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4 The Interest Rate Process and the Term Structure of Interest Rates in Japan

John Y. Campbell and Yasushi Hamao

Macroeconomists have long been interested in the term structure of interest rates as a source of information about the transmission mechanism from monetary policy to the macroeconomy. Consider, for example, private investment decisions. These depend on the cost of capital to firms, which is not directly observable. In the United States, the cost of capital is often modeled as a weighted average of the interest rate on long-term corporate debt and the required return on equity; the long-term corporate interest rate in turn can be thought of as the sum of the yield on long-term government bonds and a "quality premium" reflecting default risk and other special features of corporate bonds. Thus; the long-term government bond yield may be a useful indicator of the unobserved cost of capital.

Of course, the long-term bond yield is very different from the short-term interest rates that are most directly influenced by the monetary authority. Thus it is important to study the mechanism by which monetary policy moves the whole yield curve while acting directly on its short end. In the U.S. markets, where a great variety of bonds of different maturities are actively traded, it is natural to model the term structure as being determined by expectations of future short rates together with risk premiums that can be modeled using general equilibrium finance theory.

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Until recently this American paradigm did not seem to be applicable to the markets for Japanese fixed-income securities. Japanese corporations relied heavily on bank financing. Japanese long-term bond markets were small, illiquid, and tightly regulated, so that quoted bond prices were not necessarily reliable reflections of market conditions, and there were no strong linkages between markets for different types of bonds. Monetary policy influenced the cost of capital to corporations as much by tightening or loosening quantity constraints as by changing bond yields, so that the long-term bond yield was a highly imperfect measure of the cost of capital. And the long-term bond market was segmented from the short-term bond market, so that relative yields did not necessarily reflect either interest rate expectations or classical notions of risk.

During the last ten years, however, bond markets have been rapidly deregulated and have started to play a more important role in Japanese corporate finance.[1] It may now be possible to apply the traditional American paradigm to the Japanese term structure of interest rates. In this paper we discuss the evolving relationship between long-term government bond yields and short-term interest rates in Japan.

The organization of the paper is as follows. Section 4.1 discusses the institutional background and data sources. Section 4.2 lays out a framework for analysis of the term structure of interest rates. Section 4.3 studies the short end of the term structure, the gensaki market. Section 4.4 studies the market for long-term government bonds, and section 4.5 concludes.

4.1 Institutional Background and Data

In this section, we discuss the development of the Japanese money and bond markets and describe the data we use.[2]

4.1.1 Short-Term Interest Rates in Japan

Short-term government bills have existed in Japan only since 1986, so their history is too short for empirical research. As an alternative, the call money rate has often been used as the short-term interest rate in empirical studies of the Japanese economy. Only financial institutions participate in the call money market, however, so the call money rate may be a poor proxy for the short-term interest rate available to general investors. We will therefore use another short-term interest rate, the gensaki rate.

The gensaki market has existed since the early 1950s, but it grew substantially in volume in the 1970s and became the largest open money market in Japan. The gensaki rate is the interest rate applied to bond repurchase agree-

1. A number of studies have verified the impact of deregulation on the behavior of Japanese short-term interest rates (Takagi 1988; Leung, Sanders, and Unal 1991).

2. For more detailed surveys, see Bank of Japan (1986, 1988) and Takagi (1988).

ments. The agreement period varies from one month to three months, and unlike interbank markets such as those for call money and discounted bills, participants are no longer limited only to financial institutions, but also include corporations, government pension funds, and nonresidents.

Although the gensaki market has been the least regulated of Japanese money markets, there have been several institutional changes that may have influenced the behavior of gensaki rates. Leung, Sanders, and Unal (1991) study the time series process of gensaki rates over the period February 1980 through September 1989. Using a Goldfeld-Quandt switching regression technique, they identify four regime shifts in the behavior of the 1-month gensaki rate. The shifts correspond to regulatory changes in Japanese government bond and money markets, some of which are more important than others. The regulatory changes are (1) liberalization of secondary sales of government bonds by banks, and permission of banks to invest in the gensaki market (April 1981); (2) authorization for banks to sell newly issued 10-year bonds over the counter (April 1983); (3a) permission for banks to deal in government bonds (June 1985); (3b) the establishment of the bond futures market (October 1985); and (4) the establishment of the Tokyo offshore money market (January 1987). The regulatory changes in June and October 1985 bracket an apparent regime shift in the interest rate in August 1985. The deregulation in January 1987 seems comparatively unimportant for the behavior of domestic interest rates, since it made available to nonresidents a Tokyo-based equivalent of the Euroyen market but did not affect the investment opportunities of domestic residents. In addition to these changes identified by Leung, Sanders, and Unal, another change may have occurred more recently: several measures to deregulate the interbank market took effect in November 1988, and this seems to have increased interest arbitrage between the interbank and open money markets. As a result, interbank and open-market rates now appear to be more highly correlated (Bank of Japan 1990).

It is noteworthy that the shift in interest rate behavior in August 1985 occurred close to the time of the Plaza Accord in September 1985, at which leading central banks agreed to coordinate monetary policy and move toward more managed exchange rates. The change in interest rate behavior in 1985 is probably attributable to this change in monetary policy.[3]

4.1.2 Long-Term Interest Rates in Japan

The long-term bond market in Japan did not develop until the late 1970s. The first issue of long-term government bonds after World War II occurred in 1966 upon the amendment of the fiscal law that had prohibited the government from issuing debt. The bonds were underwritten by syndicates of financial institutions and were later purchased by the Bank of Japan through open-

3. More details on exchange rate management in this period are given in Dominguez (1990) and Funabashi (1988).

market operations. Participation in underwriting was mandatory for the financial institutions even at a low yield. The financial authorities were afraid of a drop in the price of bonds, and financial institutions were not allowed to sell government bonds in the secondary market.

Massive offerings of government bonds started in 1975 when the oil crisis caused a serious recession. In 1977, facing a rapidly increasing stock of government bonds, the Bank of Japan became unable to purchase them from the syndicates, and financial institutions were finally allowed to sell bonds 1 year after issue in the secondary market. This marked the beginning of the development of an active secondary market. In April 1981 and June 1985, secondary sales of bonds were further deregulated by reducing the required holding period after subscription. Bank dealing of government bonds was authorized for bonds with less than 2 years to maturity in June 1984, and completely liberalized in June 1985. Trading volume in government bonds in 1988 was 2,905 trillion yen, which is ten times the 1977 level. As in the United States, 97% of trading takes place over the counter. Short sales of bonds were facilitated in May 1989 by the establishment of the bond lending market.

We use yield and return data for portfolios of government bonds of different maturities. Although there are shorter-term government bonds (2–5 years to maturity at issue), 10-year government coupon bonds are most consistently and frequently issued and have the largest outstanding volume.

Our portfolios include all coupon bonds and are compiled as follows. First, all government bonds are classified according to their time to maturity: less than 1 year, 1–2 years, and so on out to 9–10 years. Then portfolio returns and yields are computed by weighting individual bond data using market values. The portfolios are rebalanced every month, since some bonds enter and leave each maturity range as their maturities shrink. Although each portfolio has a range of maturities, in our statistical analysis we take a midpoint and assume that the "less than 1 year" portfolio has a maturity of 6 months, the "1–2 year" portfolio has a maturity of 18 months, and so on.

Our sample period runs from November 1980 to August 1990 (118 observations). We split the whole sample into two subsamples, November 1980 through July 1985 (57 observations) and August 1985 through August 1990 (61 observations). The break point corresponds to the major change in the interest rate process identified by Leung, Sanders, and Unal (1991).[4] Figure 4.1 is a three-dimensional view of the term structure of interest rates in time series. To highlight the short and long ends of the yield curve as well as the midpoint, figure 4.2 plots the one-month gensaki rate and the 4–5- and 9–10-year bond portfolio yields. Both figures show a change in the character of the term structure in late 1985; before this date the short rate moves choppily

4. We also examined shorter subperiods as identified by Leung, Sanders, and Unal, but these results are not reported as they do not have any important effect on our conclusions.

