The predictability of the yield spread in regressions including dummy variables*

Dummy variables that take the value zero until July 1991 and take one thereafter are now included in Eq. (1) such that:

$$y_t^k = \alpha_0 + \alpha_1 d_t + \alpha_2\,\text{spread}_t + \alpha_3 \text{Sd}_t + \varepsilon_t \tag{2}$$

where d_t are dummy variables on constants and Sd_t are dummy variables on spread.

Table 2 presents the estimated coefficients and standard errors of the regression including structural breaks. As shown, the spread coefficients are positive and significant

[8] In addition, in Eq. (1) about other k, I test the structural change for the sample period using the Chow test for the first half from February 1985 to June 1991, and the second half from July 1991 to January 1997. As a consequence, I reject the null hypothesis that there is no structural change, at a 1% significant level, in the first half and the second half in all k.

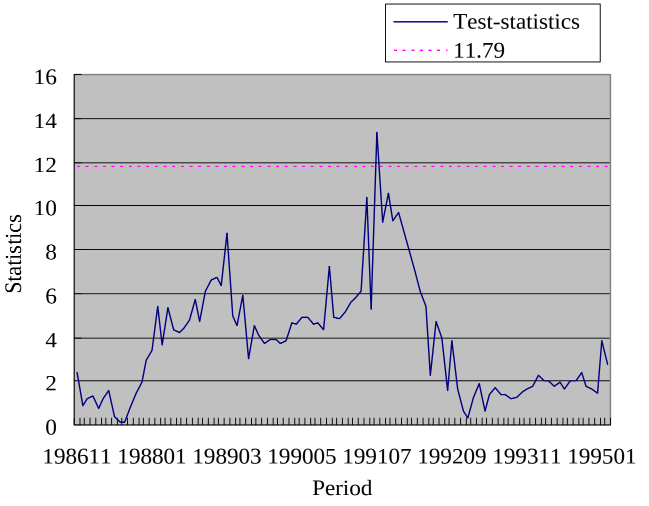

Fig. 1. Testing structural breaks.

at the 1% level of significance from 1 month to 4 years ahead. The dummy variable coefficients on spread are significant and positive for 1 and 3 months ahead, and significant and negative for 15 months to 4 years ahead. The constants also have significant positive values from 1 month ahead to 2 years ahead, while the coefficients of dummy variables on constants are significant and negative from 1 month to 2 years ahead.

These results are similar to those found in the United States where it was concluded that the yield spread is helpful for forecasting real GDP growth up to 2 years ahead. While the current analysis likewise concludes that the spread contains information useful for the predictability of future economic activity, it is also noted that the coefficients of dummy variables on constants are significantly negative. This suggests that economic activity fell after July 1991. As the coefficients of dummy variables on spread are negative from 15 months to 4 years ahead, one suggestion is that spread information on the more remote future has changed.[9] In the following, although not all dummy variables on spread are significant, for convenience, regressions including dummy variables on both constants and spread are made.

3. The predictability of the yield spread over other variables

3.1. The regression including other financial variables

A number of studies, including those by Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Estrella and Mishkin (1997), Dotsey (1998), and Hamilton and Kim

[9] In this paper, as a proxy variable of economic activity, I have adopted the index of industrial production. Even if I use indices of tertiary industry, official business, etc., it turns out similarly that the spread contains the predictability of future economic activity.