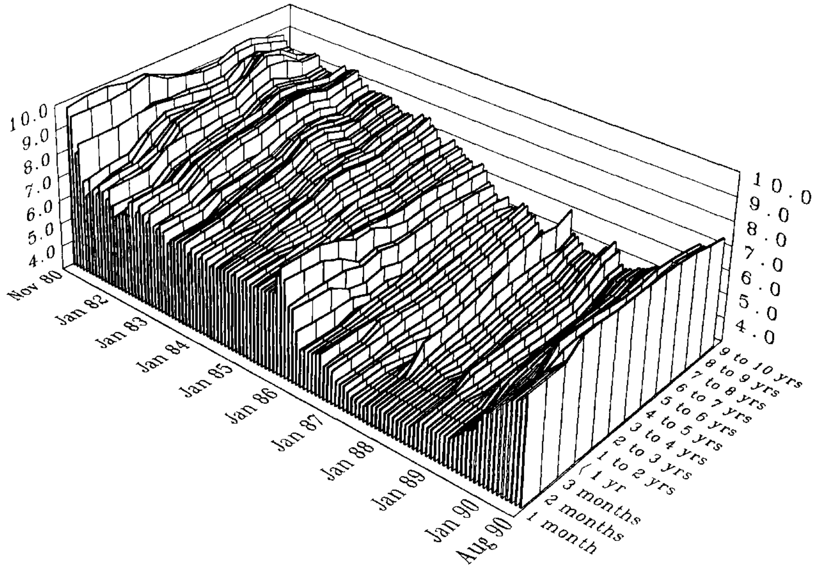

Fig. 4.1 Gensaki and Japanese government bond term structure (percent per annum)

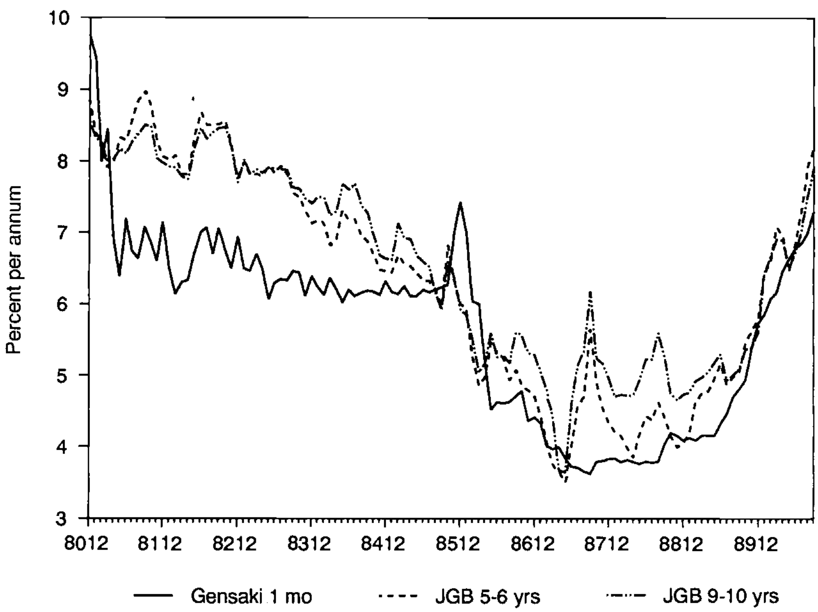

Fig. 4.2 Gensaki and Japanese government bond portfolio yields

in the range 6 to 8%, but after this date it undergoes a long, smooth movement down to below 4% and then up to 8% again at the end of the 1980s.

4.1.3 Benchmark Bond Issues

Since 1983, there has been a phenomenon known as the benchmark effect in the Japanese government bond market (Sargen, Schoenholtz, Blitz, and Elhabashi 1986). Typically, a newly issued 10-year bond with a large outstanding volume is chosen to be a benchmark and retains this status for a period of 6 months to a year. Benchmark issues are strongly preferred by bond market participants, and trading is heavily concentrated on these issues. Hence a fairly large liquidity premium is frequently observed.

Figure 4.3 shows the remaining maturity of the benchmark issue during each month of our sample period. This is almost always between 8.5 and 9.5 years, but in late 1987 and early 1988 it fell almost to 8 years before a new benchmark was chosen. This suggests that the benchmark issue should normally be highly correlated with our portfolio of 9–10-year bonds. To check this, in figures 4.4 and 4.5 we compare yields and returns of benchmark issues and the portfolio with 9–10 years to maturity. Overall the two series have a correlation of 0.986 for yields and 0.871 for returns. The unusual period in early 1988 when the benchmark issue had maturity less than 8.5 years is marked on the figures; the relation between the benchmark series and the 9–10-year series does not appear to deteriorate during this period.

4.2 An Analytical Framework for the Term Structure of Interest Rates

The study of the term structure of interest rates is greatly complicated by the nonlinearities that arise in the relation between bond prices, yields, and holding returns. When bonds do not pay coupons, these nonlinearities can be eliminated by working in logs, which is standard practice in the empirical literature on the term structure (Campbell and Shiller 1991; Fama 1984, 1990; Fama and Bliss 1987). When bonds pay coupons, however, as longer-term Japanese government bonds do, an approximation is needed to obtain a linear model relating yields and holding returns. Such a model is given in Shiller, Campbell, and Schoenholtz (1983) and elaborated in Shiller (1990). Here we briefly summarize the approximate model and indicate how we will use it.

The approximate model is accurate for coupon bonds that are close to par, that is, with yields to maturity close to their coupon rates.[5] It is obtained by taking a Taylor approximation of the nonlinear function relating holding returns to yields, around a point where the bond is selling at par. If $\bar{r}$ is the

5. The model as stated here assumes that coupons are paid once per period. Below we use monthly data, but Japanese government bonds pay coupons only twice a year. This makes little difference in practice.

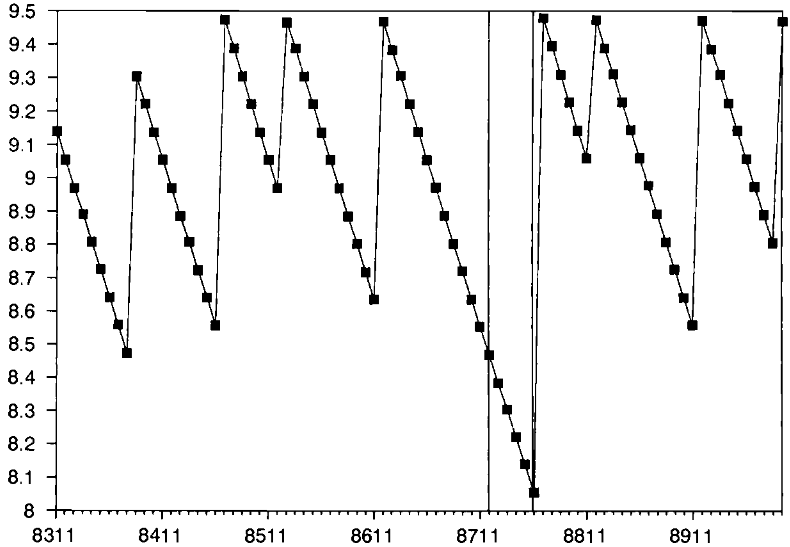

Fig. 4.3 Benchmark issues (years to maturity)

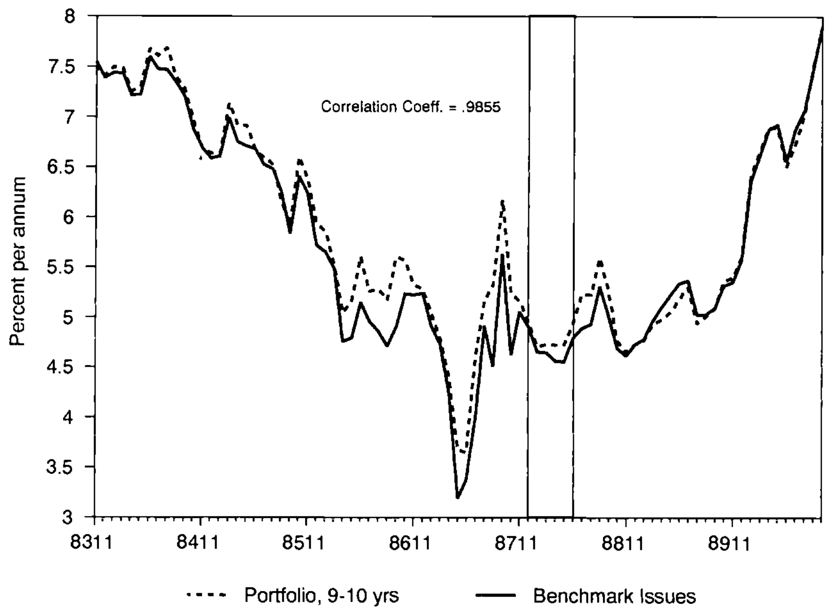

Fig. 4.4 Portfolio versus benchmark issues (yield)

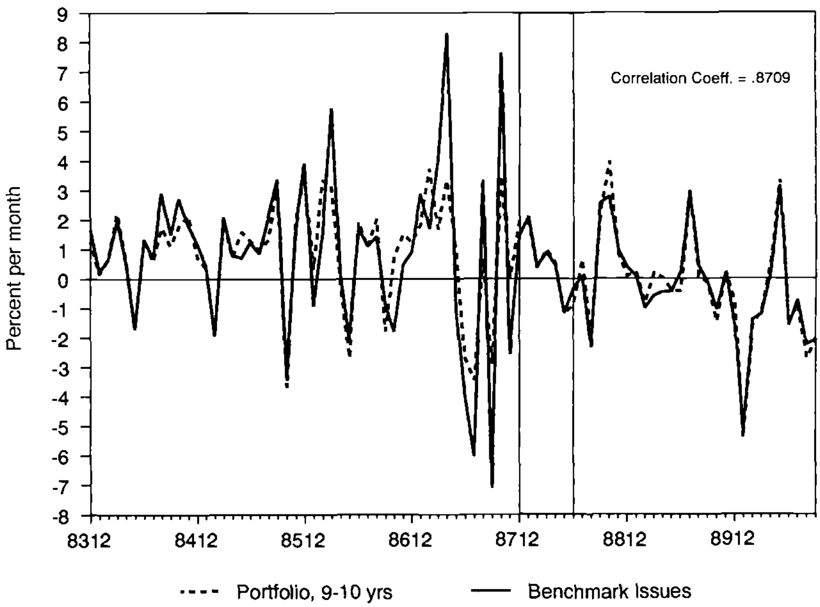

Fig. 4.5 Portfolio versus benchmark issues (return)

average yield to maturity or coupon rate of the bond, and $\gamma = 1/(1 + \bar{r})$, then Macaulay's (1938) duration of an i-period coupon bond selling at par is $D_i = (1 - \gamma^i)/(1 - \gamma)$. Now define r_t^i as the yield to maturity of an i-period coupon at time t, and $h_t^{i,j}$ as the holding-period return on an i-period coupon bond purchased at time t and held for j periods. Then the linear approximation is

$$h_t^{i,j} \approx \frac{D_i r_t^i - (D_i - D_j)\, r_{t+j}^{i-j}}{D_j}. \tag{1}$$

When the bond is held for only one period, this simplifies to

$$\begin{aligned} h_t^{i,1} &\approx D_i r_t^i - (D_i - 1)\, r_{t+1}^{i-1} \\ &\approx r_t^i - (D_i - 1)\, \Delta r_{t+1}^i, \end{aligned} \tag{2}$$

where the last equality holds because for large maturities i the difference between the i-period bond yield and the $(i - 1)$-period bond yield is negligible, that is $r_t^i \approx r_t^{i-1}$. Equation (2) relates the 1-period holding return on a long bond to the yield at the beginning of the holding period, and the change in the yield during the holding period. The longer the duration of the bond is, the more sensitive is its price and thus its holding return to changes in its yield.[6]

6. The linear approximate model thus reflects the well-known fact that duration is the elasticity of a bond's price with respect to its yield. Shiller (1990) develops this point further.

Equation (2) can be rewritten to relate the excess holding return on long bonds over short bonds to the yield spread between the two bonds and the change in the long-term yield. Subtracting the short-term interest rate r_t^1 from both sides of equation (2), we obtain

$$h_t^{i,1} - r_t^1 \approx s_t^i - (D_i - 1)\,\Delta r_{t+1}^i, \tag{3}$$

where $s_t^i = r_t^i - r_t^1$ is the spread between the i-period and 1-period bond yields.

One appealing feature of the approximate expressions in equations (1), (2), and (3) is that they all hold exactly for zero-coupon bonds, when we replace duration D_i by maturity i and work with log returns. In section 4.3 when we study the behavior of gensaki rates, we use this exact zero-coupon version of the model.

4.2.1 The Expectations Theory of the Term Structure

The linear system stated here makes it easy to study the role of interest rate expectations in moving the term structure. If we take time t expectations of equation (3) and rearrange, we obtain

$$s_t^i = E_t[h_t^{i,1} - r_t^1] - (D_i - 1)E_t\Delta r_{t+1}^i. \tag{4}$$

This says that the yield spread equals the expected excess return on the long bond over the short bond, less a multiple of the expected change in the long-term yield. If expected excess returns vary because risk is changing, or because long-term and short-term bond markets are segmented, then this variation should be reflected in the yield spread.

The expectations theory of the term structure is the hypothesis that, to the contrary, expected excess returns are constant through time. According to the expectations theory, excess bond returns are unpredictable, and the only force moving the yield spread is expected changes in interest rates. The expectations theory can always be tested by regressing the excess holding period return onto variables known at the beginning of the holding period. A natural variable to use as a regressor is the yield spread, since under almost any alternative model the yield spread will reflect variation in expected excess returns. The regression is then

$$h_t^{i,1} - r_t^1 = \beta_0 + \beta_1 s_t^i + \varepsilon_{t+1}^i, \tag{5}$$

and the expectations theory implies $\beta_1 = 0$ in this regression. If exact data on holding period returns are available, this regression can be used to test the expectations theory without invoking the linear approximate framework used here.

The expectations theory can also be framed as a statement about the predictive power of the yield spread for future changes in long-term interest rates. If the expectations theory holds, then the first term on the right-hand side of equation (4) is zero. It follows that the yield spread is proportional to an optimal forecast of the change in the long-term bond yield. If we run the regression

(6) $$\Delta r^i_{t+1} = \beta_0 + \beta_1[s^i_t/(D_i - 1)] + \varepsilon^i_{t+1},$$

the coefficient β_1 should equal one. Intuitively, when the yield spread is unusually high this implies excess returns on long bonds unless the long-term yield rises to deliver offsetting capital losses. Thus if the expectations theory holds, a high yield spread must tend to be followed by rising long-term interest rates.[7]

The expectations theory of the term structure also implies that long-term interest rates forecast future short-term interest rates. According to the expectations theory,

(7) $$r^i_t = (1/D_i) \sum_{k=0}^{i-1} \gamma^k E_t r^1_{t+k} ,$$

or in terms of the yield spread,

(8) $$s^i_t = (1/D_i) \sum_{k=0}^{i-1} \gamma^k D_{i-k} E_t \Delta r^1_{t+k} .$$

As before, equations (7) and (8) can be applied to data on zero-coupon bonds by setting $\gamma = 1$ and $D_i = i$; they then hold exactly rather than as approximations.