Table 2
Includes dummy variables on constants and on spread

k (months ahead)	α_0	α_1	α_2	α_3	R^2
1	3.428*** (0.932)	−10.422*** (1.329)	3.229*** (1.034)	2.242** (1.130)	0.018
2	3.466*** (0.817)	−9.889*** (1.402)	3.671*** (0.764)	1.409 (1.076)	0.104
3	3.380*** (0.838)	−9.798*** (1.319)	3.496*** (0.624)	1.508* (0.900)	0.194
4	3.319*** (0.854)	−9.289*** (1.607)	3.509*** (0.614)	1.188 (1.030)	0.217
5	3.286*** (0.840)	−9.300*** (1.611)	3.531*** (0.512)	1.245 (0.966)	0.260
6	3.196*** (0.840)	−8.949*** (1.711)	3.725*** (0.552)	0.913 (1.022)	0.289
7	3.152*** (0.862)	−8.810*** (1.601)	3.585*** (0.667)	1.025 (0.984)	0.314
8	3.096*** (0.846)	−8.467*** (1.627)	3.904*** (0.571)	0.533 (0.961)	0.328
9	3.023*** (0.854)	−8.288*** (1.546)	4.018*** (0.736)	0.364 (0.963)	0.348
10	2.933*** (0.882)	−7.814*** (1.517)	4.250*** (0.814)	−0.121 (0.992)	0.350
11	2.877*** (0.863)	−7.600*** (1.478)	4.537*** (0.870)	−0.539 (0.988)	0.375
12	2.832*** (0.860)	−7.557*** (1.441)	4.735*** (0.876)	−0.713 (0.957)	0.408
13	2.739*** (0.864)	−7.042*** (1.389)	5.007*** (0.822)	−1.294 (0.879)	0.416
14	2.712*** (0.858)	−6.892*** (1.414)	5.059*** (0.874)	−1.492 (0.909)	0.433
15	2.695*** (0.899)	−6.616*** (1.422)	5.061*** (0.785)	−1.720** (0.845)	0.407
16	2.643*** (0.936)	−6.240*** (1.393)	5.107*** (0.776)	−2.026** (0.829)	0.403
17	2.564*** (0.968)	−5.789*** (1.336)	5.118*** (0.785)	−2.329*** (0.800)	0.399
18	2.536** (1.016)	−5.540*** (1.329)	4.971*** (0.804)	−2.368*** (0.802)	0.382
19	2.566** (1.068)	−5.391*** (1.381)	4.859*** (0.865)	−2.418*** (0.857)	0.374
20	2.525** (1.142)	−5.110*** (1.368)	4.719*** (0.980)	−2.454*** (0.931)	0.354
21	2.502** (1.203)	−4.863*** (1.397)	4.538*** (1.140)	−2.457** (1.051)	0.338
22	2.488** (1.240)	−4.806*** (1.396)	4.322*** (1.107)	−2.297** (1.046)	0.329
23	2.484* (1.311)	−4.569*** (1.460)	4.125*** (1.208)	−2.288** (1.135)	0.306
24	2.478* (1.365)	−4.460*** (1.480)	3.969*** (1.256)	−2.217* (1.182)	0.293
36	2.047 (1.624)	−1.846 (1.465)	3.235*** (1.010)	−3.018*** (0.937)	0.219
48	1.746 (1.496)	−1.091 (1.367)	1.878*** (0.580)	−1.916*** (0.626)	0.124

In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors corrected. ***, ** and * denote statistically significant data at the 1, 5, and 10% levels in robust 't' statistics. R^2 is adjusted R-squared.

(2002) have examined whether the yield spread contains useful additional information beyond that of other financial variables. Following Hamilton and Kim (2002) the following equation takes into consideration the influence of the crude price of economic activity:

$$y_t^k = \alpha_0 + \alpha_0 d_t + \alpha_1\,\mathrm{spread}_t + \mathrm{Sd}_t + \delta_1 y_{t-1}^1 + \delta_2 M1_t + \delta_3 M2_t + \delta_4 o_t + \delta_5 \mathrm{Ho}_t + \varepsilon_t, \tag{3}$$

where y_{t-i}^1 is annualized monthly industrial production growth beginning in month $t-i$, d_t are dummy variables on constants, Sd_t the dummy variables on spread, $M1$ is narrow monetary aggregates, $M2+\mathrm{CD}$ the broad monetary aggregates, o the crude price given in yen, and Ho is Hamilton's (1996) measure of the net oil price increase.[10]

[10] $M1$ and $M2+\mathrm{CD}$ are a seasonally adjusted series from the Bank of Japan. It is the average balance. The crude price given in yen is the price of imported crude oil in yen (yen/kl). The source is Nihon Keizai Shimbun. I used the logarithms of the original data series. The net oil price increase in yen is Hamilton's (1996) measure. See Hamilton (1996). The period of data is from February 1985 to January 1997.

Table 3
The predictability of economic activity using the yield spread and other financial variables