An obvious way to test (8) is to regress the ex post value of the right-hand side of (8) onto the yield spread; this is the method of Fama and Bliss (1987), Fama (1990), and Mishkin (1990).[8] However, this straightforward approach is hard to apply when the maturity i of the long-term bond is large, because one loses i periods at the end of the sample period and the equation errors become highly serially correlated. Standard asymptotic corrections for equation error overlap are known to perform poorly when the degree of overlap is large relative to the sample size (Richardson and Stock 1989; Hodrick 1992).

An alternative approach, developed by Campbell and Shiller (1987, 1991), is to use a vector autoregression (VAR) to construct an empirical proxy for the multiperiod expectations in (8). In effect this method imputes the long-run dynamics of interest rates from the short-run dynamics. The yield spread itself is included in the VAR, so that if the expectations theory is true, the VAR system can match the best possible forecast of long-horizon movements in short rates by setting its forecast equal to the yield spread. If the expectations theory is false, the VAR forecast will diverge from the yield spread, and this

7. Recall, however, that equation (6) holds only when the maturity i is long enough that the i-period yield and the $(i - 1)$-period yield are approximately equal.

8. In fact Fama and Bliss (1987) and Fama (1990) use "forward premiums," differences between forward rates and current short rates, as their regressors. The dependent variables in the regressions are modified accordingly.

can be used to test the theory. The VAR method can be applied in much smaller samples than the direct regression method because the VAR can be estimated without losing i observations at the end of the sample. The VAR residuals are serially uncorrelated, and this helps to give the method quite good small-sample properties (Hodrick 1992).[9]

4.2.2 Approximation Accuracy

An important question in all this work is how accurate is the underlying approximation, equation (1). In our data set we can check this approximation by comparing the approximated return with the observed exact return. For our series of benchmark issues, the correlation between the approximated and the exact return exceeds .99. The correlations for our maturity-based portfolios tend to be somewhat lower, but they all exceed .96 except for the 9–10-year portfolio, where the correlation is .94. This suggests that the approximate term structure model should be applied with some caution to the long end of the Japanese government yield curve.

4.3 The Behavior of Japanese Short-Term Interest Rates

In this section, we analyze the behavior of the short end of the term structure. We begin in table 4.1 by presenting summary statistics for 1-, 2-, and 3-month gensaki rates, their first differences, and the yield spread between them. The table also reports the results of Dickey-Fuller unit root tests.

4.3.1 The Univariate Short Rate Process

In the postwar United States, the short-term interest rate has behaved much like a univariate random walk. That is, the short rate process seems to have a unit root, and there is little predictability of short rate changes from lagged short rate changes. In Germany and Switzerland, by contrast, Kugler (1988) finds considerable predictability of short rate changes. He attributes the difference to the fact that the Federal Reserve Board has pursued an interest rate smoothing policy for most of the postwar period (with the exception of 1979–82), while the monetary authorities in Germany and Switzerland have tolerated nominal interest rate variability in order to stabilize money growth.[10]

We begin our investigation of Japanese short-term interest rates by asking whether the 1-month gensaki rate follows a unit root process as the U.S. short rate appears to do. The results in table 4.1 show a striking difference between the two halves of our sample period. The unit root hypothesis for the short rate is rejected for the full sample period and the first subsample. In the second subsample, by contrast, the unit root hypothesis cannot be rejected at a con-

9. The VAR residuals may be conditionally heteroscedastic, but standard errors can be corrected for this in the usual way.

10. For more on shifts in U.S. interest rate behavior around the 1979–82 period, see Huizinga and Mishkin (1986).

Table 4.1 **Summary Statistics, Gensaki Rates**

Series	Mean	Standard Deviation	Autocorrelations ρ_1	ρ_2	ρ_3	ρ_4	Dickey-Fuller Test
			Full sample (1980:11–1990:8, 118 observations)				
r_t^1	5.701	1.318	0.921	0.851	0.809	0.734	−4.32
r_t^2	5.764	1.343	0.929	0.862	0.817	0.751	−4.56
r_t^3	5.799	1.356	0.932	0.867	0.822	0.759	−4.55
Δr_t^1	−0.021	0.337	−0.018	0.026	0.392	−0.174	−55.45
Δr_t^2	−0.022	0.299	0.137	0.083	0.336	−0.124	−60.15
Δr_t^3	−0.022	0.287	0.196	0.096	0.311	−0.100	−60.18
s_t^2	0.063	0.075	0.478	0.427	0.547	0.247	−40.25
s_t^3	0.098	0.107	0.494	0.421	0.541	0.236	−38.37
			Subsample 1 (1980:11–1985:7, 57 observations)				
r_t^1	6.623	0.735	0.686	0.465	0.402	0.150	−7.56
r_t^2	6.724	0.739	0.726	0.513	0.423	0.219	−7.65
r_t^3	6.778	0.735	0.736	0.523	0.420	0.228	−8.33
Δr_t^1	−0.064	0.399	−0.239	−0.035	0.464	−0.293	−267.45
Δr_t^2	−0.065	0.335	−0.096	0.023	0.402	−0.258	−244.01
Δr_t^3	−0.065	0.317	−0.023	0.043	0.355	−0.234	−6207.23
s_t^2	0.101	0.088	0.344	0.266	0.408	−0.007	−540.40
s_t^3	0.155	0.120	0.308	0.196	0.355	−0.102	79.90
			Subsample 2 (1985:8–1990:8, 61 observations)				
r_t^1	4.839	1.148	0.923	0.833	0.728	0.605	1.80
r_t^2	4.867	1.147	0.924	0.832	0.725	0.602	1.92
r_t^3	4.884	1.150	0.924	0.833	0.726	0.603	1.81
Δr_t^1	0.018	0.265	0.402	0.128	0.225	0.055	−6.06
Δr_t^2	0.018	0.257	0.462	0.152	0.216	0.065	−5.94
Δr_t^3	0.017	0.254	0.475	0.147	0.236	0.074	−6.07
s_t^2	0.028	0.034	0.169	0.103	0.388	0.085	−18.82
s_t^3	0.045	0.054	0.342	0.251	0.445	0.200	−12.53

Notes: Dickey-Fuller test is a t-statistic from the augmented Dickey-Fuller test with six lagged changes. The Dickey-Fuller critical values are:
50 observations: −2.60 (10%), −2.93 (5%), −3.58 (1%)
100 observations: −2.58 (10%), −2.89 (5%), −3.51 (1%)

ventional significance level.[11] This reflects the fact that, as shown in figure 4.2, the short rate moved up and down in a narrow range during most of the early 1980s but then began to move more smoothly over a wider range in the

11. We use Dickey-Fuller regressions of the change in the gensaki rate on the lagged level and six lagged changes (the number of lagged changes was suggested by Akaike's information criterion, as discussed below). There are well-known difficulties with the interpretation of unit root tests in finite samples (see Campbell and Perron 1991 for a review). We use them here as a simple way to characterize the time series properties of the gensaki rate.

late 1980s. As discussed above, this change in behavior may be due to a change in monetary policy in the mid-1980s.

We examine the predictability of the 1-month gensaki rate by running a univariate regression of the change in the gensaki rate on lagged changes. Preliminary analysis using Akaike's information criterion suggested a lag length of 6. Thus the forecasting regression is

$$\Delta r_{t+1} = b_0 + \sum_{i=1}^{6} b_i \Delta r_{t+1-i} + \varepsilon_{t+1} . \tag{9}$$

The results, which are tabulated in table 4.2, panel A, indicate that there is substantial univariate forecastability of the Japanese short rate process. For the full sample, the adjusted R^2 is 0.231, and the coefficients are in general significant. The forecastability is concentrated in the first subsample, where the adjusted R^2 is 0.455; in the second subsample, it drops to 0.180. This fits the pattern of the unit root tests, suggesting that the univariate interest rate process changed in the mid-1980s from a stationary, highly forecastable process to a nonstationary, less forecastable one. Looking across the two subsamples, the coefficients on lagged short rate changes switch sign from predominantly negative to predominantly positive; this again suggests a change from a mean-reverting interest rate process to a "mean-abandoning" nonstationary process.[12]

4.3.2 The Term Structure of Gensaki Rates

Our analysis of the univariate properties of the 1-month gensaki rate has suggested that this rate became harder to forecast after 1985. However, gensaki market participants may have many sources of information other than just the history of 1-month gensaki rates themselves. For example, they may know more about the likely direction of monetary policy than is revealed by the history of 1-month interest rates. This means that it is important to go beyond a univariate approach in analyzing the interest rate process.