k	α_0	α_1	α_2	α_3	δ_1	δ_2	δ_3	δ_4	δ_5	R^2
1	−2.357 (1.660)	−5.646*** (1.680)	2.801* (1.537)	1.154 (1.296)	0.003 (0.059)	0.306*** (0.100)	0.415*** (0.153)	−0.009 (0.006)	0.032 (0.025)	0.041
2	1.713 (1.131)	−7.690*** (1.483)	2.838*** (0.860)	1.262 (1.183)	0.097* (0.053)	0.095*** (0.029)	0.115 (0.084)	0.003 (0.006)	−0.014 (0.031)	0.123
3	−1.527 (1.210)	−4.548*** (1.725)	1.404** (0.701)	2.376** (1.143)	0.053*** (0.018)	0.025 (0.016)	0.547*** (0.107)	0.004 (0.004)	−0.004 (0.015)	0.266
4	−0.466 (1.153)	−5.484*** (1.635)	2.279*** (0.667)	1.408 (1.229)	0.035 (0.022)	0.076*** (0.013)	0.364*** (0.099)	0.00002 (0.003)	0.015 (0.026)	0.271
5	0.915 (1.006)	−6.826*** (1.455)	2.671*** (0.572)	1.594 (1.156)	0.023 (0.021)	0.014 (0.014)	0.273** (0.119)	0.001 (0.003)	−0.023 (0.017)	0.271
6	−0.307 (1.129)	−5.278*** (1.544)	2.406*** (0.522)	1.433 (1.269)	0.034* (0.020)	0.020 (0.014)	0.392*** (0.116)	0.001 (0.003)	−0.014 (0.017)	0.346
7	−0.313 (1.083)	−5.302*** (1.631)	2.445*** (0.543)	1.431 (1.120)	0.023** (0.010)	0.029** (0.012)	0.380*** (0.115)	0.0003 (0.003)	−0.011 (0.019)	0.375
8	0.358 (0.788)	−5.667*** (1.422)	2.961*** (0.572)	0.943 (1.158)	0.018 (0.015)	0.013 (0.019)	0.322*** (0.092)	0.001 (0.004)	−0.029 (0.026)	0.371
9	0.329 (0.948)	−5.521*** (1.175)	3.000*** (0.590)	0.876 (1.094)	0.013 (0.011)	0.005 (0.027)	0.329*** (0.105)	0.003 (0.004)	−0.032 (0.020)	0.397
10	−0.115 (0.859)	−4.740*** (1.200)	3.157*** (0.615)	0.375 (1.031)	0.012 (0.016)	0.021 (0.018)	0.362*** (0.091)	0.003 (0.003)	−0.035** (0.015)	0.428
11	0.392 (0.907)	−5.105*** (1.227)	3.669*** (0.633)	−0.066 (1.006)	0.005 (0.012)	0.003 (0.024)	0.315*** (0.070)	0.003 (0.004)	−0.042** (0.017)	0.432
12	0.490 (0.848)	−5.274*** (1.137)	3.963*** (0.716)	−0.304 (0.993)	−0.001 (0.009)	0.0157 (0.026)	0.297*** (0.072)	0.003 (0.004)	−0.048*** (0.017)	0.475
13	0.408 (0.898)	−4.681*** (1.034)	4.226*** (0.728)	−0.935 (0.964)	0.014 (0.014)	0.018 (0.022)	0.290*** (0.080)	0.003 (0.004)	−0.054*** (0.015)	0.497
14	0.682 (0.799)	−4.942*** (1.258)	4.478*** (0.720)	−1.145 (0.953)	−0.003 (0.010)	0.007 (0.024)	0.272*** (0.055)	0.003 (0.003)	−0.060*** (0.015)	0.509
15	0.606 (0.931)	−4.709*** (1.144)	4.651*** (0.690)	−1.526* (0.916)	−0.006 (0.012)	0.023 (0.022)	0.268*** (0.058)	0.001 (0.003)	−0.066*** (0.013)	0.501
16	0.446 (0.961)	−4.195*** (1.132)	4.733*** (0.713)	−1.892** (0.899)	0.002 (0.012)	0.022 (0.029)	0.273*** (0.066)	−0.0001 (0.003)	−0.065*** (0.014)	0.504
17	0.866 (1.044)	−4.296*** (0.973)	4.976*** (0.770)	−2.250** (0.892)	−0.006 (0.013)	0.015 (0.026)	0.231*** (0.079)	−0.00007 (0.003)	−0.077*** (0.014)	0.507
18	0.765 (1.064)	−4.009*** (1.023)	4.934*** (0.841)	−2.407*** (0.896)	−0.003 (0.011)	0.023 (0.025)	0.227*** (0.067)	−0.001 (0.003)	−0.076*** (0.015)	0.505
19	0.823 (0.947)	−3.927*** (1.043)	4.895*** (0.963)	−2.506*** (0.956)	−0.005 (0.010)	0.028 (0.023)	0.223*** (0.061)	−0.002 (0.003)	−0.082*** (0.013)	0.517
20	0.774 (1.049)	−3.597*** (1.091)	4.728*** (1.068)	−2.536** (1.023)	−0.0008 (0.010)	0.024 (0.018)	0.221*** (0.064)	−0.002 (0.003)	−0.075*** (0.014)	0.486
21	0.856 (1.063)	−3.496*** (1.000)	4.601*** (1.230)	−2.541** (1.146)	−0.007 (0.010)	0.023 (0.019)	0.213*** (0.074)	−0.002 (0.002)	−0.077*** (0.013)	0.474
22	1.056 (1.011)	−3.633*** (1.065)	4.475*** (1.275)	−2.451** (1.174)	−0.002 (0.008)	0.027 (0.018)	0.187*** (0.066)	−0.002 (0.002)	−0.083*** (0.013)	0.478
23	1.044 (1.097)	−3.436*** (1.111)	4.315*** (1.371)	−2.440* (1.254)	−0.009 (0.008)	0.024 (0.015)	0.188*** (0.072)	−0.003 (0.002)	−0.077*** (0.015)	0.447
24	1.224 (1.071)	−3.507*** (1.138)	4.187*** (1.437)	−2.378* (1.310)	−0.009 (0.008)	0.028** (0.013)	0.170** (0.072)	−0.001 (0.002)	−0.084*** (0.012)	0.44
36	1.521 (1.004)	−1.599 (1.056)	3.786*** (1.436)	−3.390*** (1.211)	−0.003 (0.005)	0.024 (0.023)	0.073 (0.081)	−0.004 (0.001)	−0.073*** (0.014)	0.389
48	1.956 (1.091)	−1.573 (1.125)	2.554*** (0.984)	−2.380*** (0.857)	−0.007 (0.005)	0.033** (0.015)	−0.029 (0.065)	−0.003 (0.002)	−0.046** (0.019)	0.234

In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors corrected. ***, ** and * denote statistically significant at the 1, 5, and 10% levels in robust 't' statistics. R^2 is adjusted R-squared.

Table 3 show the estimates for Eq. (3). The spread coefficients are significant to 4 years ahead. The coefficients of the dummy variables on spread are a significant positive at 3 months ahead and are significantly negative from 15 months to 4 years ahead. Other than 2 months, 3 and 4 years ahead, the coefficients on $M2 + \mathrm{CD}$ are also significant across all periods ahead. We may conclude that both the spread and $M2 + \mathrm{CD}$ include useful information about future economic activity in the future.[11]

4. An analysis of the yield spread

Previously it was shown that the yield spread—the difference between long- and short-term interest rates—contains information for predicting future economic growth. In this section, and following Hamilton and Kim (2002, p. 348), the yield spread was divided into two factors: a factor associated with expected future changes in short rates, and a factor representing the term premium. These are used to examine further in which particular factor the information about future economic activity is included.

First, let i_t^n and i_t^1 denote the n-period interest rate (long-term rate) and the one-period interest rate (short-term rate), respectively. Consider the following definition of the time-varying term premium TP_t:

$$i_t^n = \frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1 + \mathrm{TP}_t, \tag{4}$$

where $E_t(i_{t+j}^1)$ denotes the market's expectation at time t of the value of i_{t+j}^1. The term premium TP_t could be viewed as the sum of a liquidity premium and a risk premium. Eq. (4) can also be rewritten as:

$$i_t^n - i_t^1 = \left(\frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1 - i_t^1\right) + \mathrm{TP}_t \tag{5}$$

Eq. (5) implies that the spread can be split into two terms. The first term is the difference between short-term interest rates expected over the next n periods and the current rate. The second term is the time-varying term premium. Knowing that either the first term or the second term is a source of predictability, Eq. (5) is rewritten as:

$$i_t^n - i_t^1 = \left(\frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1 - i_t^1\right) + \left(i_t^n - \frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1\right) \tag{6}$$

Substituting Eq. (6) into (1),

$$y_t^k = \gamma_0 + \gamma_1\left(\frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1 - i_t^1\right) + \gamma_2\left(i_t^n - \frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1\right) + \mathrm{e}_t \tag{7}$$

[11] As current and lagged rates of growth of real economic activity may contain information about future economic conditions, I investigated whether the yield spread contains additional information beyond that contained in the growth rates. The yield contains additional information. Regression results are available on request.

and estimating, investigates which factor includes the source of the predictability of the yield spread about future economic growth. Replacing the average or expected value, $(1/n)\sum_{j=0}^{n-1} E_t i_{t+j}^1$, by the sample average, $(1/n)\sum_{j=0}^{n-1} i_{t+j}^1$, and including dummy variables on constants and spread yields:

$$y_t^k = \gamma_0 + \gamma_1 d_t + \gamma_2 efi_t + \gamma_3 efid_t + \gamma_4 \mathrm{Tp}_t + \gamma_5 \mathrm{Tp}d_t + u_t, \tag{8}$$

where $(1/n)\sum_{j=0}^{n-1} i_{t+j}^1 - i_t^1 = efi_t$, $i_t^n - (1/n)\sum_{j=0}^{n-1} i_{t+j}^1 = \mathrm{Tp}_t$, $v_{t+n} = (1/n)\sum_{j=0}^{n-1} i_{t+j}^1 - (1/n)\sum_{j=0}^{n-1} E_t i_{t+j}^1$ and $u_t = \mathrm{e}_t + (\gamma_4 + \gamma_5 - \gamma_2 - \gamma_3)v_{t+n}$. Here, i_t^n is the 5-year government bond rate, i_t^1 is the 1-month bond and debenture rate, e_t is the disturbance term, and all other variables are as previously defined.