If the expectations theory of the term structure holds, the yield spread between longer- and shorter-term gensaki rates embodies all the relevant information of market participants about the likely path of interest rates over the life of the longer-term gensaki agreement. Thus a natural next step is to examine the forecasting power of the gensaki yield spread in a regression of 1-month gensaki rate changes on this variable. Such a regression can also be used to test the expectations theory of the gensaki term structure.[13]

For 2-month rates, the regression can be written as

$$(r^1_{t+1} - r^1_t) = \alpha + \beta s^2_t + \varepsilon_{t+1} , \tag{10}$$

12. Variance ratio statistics for short rates confirm this casual observation. At horizon 12 months, the variance ratio is 0.81 in the first subsample, but 2.55 in the second. See Cochrane (1988) for details on the variance ratio statistic and its interpretation as a measure of persistence.

13. Similar regressions can be found in Campbell and Shiller (1991), Fama (1984), Kugler (1988), Mankiw and Miron (1986), and Shiller, Campbell, and Schoenholtz (1983).

Table 4.2 Forecastability of Gensaki Rates

	Full Sample (81:6–90:8)		Subsample 1 (81:6–85:7)		Subsample 2 (85:8–90:8)	
A. Regression of Δr^1_{t+1} on Δr^1_{t+1-i} ($i = 1, \ldots, 6$)						
Adjusted R^2 and joint significance level	0.231 [0.000]		0.455 [0.000]		0.180 [0.000]	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	0.004	0.022	−0.025	0.027	0.011	0.029
lag 1	0.202	0.129	−0.274	0.179	0.473	0.202*
2	0.008	0.149	−0.155	0.164	−0.102	0.263
3	0.300	0.111*	0.177	0.108	0.230	0.196
4	−0.198	0.082*	−0.170	0.115	−0.073	0.127
5	−0.111	0.098	−0.172	0.093	−0.202	0.191
6	0.151	0.077	0.099	0.082	0.166	0.142
B. Regression of ($\Delta r^1_{t+2} + 2\Delta r^1_{t+1}$) on Δr^1_{t+1-i} ($i = 1, \ldots, 6$)						
	Full Sample (81:6–90:8)		Subsample 1 (81:6–85:7)		Subsample 2 (85:8–90:8)	
Adjusted R^2 and joint significance level	0.162 [0.000]		0.434 [0.000]		0.129 [0.000]	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	0.008	0.054	−0.069	0.052	0.032	0.075
lag 1	0.450	0.276	−0.639	0.393	1.049	0.402*
2	0.284	0.434	−0.199	0.303	0.010	0.762
3	0.452	0.245	0.076	0.212	0.454	0.448
4	0.586	0.161*	−0.531	0.227*	−0.375	0.221
5	0.104	0.254	−0.168	0.177	−0.410	0.495
6	0.353	0.169*	0.244	0.161	0.477	0.295
C. Simple test of expectations hypothesis for 2-month gensaki rate $\Delta r^1_{t+1} = \alpha + \beta s^2_t + \varepsilon_{t+1}$						
	Full Sample (80:12–90:8)		Subsample 1 (80:12–85:7)		Subsample 2 (85:8–90:8)	
Adjusted R^2 and joint significance level	0.142 [0.000]		0.233 [0.000]		0.389 [0.000]	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
α	−0.131	0.046*	−0.292	0.094*	−0.199	0.047*
β	1.733	0.477*	2.251	0.659*	4.850	1.107*
Test of expectations theory ($\beta = 2$)	[0.476]		[0.703]		[0.010]	
Standard deviation of fitted value	0.130		0.198		0.167	

Table 4.2 (continued)

D. Simple test of expectations hypothesis for 3-month gensaki rate

$$(\Delta r^1_{t+2} + 2\Delta r^1_{t+1}) = \gamma + \delta s^3_t + \nu_{t+2}$$

	Full Sample (80:12–90:8)		Subsample 1 (80:12–85:7)		Subsample 2 (85:8–90:8)	
Adjusted R^2 and joint significance level	0.099 [0.001]		0.173 [0.002]		0.428 [0.000]	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
γ	−0.290	0.110*	−0.638	0.215*	−0.335	0.097*
δ	2.275	0.659*	2.872	0.918*	8.197	1.317*
Test of expectations theory ($\delta = 3$)	[0.272]		[0.889]		[0.000]	
Standard deviation of fitted value	0.245		0.351		0.448	

E. Multiple regression of Δr^1_{t+1} on Δr^1_{t+1-i} ($i = 1, \ldots, 6$) and s^2

	Full Sample (81:6–90:8)		Subsample 1 (81:6–85:7)		Subsample 2 (85:8–90:8)	
Adjusted R^2 and joint significance level	0.293 [0.000]		0.454 [0.000]		0.454 [0.000]	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
s^2_t	0.995	0.420*	0.411	0.401	4.314	1.116*
Exclusion of s^2_t	[0.019]		[0.305]		[0.000]	
Test of expectations theory (i.e., s_t coefficient = 2 and other coefficients = 0)	[0.000]		[0.000]		[0.000]	

F. Multiple regression of $(\Delta r^1_{t+2} + 2\Delta r^1_{t+1})$ on Δr^1_{t+1-i} ($i = 1, \ldots, 6$) and s^3_t

	Full Sample (81:6–90:8)		Subsample 1 (81:6–85:7)		Subsample 2 (85:8–90:8)	
Adjusted R^2 and joint significance level	0.856 [0.000]		0.423 [0.000]		0.453 [0.000]	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
s^3_t	0.221	0.650*	0.251	0.579	7.710	1.582*
Exclusion of s^3_t	[0.019]		[0.665]		[0.000]	
Test of expectations theory (i.e., s^3_t coefficient = 3 and other coefficients = 0)	[0.000]		[0.000]		[0.000]	

Notes: Numbers in brackets are p-values. All standard errors and p-values are corrected for heteroscedasticity. Asterisks indicate significance at the 5% level.

where r_t^1 and r_t^2 are 1- and 2-month gensaki rates, respectively, and $s_t^2 = r_t^2 - r_t^1$. If the expectations theory holds, then we should find $\beta = 2$, while if the yield spread contains no relevant information about future short rates, we will find $\beta = 0$.

For 3-month rates, the regression can be written as

$$(11) \qquad (r_{t+2}^1 + r_{t+1}^1 - 2r_t^1) = \gamma + \delta s_t^3 + \nu_{t+2} ,$$

where r_t^3 is the 3-month gensaki rate and $s_t^3 = r_t^3 - r_t^1$. According to the expectations theory, $\delta = 3$, while $\delta = 0$ if there is no relevant information in the term structure of gensaki rates. In this regression the equation errors overlap, for which standard errors must be adjusted. In addition, all standard errors and hypothesis tests in this and following tables are adjusted for conditional heteroscedasticity in interest rates, although this makes little difference to our results.[14]

Table 4.2, panels C and D, report estimates of equation (10) and (11), with very similar results for the two specifications. We obtain two striking results. First, there is no decline in the forecastability of short-term rates when the yield spread is used as the forecasting variable. In fact, the R^2 statistics for regressions (10) and (11) increase after 1985, while the standard deviations of the fitted values fall very slightly in (10) and rise in (11). This illustrates the danger of relying too heavily on the univariate properties of the short rate process.

Second, regressions (10) and (11) provide no evidence against the expectations theory in the full sample or the first subsample, but they strongly reject the theory in the second subsample. In the post-1985 period, the coefficient on the yield spread is more than twice as large as it should be under the expectations theory, indicating that the yield spread was less variable than the optimal forecast of future gensaki rate changes. As shown in table 4.1, the variability of gensaki yield spreads declined considerably after 1985; regressions (10) and (11) indicate that this was not due to a decline in the forecastability of short rate changes, but to a failure of the expectations hypothesis in the post-1985 period.

As a final empirical exercise, we combine the regressors of table 4.2, panels A and B (lagged short rate changes) with those of panels C and D (yield spreads). The results are reported in panels E and F. We find that when both the history of short rates and the slope of the term structure are taken into account, there was little change in the forecastability of short rates between the early and the late 1980s. What changed was that in the early 1980s short rates could be well forecast from their own history with no marginal predictive power from the yield spread; in the late 1980s the yield spread was essential for forecasting short rates. In these regressions the expectations hypothesis is strongly rejected in the full sample and both our subsamples.

14. The adjustments can be seen as an application of Hansen's (1982) generalized method of moments.

4.4 The Long-Term Government Bond Market

In this section we extend our investigation to the longer end of the yield curve. We begin in table 4.3 by reporting summary statistics, parallel to those of table 4.1, for bond portfolios with maturities of 1–2 years (18 months), 3–4 years (42 months), 5–6 years (66 months), 7–8 years (90 months), and 9–10 years (114 months). Once again we reject the unit root hypothesis for most maturities in the full sample and first subsample, but we fail to reject it in the second subsample.

It is noteworthy that the standard deviation of the change in the bond yield (which is approximately proportional to the standard deviation of the bond return) is lower in the first subsample than in the second subsample. Also this standard deviation declines with maturity in the first subsample, whereas it increases with maturity in the second. This is what the expectations theory of the term structure would predict when there is a shift in the interest rate process from a stationary mean-reverting process to a nonstationary "mean-abandoning" one.[15]

4.4.1 Term Structure Forecasts of Long-Term Interest Rates

We now proceed to a more formal evaluation of the expectations theory of the term structure as a description of the long-term Japanese yield curve. In table 4.4, panel A, we run regressions of the form (6), with the change in the long-term bond yield as the dependent variable and the yield spread (appropriately scaled by bond duration) as the regressor. According to the expectations theory, the scaled yield spread should be the best possible forecast of the change in the long bond yield over the next period, so the coefficient on the scaled yield spread should equal one. The point estimates in table 4.4, panel A, are not very favorable to the expectations theory, at least over the full sample and the second subsample. We find that the regression coefficient on the scaled yield spread tends to be negative rather than positive, and it becomes increasingly negative as the long bond maturity increases. These results parallel those obtained for the United States by Campbell and Shiller (1991). The standard errors in this regression are very large, however, so we have no strong statistical evidence against the expectations theory. Over the first subsample the results are rather erratic and do not provide any evidence against the expectations theory.

Table 4.4, panel B, adds six lags of short rate changes to the regression of panel A. Just as in table 4.2, panels E and F, the use of lagged short rates strengthens the evidence against the expectations hypothesis. We now reject the hypothesis at the 5% level in seven out of fifteen regressions, and at the 10% level in ten out of fifteen regressions.

15. Chan, Karolyi, Longstaff, and Sanders (1991), Sargen, Schoenholtz, and Alcamo (1987), and Singleton (1990) discuss the changing volatility of Japanese government bond markets. Shikano (1985) and Shirakawa (1987) use the expectations theory to interpret movements in the Japanese term structure.

Table 4.3 Summary Statistics, Government Bond Yields

Series	Mean	Standard Deviation	Autocorrelations ρ_1	ρ_2	ρ_3	ρ_4	Dickey-Fuller Test
Full sample (1980:11–1990:8, 118 observations)							
Level							
1–2 yrs	6.057	1.521	0.948	0.895	0.855	0.818	−5.64
3–4 yrs	6.176	1.533	0.960	0.919	0.885	0.854	−4.22
5–6 yrs	6.350	1.579	0.967	0.933	0.903	0.878	−3.61
7–8 yrs	6.468	1.544	0.963	0.926	0.891	0.858	−4.10
9–10 yrs	6.533	1.361	0.963	0.924	0.889	0.858	−4.47
Difference							
1–2 yrs	−0.015	0.299	0.168	0.110	0.002	−0.094	−77.87
3–4 yrs	−0.009	0.301	0.132	0.043	−0.003	−0.099	−92.61
5–6 yrs	−0.008	0.295	0.159	0.031	−0.005	−0.149	−94.02
7–8 yrs	−0.012	0.302	0.147	0.055	−0.055	−0.165	−90.73
9–10 yrs	−0.010	0.294	0.129	−0.012	−0.024	−0.198	−106.09
Spread with 1-month gensaki							
1–2 yrs	0.357	0.481	0.821	0.666	0.567	0.424	−21.90
3–4 yrs	0.476	0.573	0.802	0.638	0.558	0.398	−23.76
5–6 yrs	0.650	0.705	0.845	0.714	0.649	0.505	−18.00
7–8 yrs	0.768	0.695	0.828	0.664	0.553	0.384	−22.61
9–10 yrs	0.832	0.696	0.815	0.644	0.541	0.362	−23.34
Subsample 1 (1980:11–1985:7, 57 observations)							
Level							
1–2 yrs	7.221	0.886	0.866	0.726	0.637	0.553	−7.45
3–4 yrs	7.440	0.717	0.864	0.720	0.606	0.520	−6.58
5–6 yrs	7.688	0.775	0.911	0.809	0.731	0.663	−3.00
7–8 yrs	7.775	0.803	0.912	0.825	0.753	0.689	−2.30
9–10 yrs	7.747	0.577	0.874	0.756	0.652	0.578	−2.57
Difference							
1–2 yrs	−0.063	0.270	0.021	0.118	−0.056	−0.145	−40.62
3–4 yrs	−0.048	0.264	0.022	0.014	−0.130	−0.118	−46.18
5–6 yrs	−0.046	0.213	0.173	−0.078	−0.065	−0.085	−46.47
7–8 yrs	−0.050	0.199	0.082	−0.035	−0.142	−0.033	−45.48
9–10 yrs	−0.039	0.195	0.025	0.005	−0.129	−0.108	−56.31
Spread with 1-month gensaki							
1–2 yrs	0.598	0.468	0.783	0.619	0.562	0.375	−10.10
3–4 yrs	0.817	0.510	0.637	0.385	0.335	0.078	−20.33
5–6 yrs	1.065	0.668	0.745	0.571	0.541	0.333	−11.58
7–8 yrs	1.152	0.623	0.707	0.499	0.435	0.191	−14.78
9–10 yrs	1.124	0.600	0.649	0.420	0.372	0.110	−19.42
Subsample 2 (1985:8–1990:8, 61 observations)							
Level							
1–2 yrs	4.969	1.135	0.893	0.794	0.691	0.598	−0.47
3–4 yrs	4.996	1.081	0.883	0.782	0.677	0.587	−0.44

Table 4.3 (continued)

Series	Mean	Standard Deviation	Autocorrelations ρ_1	ρ_2	ρ_3	ρ_4	Dickey-Fuller Test
5–6 yrs	5.101	1.007	0.863	0.743	0.619	0.522	−1.12
7–8 yrs	5.246	0.953	0.853	0.719	0.569	0.447	−2.93
9–10 yrs	5.398	0.770	0.820	0.644	0.470	0.319	−6.34
Difference							
1–2 yrs	0.028	0.319	0.233	0.083	0.032	−0.088	−40.62
3–4 yrs	0.025	0.329	0.178	0.041	0.053	−0.092	−46.18
5–6 yrs	0.026	0.352	0.139	0.052	0.001	−0.175	−46.47
7–8 yrs	0.021	0.370	0.151	0.064	−0.052	−0.214	−45.48
9–10 yrs	0.016	0.362	0.145	−0.032	−0.009	−0.232	−56.31
Spread with 1-month gensaki							
1–2 yrs	0.131	0.374	0.692	0.406	0.163	−0.031	−23.49
3–4 yrs	0.157	0.429	0.719	0.432	0.213	0.002	−23.85
5–6 yrs	0.262	0.484	0.726	0.420	0.181	−0.075	−25.75
7–8 yrs	0.408	0.555	0.768	0.466	0.188	−0.049	−25.57
9–10 yrs	0.560	0.672	0.842	0.627	0.437	0.254	−16.19

Notes: Dickey-Fuller test is a t-statistic from the augmented Dickey-Fuller test with one lagged change. The Dickey-Fuller critical values are:
50 observations: −2.60 (10%), −2.93 (5%), −3.58 (1%)
100 observations: −2.58 (10%), −2.89 (5%), −3.51 (1%)

4.4.2 Term Structure Forecasts of Short-Term Interest Rates

In the United States, the expectations theory of the term structure is rejected statistically; nevertheless the U.S. yield curve contains useful forecasts of short-term interest rates over a long horizon, as emphasized by Fama and Bliss (1987) and Campbell and Shiller (1991). Jorion and Mishkin (1991) report that British, German, and Swiss yield curves have similar properties. We now ask whether the same is true for the Japanese yield curve.