Under rational expectations, the error term u_t should be uncorrelated with any variable known at time t. Thus, Eq. (8) can be estimated using instrumental variable estimation, with any variables dated t or earlier as instruments.

Table 4 shows the estimated coefficients for Eq. (8), with constant i_t^n and i_t^1 as instruments. The results indicate that γ_2 are mostly significant, whereas γ_3 on the dummy variables are significant in the near future. On the other hand, γ_4 are significant only 22 and 23 months ahead, while γ_5 on the dummy variables are significant only 1, 23, and 24 months, and 4 years ahead.

We next explore alternative approximations of expected interest rates by replacing $(1/n)\sum_{j=0}^{n-1} E_t i_{t+j}^1$ by the average of the dynamic forecasts for the 1-month bond and debenture rates at each time point over 5 years, $(1/n)\sum_{j=0}^{n-1} E_t fi_{t+j}^1$. The dynamic forecasts are obtained from sample forecasts with rolling regressions produced from an autoregressive process AR(P). The degree of the lags, P, is chosen each period to minimize the Bayes Information Criterion (BIC). Rolling start date models use a regression estimate based on the prior 8 years of data.[12] Eq. (9) is as follows:

$$y_t^k = \gamma_0 + \gamma_1 d_t + \gamma_2 Fi_t + \gamma_3 Fid_t + \gamma_4 F\mathrm{Tp}_t + \gamma_5 F\mathrm{Tp}d_t + \zeta_t \tag{9}$$

where $(1/n)\sum_{j=0}^{n-1} E_t fi_{t+j}^1 - i_t^1 = Fi_t, i_t^n - (1/n)\sum_{j=0}^{n-1} E_t fi_{t+j}^1 = F\mathrm{Tp}_t. \xi_{t+n} = (1/n)\sum_{j=0}^{n-1} E_t fi_{t+j}^1 - (1/n)\sum_{j=0}^{n-1} E_t i_{t+j}^1$, and $\zeta_t = e_t + (\gamma_4 + \gamma_5 - \gamma_2 - \gamma_3)\xi_{t+n}$. Here, $E_t fi_{t+j}^1$ is the dynamic forecast at time $t+j$ for the 1-month bond and debenture rates made using information in time period t, ξ_{t+n} is approximation error. ζ_t is the error term, and all other variables are as previously defined.

Table 5 presents the estimated coefficients and standard errors of regressions using Eq. (9), with constant i_t^n and i_t^1 as instruments. These coefficients indicate that γ_2 are significant from 1 month to 4 years ahead, γ_3 are significant from 1 month to 6 months, 8 months, and 3 and 4 years ahead. On the other hand, γ_4 are negative and not significant, γ_5 are significant and positive from 1 month to 19 months ahead, and for 22 and 23 months ahead. On this basis, the term premium has information about future economic activity, largely after July 1991.

Based on both analyses, it may be concluded that the factor associated with expected future changes in short rates includes useful information about future economic activity.

[12] Dynamic forecasts are multi-step forecasts, where forecasts computed at earlier horizons are used for the lagged dependent variable terms at later horizons. See Doan (2000), Brooks (2002), and Dotsey et al. (2003), regarding forecasting.

Table 4
The contribution of the analyzed terms to the predictability of economic activity by realized values