We cannot evaluate the long-horizon forecasting power of the Japanese term structure by direct regression as we did for gensaki rates, because the regression would require shortening the sample period by the long bond's maturity (so we would have no data at all for the 9–10-year bond) and would have an equation error overlap equal to the long bond's maturity (which has very bad effects on inference in a short sample). Instead we use the indirect VAR approach proposed by Campbell and Shiller (1991). We run a VAR with four lags of the yield spread and the change in the short rate, and we calculate the unrestricted VAR forecast of the weighted sum of short rate changes given on the right-hand side of equation (8).[16] We call this the "theoretical spread."

16. We also ran VAR systems with two lags and obtained very similar results. Note that a low-order VAR system can approximate a high-order univariate process, so we do not necessarily need the VAR lag length to equal the number of lags used in the univariate regressions of section 4.3.

Table 4.4 **Forecastability of Long Rate Changes**

Bond Maturity i	Full Sample (80:11–90:8)	Subsample 1 (80:11–85:7)	Subsample 2 (85:8–90:8)
	A. Regression of Long Rate Change on Scaled Yield Spread $\Delta r^i_{t+1} = \beta_0 + \beta_1[s^i_t/(D_i - 1)] + \varepsilon^i_{t+1}$		
18	−0.087	0.216	2.034
	(0.949)	(1.289)	(2.065)
42	−0.673	0.181	2.434
	(1.829)	(2.748)	(4.166)
66	−1.638	1.921	−3.592
	(2.304)	(2.412)	(7.177)
90	−4.231	0.514	−7.806
	(3.605)	(3.522)	(9.316)
114	−3.733	2.481	−7.377
	(4.261)	(2.973)	(8.415)

B. Test of Expectations Theory: Regression of Long Rate Change on Scaled Yield Spread and Lagged Short Rate Changes

$$\Delta r^i_{t+1} = \beta_0 + \beta_1[s^i_t/(D_i - 1)] + \sum_{j=1}^{6} \gamma_j \Delta r^1_{t+1-j} + \varepsilon^i_{t+1}$$

Significance level for H_0: $\beta_1 = 1$, and $\gamma_1 = \ldots = \gamma_6 = 0$

Bond Maturity i	Full Sample (81:6–90:8)	Subsample 1 (81:6–85:7)	Subsample 2 (85:8–90:8)
18	0.009	0.059	0.017
42	0.081	0.012	0.026
66	0.185	0.003	0.166
90	0.387	0.014	0.086
114	0.195	0.106	0.004

Notes: Numbers in parentheses are heteroscedasticity-consistent standard errors. Panel B significance levels are also heteroscedasticity-consistent.

Table 4.5 reports the estimated correlation of the theoretical and actual spreads, while table 4.6 reports the standard deviation of the theoretical spread divided by the standard deviation of the actual spread. For completeness we apply this method to the gensaki term structure as well as the term structure of bond yields.

Our results are quite similar to those of Campbell and Shiller (1991) for postwar U.S. data. We find contrasting results for the short and long ends of the term structure. At the short end the theoretical and actual yield spreads have a positive correlation of about .5 in the full sample and first subsample; this increases to almost .9 in the second subsample. The actual yield spread is somewhat less variable than the theoretical yield spread, particularly in the second subsample. This is what one would expect from our direct regression analysis in table 4.2. There we found that in the early 1980s lagged short rates contained information about future short rates that was not available from the yield spread; in the late 1980s the yield spread was the only useful forecasting

Table 4.5 Correlation of Theoretical and Actual Yield Spreads

Bond Maturity	Full Sample (80:11–90:8)	Subsample 1 (80:11–85:7)	Subsample 2 (85:8–90:8)
2	0.526	0.566	0.876
	(0.081)	(0.077)	(0.057)
3	0.584	0.561	0.907
	(0.128)	(0.127)	(0.043)
6	0.758	0.405	0.891
	(0.208)	(0.294)	(0.095)
18	0.842	−0.068	0.957
	(0.247)	(0.883)	(0.067)
42	0.883	0.256	0.958
	(0.236)	(0.992)	(0.046)
66	0.493	0.130	0.883
	(1.558)	(2.013)	(0.208)
90	0.519	0.133	0.820
	(1.403)	(2.023)	(0.349)
114	0.801	0.844	0.894
	(0.707)	(0.233)	(0.271)

Notes: This table gives correlation coefficients of theoretical and actual yield spreads between long-term government bonds (including 2- and 3-month gensaki) and the 1-month gensaki rate. The theoretical spread is calculated by using a VAR model with four lags of $[\Delta r_t^1\ s_t^i]$ to construct the weighted sum of expectations in equation (8). The first column indicates the number of months to maturity of the longer-term bond. Numbers in parentheses are heteroscedasticity-consistent standard errors.

variable for short rates, but the coefficient on this variable was larger than required by the expectations theory, indicating an insufficiently variable spread.

At the long end of the term structure, the correlations between the theoretical and actual yield spreads are also consistently positive, and highest in the late 1980s. However, the actual yield spread is now considerably more variable than the theoretical yield spread (the ratio of theoretical to actual standard deviations ranges from about one-quarter to about one-half for the two longest bond maturities). In the full sample and the first subsample the standard deviation ratios are significantly different from one at the long end of the term structure.

A visual impression of these results is given in figures 4.6 and 4.7. Figure 4.6 plots the actual and theoretical 3-month yield spreads over our full sample period, while figure 4.7 plots the actual and theoretical 9–10-year yield spreads. The figures clearly show the contrast between the short and long ends of the yield curve: at the long end, the actual yield spread is much more variable than its theoretical counterpart, while if anything the opposite is true at the short end of the yield curve.

Our VAR system can also be used to calculate a theoretical excess return, defined as the excess return that bondholders would obtain if the yield spread

Table 4.6 Standard Deviation Ratio of Theoretical and Actual Yield Spread

Bond Maturity	Full Sample (80:11–90:8)	Subsample 1 (80:11–85:7)	Subsample 2 (85:8–90:8)
2	1.331	1.328	2.769
	(0.113)	(0.107)	(0.446)
3	1.127	1.085	3.115
	(0.169)	(0.105)	(0.435)
6	0.471	0.366	1.078
	(0.139)	(0.036)	(0.241)
18	0.460	0.288	1.134
	(0.223)	(0.085)	(0.321)
42	0.416	0.314	0.983
	(0.276)	(0.040)	(0.263)
66	0.226	0.260	0.681
	(0.160)	(0.039)	(0.250)
90	0.224	0.257	0.559
	(0.151)	(0.073)	(0.262)
114	0.263	0.468	0.503
	(0.312)	(0.215)	(0.285)

Notes: This table gives the standard deviation of the theoretical yield spread divided by the standard deviation of the actual yield spread between long-term government bonds (including 2- and 3-month gensaki) and the 1-month gensaki rate. The theoretical spread is calculated by using a VAR model with four lags of $[\Delta r_t^1\ s_t^i]$ to construct the weighted sum of expectations in equation (8). The first column indicates the number of months to maturity of the longer-term bond. Numbers in parentheses are heteroscedasticity-consistent standard errors.