k (months ahead)	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	R^2
1	4.308*** (0.925)	−7.839** (3.515)	1.368 (1.245)	3.787*** (1.307)	0.195 (1.342)	3.867** (1.891)	0.009
2	4.278*** (0.759)	−2.225 (2.752)	1.955*** (0.741)	2.352*** (0.872)	0.873 (0.758)	0.760 (1.366)	0.121
3	4.276*** (0.658)	−3.124 (2.763)	1.603** (0.722)	0.410*** (1.112)	2.711 (0.980)	1.515 (1.722)	0.238
4	4.310*** (0.628)	0.362 (2.789)	1.416* (0.732)	0.097** (1.149)	2.311 (0.936)	0.272 (1.795)	0.306
5	4.342*** (0.585)	0.963 (3.038)	1.299** (0.612)	2.446*** (0.813)	−0.107 (1.096)	0.281 (1.800)	0.388
6	4.310*** (0.534)	1.918 (2.996)	1.371** (0.694)	2.175*** (0.843)	−0.112 (1.193)	−0.120 (1.805)	0.457
7	4.367*** (0.944)	1.259 (4.092)	1.016 (0.989)	2.565** (1.181)	−0.602 (1.458)	0.623 (2.109)	0.513
8	4.371*** (0.489)	1.480 (2.965)	1.209** (0.556)	2.205*** (0.667)	−0.489 (1.044)	0.363 (1.602)	0.551
9	4.340 (0.436)	0.603 (3.020)	1.234 (0.777)	2.218 (0.860)	−0.520 (1.298)	0.751 (1.799)	0.583
10	4.289*** (0.425)	0.266 (3.160)	1.383** (0.745)	1.884*** (0.828)	−0.423 (1.205)	0.713 (1.710)	0.600
11	4.230*** (1.710)	−0.003 (3.284)	1.676** (0.783)	−0.127* (1.238)	1.505 (0.855)	0.484 (1.778)	0.629
12	4.176 *** (0.363)	−0.520 (3.219)	1.895** (0.737)	1.363* (0.771)	0.104 (1.154)	0.509 (1.652)	0.666
13	4.064*** (0.334)	−0.668 (2.975)	2.152*** (0.558)	0.858 (0.581)	0.357 (0.906)	0.224 (1.348)	0.676
14	4.058*** (0.321)	−0.932 (3.355)	2.215*** (0.598)	0.687 (0.604)	0.421 (0.931)	0.175 (1.468)	0.696
15	4.106*** (0.312)	−1.287 (3.814)	2.079*** (0.428)	0.647 (0.468)	0.199 (0.738)	0.400 (1.449)	0.677
16	4.083*** (0.318)	−1.719 (4.072)	2.063*** (0.335)	0.475 (0.418)	0.143 (0.605)	0.513 (1.447)	0.682
17	4.031*** (0.342)	−2.151 (4.035)	2.019*** (0.352)	0.304 (0.423)	0.065 (0.620)	0.647 (1.404)	0.690
18	4.042*** (0.362)	−2.465 (3.868)	1.789*** (0.280)	0.396 (0.362)	−0.217 (0.522)	0.956 (1.268)	0.686
19	4.090*** (0.408)	−2.608 (3.720)	1.637*** (0.311)	0.410 (0.406)	−0.394 (0.534)	1.083 (1.183)	0.686
20	4.081*** (0.461)	−3.268 (0.461)	1.430*** (0.412)	0.524 (0.487)	−0.643 (0.625)	1.526 (1.162)	0.683
21	4.073*** (0.640)	−3.721 (3.850)	1.217** (0.537)	0.615 (0.956)	−0.876 (0.693)	1.853 (1.408)	0.678
22	4.036*** (0.634)	−4.507 (3.856)	1.051** (0.499)	0.805 (1.000)	−1.011 (0.616)	2.285 (1.421)	0.670
23	4.056*** (0.619)	−4.692 (3.376)	0.801 (0.542)	0.903 (0.632)	−1.294 (0.682)	2.541 (1.131)	0.663
24	4.043*** (0.669)	−5.145 (3.323)	0.662 (0.552)	1.009 (0.657)	−1.422 (0.663)	2.817 (1.104)	0.655
36	3.068*** (1.097)	−3.036 (2.362)	1.078*** (0.312)	−0.845 (0.565)	−0.281 (0.369)	0.567 (0.618)	0.493
48	2.222* (1.228)	0.776 (1.695)	0.873*** (0.295)	−1.124** (0.478)	0.239 (0.477)	−1.230 (0.609)	0.260

In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors corrected. ***, ** and * denote statistically significant data at the 1, 5, and 10% levels in robust 't' statistics. R^2 is adjusted R-squared.

Table 5
The contribution of the analyzed terms to the predictability of economic activity by average of dynamic forecasts