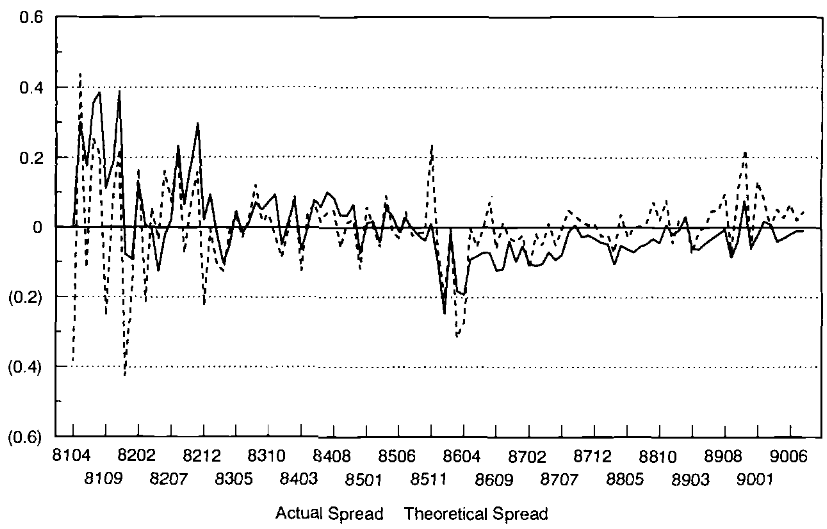

Fig. 4.6 Actual versus theoretical spread, 3-month gensaki

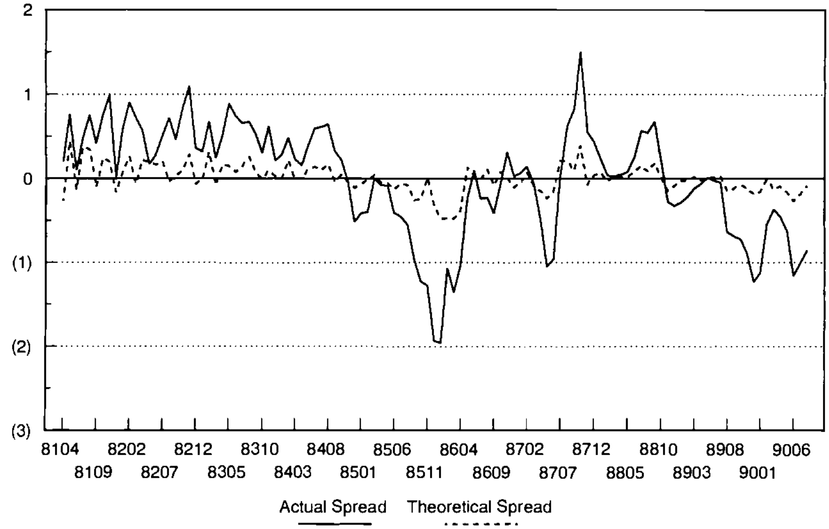

Fig. 4.7 Actual versus theoretical spread, 9–10-year Japanese government bonds

were equal to its theoretical value. Figure 4.8 plots the actual and theoretical excess returns on 9–10-year bonds over the full sample period. The figure shows that, although the Japanese yield spread is more variable than can be explained by the expectations theory, the Japanese excess bond return is not. The variability of the actual excess return is close to its theoretical counterpart, or even a little lower in 1987. According to these estimates, the increased volatility of Japanese government bond returns in the late 1980s can be explained by the changing behavior of short-term interest rates. Even though the Japanese term structure deviates from the predictions of the simple expectations theory, this deviation does not increase the volatility of returns on Japanese government bonds.

4.5 Conclusions

In this paper we have studied the behavior of short- and long-term interest rates in Japan during the 1980s. We have three main findings.

First, we find evidence that the univariate short-term interest rate process changed in Japan around 1985. Before that date the short-term rate appears to be mean-reverting, and changes in short rates are highly forecastable from their own history. In the late 1980s, changes in the Japanese short rate show no tendency to reverse themselves. The short rate behaves very much like a random walk, or even a nonstationary process that is more persistent than a

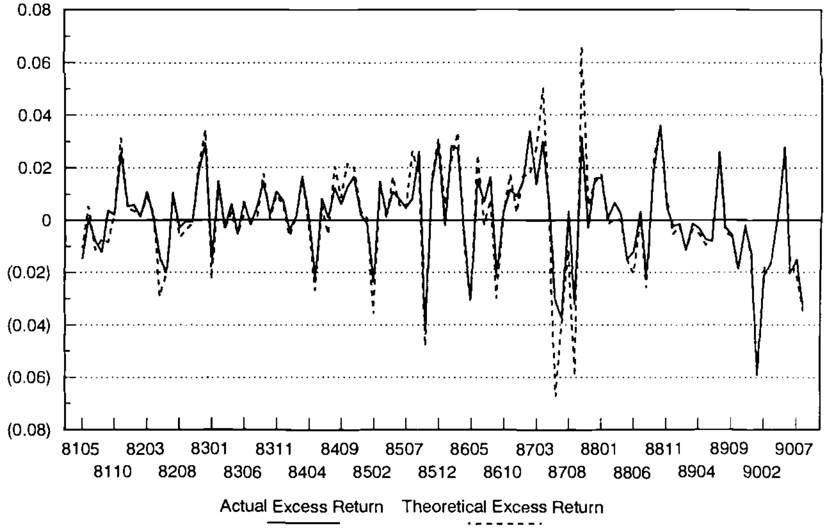

Fig. 4.8 Actual versus theoretical excess return, 9–10 year Japanese government bonds

random walk (a "mean-abandoning" process). We suggest that this change in interest rate behavior may be due to a shift in Japanese monetary policy around the time of the September 1985 Plaza Accord.

Our second finding is that there has also been a shift in the ability of the Japanese yield curve to forecast Japanese short rates. At the short end of the term structure, we find that the yield spread between the 2- or 3-month gensaki rate and the 1-month gensaki rate had no marginal predictive power for changes in 1-month rates in the early 1980s. In the late 1980s, by contrast, this yield spread was a powerful forecasting variable. In fact, the decline in the forecastability of Japanese short rates from their own past history is completely offset by the increase in forecastability of Japanese short rates from the gensaki yield curve; the overall forecastability of short rates is roughly constant through the 1980s. At the long end of the term structure, we calculate the correlation between the long-short yield spread and an unrestricted VAR forecast of future short rate changes over the life of the long-term bond. We find that this correlation increased from the early 1980s to the late 1980s; this again suggests an increase in the ability of the term structure to forecast interest rate movements.

Our third finding is that the expectations theory of the term structure fails to describe our data on Japanese gensaki and government bond yields. This result may not be unexpected, given the overwhelming evidence against the expectations theory in U.S. and European data and the earlier findings of Shikano (1985) and Singleton (1990). We use a VAR approach to characterize the failure of the expectations theory and argue that, at the long end of the term structure, the yield spread is consistently more variable than can be justified by rational forecasts of future movements in short-term interest rates. This result parallels the findings of Campbell and Shiller (1991) for the U.S. term structure. On the other hand, there is no excess volatility of returns, in that the volatility of returns on long-term Japanese government bonds is roughly equal to that predicted by the expectations theory of the term structure.

We leave several issues for further research. Perhaps the most important of these is the question of why the interest rate forecasting ability of the Japanese term structure has increased since the mid-1980s. One possibility is that the information available to market participants has increased over time, either because of institutional changes in the formulation of monetary policy or because of increased linkages between interest rates in different countries. A second possibility is that the efficiency of Japanese bond markets has increased with the steady deregulation of the past 10 years, so that bond prices now reveal market participants' information more effectively.

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