k (months ahead)	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	R^2
1	1.533 (2.078)	−8.674*** (2.219)	2.813*** (0.853)	2.874*** (1.089)	−0.788 (1.905)	6.060*** (2.038)	−0.005
2	1.062 (2.506)	−7.505** (3.095)	3.143*** (0.568)	1.967** (0.568)	−1.427 (2.647)	6.479*** (2.466)	0.033
3	0.909 (2.600)	−7.521** (2.600)	2.953*** (0.787)	2.339*** (0.884)	−1.745 (2.737)	6.483** (2.597)	0.092
4	0.276 (3.072)	−6.501* (3.841)	2.840*** (0.884)	2.235** (0.861)	−2.944 (3.546)	7.291** (3.216)	0.020
5	0.036 (3.151)	−6.349 (3.938)	2.817*** (0.851)	2.402*** (0.778)	−3.361 (3.666)	7.728** (3.274)	0.039
6	−0.224 (3.250)	−5.804 (4.188)	2.973*** (0.953)	2.075** (0.850)	−3.530 (3.907)	7.789** (3.440)	0.013
7	−0.339 (2.901)	−5.597 (3.471)	2.818** (1.353)	2.205 (1.560)	−3.819 (3.546)	8.048** (3.395)	0.020
8	−0.481 (3.084)	−5.164 (4.027)	3.118*** (0.984)	1.725** (0.830)	−3.681 (3.618)	7.743** (3.141)	0.027
9	−0.500 (2.957)	−5.080 (3.811)	3.244*** (1.197)	1.605 (1.038)	−3.454 (3.546)	7.404** (3.113)	0.069
10	−0.544 (2.785)	−4.632 (3.635)	3.485*** (1.251)	1.080 (1.109)	−3.126 (3.364)	6.848** (2.945)	0.094
11	−0.545 (2.650)	−4.514 (3.478)	3.784*** (1.298)	0.712 (1.157)	−2.721 (3.269)	6.256** (2.896)	0.135
12	−0.498 (2.470)	−4.557 (3.305)	4.003*** (1.288)	0.508 (1.128)	−2.328 (3.089)	5.896** (2.696)	0.190
13	−0.500 (2.270)	−4.169 (3.062)	4.295*** (1.203)	−0.038 (1.050)	−1.865 (2.872)	5.073** (2.552)	0.234
14	−0.508 (2.159)	−4.089 (3.009)	4.352*** (1.246)	−0.165 (1.072)	−1.770 (2.808)	4.763* (2.497)	0.266
15	−0.567 (2.039)	−3.815 (2.879)	4.344*** (1.145)	−0.321 (0.980)	−1.857 (2.647)	4.566** (2.386)	0.279
16	−0.568 (1.852)	−3.503 (2.657)	4.401*** (1.102)	−0.618 (0.951)	−1.703 (2.409)	4.134* (2.207)	0.323
17	−0.585 (1.688)	−3.146 (2.414)	4.426*** (1.102)	−0.885 (0.964)	−1.563 (2.230)	3.655* (2.122)	0.364
18	−0.615 (1.545)	−2.923 (2.257)	4.278*** (1.109)	−0.883 (0.952)	−1.714 (2.028)	3.582* (1.970)	0.382
19	−0.591 (1.408)	−2.803 (2.183)	4.165*** (1.171)	−0.882 (0.986)	−1.836 (1.944)	3.495* (1.894)	0.403
20	−0.554 (1.236)	−2.572 (1.965)	4.042*** (1.283)	−0.976 (1.092)	−1.811 (1.778)	3.333* (1.776)	0.442
21	−0.517 (1.172)	−2.404 (1.605)	3.874*** (1.300)	−0.964 (1.366)	−1.865 (1.850)	3.177 (2.239)	0.461
22	−0.383 (1.012)	−2.505* (1.441)	3.691*** (1.241)	−0.820 (1.294)	−1.769 (1.642)	3.010 (2.039)	0.511
23	−0.389 (0.824)	−2.312 (1.548)	3.494** (1.490)	−0.744 (1.286)	−1.969 (1.468)	2.960** (1.475)	0.527
24	−0.314 (0.703)	−2.306* (1.391)	3.355** (1.523)	−0.656 (1.320)	−1.954 (1.341)	2.828** (1.349)	0.555
36	0.268 (1.050)	−0.661 (0.992)	2.844*** (1.103)	−1.747* (0.976)	−0.537 (0.520)	−0.060 (0.411)	0.737
48	0.610 (1.216)	−0.197 (1.244)	1.629*** (0.589)	−1.307** (0.558)	−0.531 (0.722)	0.161 (0.586)	0.607

In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors corrected. ***, ** and * denote statistically significant at the 1, 5, and 10% levels in robust 't'-statistics. R^2 is adjusted R-squared.

Since dynamic forecasts of expected future changes in short-term rates are also found to be more appropriate, we may conclude that the term premium does not have useful information about future economic activity before July 1991, but does after that date. Put differently, the term premium is insignificant and negative before July 1991, but significant and positive afterwards. By way of comparison, Hamilton and Kim (2002) showed that the term premium was significant and positive.

How might one account for these differences? One possibility follows Smets and Tsatsaronis' (1997) analysis of the yield curve as a predictor for future economic activity in Germany and the United States. Smets and Tsatsaronis (1997) showed that, in response to a supply shock that raised output permanently, the term premium of Germany initially fell, whereas that in the United States rose. Smets and Tsatsaronis (1997) suggested that one interpretation of this difference is that the German monetary authorities responded more vigorously to the inflation effects of a supply shock, while the US authorities were more concerned with output stabilization. Their interpretation, together with the signs of the term premium, might suggest that the Japanese authorities may resemble the German authorities before July 1991 and the US authorities thereafter.

5. Conclusion

Estrella and Hardouvelis (1991), amongst others, have documented the fact that the yield spread between the 10-year Treasury Bond rate and the 3-month Treasury Bill rate contains useful information about future growth in the United States. Unfortunately, there is no similar consensus that the yield spread contains information about future economic activity in Japan. Kim and Limpaphayom (1997) argue that the Japanese yield spread does contain this information, although Galbraith and Tkacz (2000) insist that it does not.

In the first part of this paper, spread data from February 1985 to January 1997 was used to re-examine this relationship. The results indicate that the hypothesized relationship does not exist. However, following Estrella and Mishkin (1997), Dotsey (1998), and Smets and Tsatsaronis (1997), structural change in spreads was then assessed, thereby taking into consideration the possibility that the structure of the relationship between the yield spread and future economic activity will change over time. Once structural change in July 1991 is taken into account, the relationship between yield spread and economic activity is established for the period following deregulation, as per Kim and Limpaphayom (1997).

The second part of the analysis investigated whether the yield spread contains more useful information about future economic activity when compared with other variables. The results showed that the yield spread contains information about future economic activity beyond other variables available for each period. Next, and following Hamilton and Kim (2002), the yield spread is split into two terms: a factor associated with expected future change in short-term rates, and a factor associated with the term premium. In their analysis, Hamilton and Kim (2002) showed that both terms are significant predictors of future economic growth, but that the expected future changes in short-term rates was significantly larger than the term premium. Unlike Hamilton and Kim's (2002) findings, the results of the current analysis show that the factor associated with expected future changes in short-term rates was statistically significant throughout the sample period,

May 31, 1989	Official discount rate rise (2.5%→3.25%)
October 11, 1989	Official discount rate rise (3.25%→3.75%)
December 25, 1989	Official discount rate rise (3.75%→4.25%)
March 20, 1990	Official discount rate rise (4.25%→5.25%)
August 30, 1990	Official discount rate rise (5.25%→6%)
July 1, 1991	Official discount rate reduction (6%→5.5%)
November 24, 1991	Official discount rate reduction (5.5%→5.0%)

Fig. 2. Changes of monetary policy.

although the term premium is insignificant and negative before July 1991, and significant and positive thereafter. As the factor of expected future change in short-term rates is positive over time, we may conclude that information about future Japanese economic activity is inevitably included in future expected changes in short-term interest rates in Japan. It also suggests that if the short-term interest rate is thought to be a good measure of monetary policy, people will predict monetary policy through its movements, and if the central bank is expected to raise interest rates, they may believe that future economic activity will then increase. Differences in the impact of the term premium may then be associated by different attitudes towards the output-inflation trade-off by the Bank of Japan in the first and second half of the sample period.

A question presents itself about what was associated with the empirically established structural break occurring around July 1991. In fact, and as shown in Fig. 2, the Bank of Japan changed its policy stance in July 1991. The official discount rate was intermittently raised from 2.5 to 6% between May 1989 and August 1990, largely in response to the overheating of business activity in the second half of the 1980s. After August 1990, the Bank of Japan reduced the official discount rate following business aggravation in February 1991 and afterwards.[13] Hence, both the environment of the Japanese economy and the attitudes of the Bank of Japan changed in July 1991. Under that interpretation, it may be concluded that the policy change in July 1991 by the Bank of Japan caused the structural change in the relationship between the yield spread and future economic activity. This also suggests that while the movement in the yield spread includes useful information about future economic activity, policy makers must also take into account the possibility and impact of structural change.[14]

There is also the problem of why the Japanese term premium was insignificant and negative before July 1991, but significant and positive thereafter, not least when considering that in the United States the term premium has been found to include useful

[13] See Harada (1999), Kousai et al. (2001) regarding the changes in monetary policy from the second half of the 1980s to the first half of the 1990s.

[14] What does the fact that the yield spread of nominal interest rates contains information on future economic growth mean? In order to consider this problem, it is necessary to think about the composition of the yield spread. Since spread is nominal, the factor of the change can take into account a change in the expected rate of inflation, and a change in real interest rates. If a change in real interest rates is the main factor, it means that people can increase future consumption above current levels if the coefficient of spread is significantly positive, because future economic activity is an active factor. Therefore, I am able to make the interpretation by C-CAPM that the relative worth of present goods goes up and the real interest rate becomes high. On the hand, if a change in the expected rate of inflation is the main factor, I am able to make the interpretation that the Phillips curve exists. As for change in the yield spread nominal interest rate, according to Fukuta and Saito (2000), it turns out that both real interest rates and the expected rate of inflation are factors.

information about future economic activity. One possibility follows Estrella (2003), who constructs an analytical rational expectations model to investigate the reasons why spread has predictability for economic activity by suggesting that the relationships are influenced by the monetary policy regime. However, differences may also arise from the use of monthly data in the current analysis, unlike Hamilton and Kim (2002) who analyzed quarterly data, or by differences in the exchange rate regime.[15]

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