The Determination of Interest Rates in Japan, 1967–1978*

Kunio Kama

I. Introduction

The relationship between the expected rate of inflation and nominal interest rates has recently been receiving much attention in the field of the monetarist approach to macroeconomics. One of the important elements of the rational expectations macromodels is the Irving Fisher's equation (Fisher, 1930)

$$i_t = r_t + \Pi_t, \tag{1}$$

where i_t is the nominal interest rate on bond, Π_t is the rate of inflation expected to occur over the life of bonds, and r_t is the rate of return associated with holding real assets. Equation (1) states that the nominal interest rate prevailing at time t for a bond is equal to the expected inflation plus its real rate of interest[1]. Equation (1) is rationalized by the following argument. Investors regard real assets, whose returns are more or less fixed in real terms, as perfect substitutes for bonds, whose yields are fixed in nominal terms. Expectation of inflation implies a depreciation of dividends and induces investors to require additional interest payment to attain the same real interest rate on bonds as on real assets. Thus in equilibrium equation (1) holds.

The expected rate of inflation (Π_t) is typically unobservable. Fisher introduced a very simple expectational model which representing Π_t by a distributed lag on past inflation rates. That is,

$$\Pi_t = \sum_{i=0}^{n} w_i \frac{\Delta p_{t-i}}{p_{t-i}} \tag{2}$$

Substituting equation (2) into equation (1) yields the form of the equation that is usually estimated:

$$i_t = r_t + \sum_{i=0}^{n} w_i \frac{\Delta p_{t-i}}{p_{t-i}}. \tag{3}$$

In the United States, equation (3) or its extended versions have been extensively investigated since Fisher's original work (1930)[2]. In estimating equation (3) for Japan, we face severe data problems. Though the official data on the yields of bond trading with repurchase agreement are available nowadays, the time series is too short to be used in the present study. Hence I used the call money rate for the Tokyo call market and the yields on interest-bearing Telegraph and Telephone Bond. In the U. S., Gibson

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1) Strictly speaking, Fisher's original equation is $i_t = r_t + \pi_t + r_t\pi_t$. The interaction term, $r_t\pi_t$, is neglected in the text, as it is dwarted by the other terms.

2) See, for example, Meiselman (1963), Cagan (1965), Friedman (1968), Yohe and Karnosky (1969), Hamberger and Silber (1969), Gibson (1970), Feldstein and Eckstein (1970), Sargent (1969, 1972, 1973).

(1970) used one-day call rates in his study of price-expectations effects on interest rates. The motivation behind choosing these two markets is that there are many differences between the two: 1) the former deals with very short-term funds, the latter long-term capitals, 2) the traders are limited to commercial banks and other financial institutes in the call market, wheareas the interest-bearing Telegraph and Telephone bonds are held and traded by many institutions including business firms and households, 3) the call rate has been subject to discretionary control by the central bank authority, but the bond rate has not been subject to such control and therefore reflected more sensitivity to changes in economic conditions.

Since observations of the long term bond rate are available only from 1967, present study covers from 1976 to 1978 calender years.

II. Empirical Results

For empirical implementation of equation (3), it is necessary to formulate the determination of the real interest rate. Fisher assumed that the real rate of interest r_t is equal to the sum of a constant, α, and a stochastic term u_t;

$$r_t=\alpha+u_t. \tag{4}$$

Substituting equation (4) into equation (3) yields

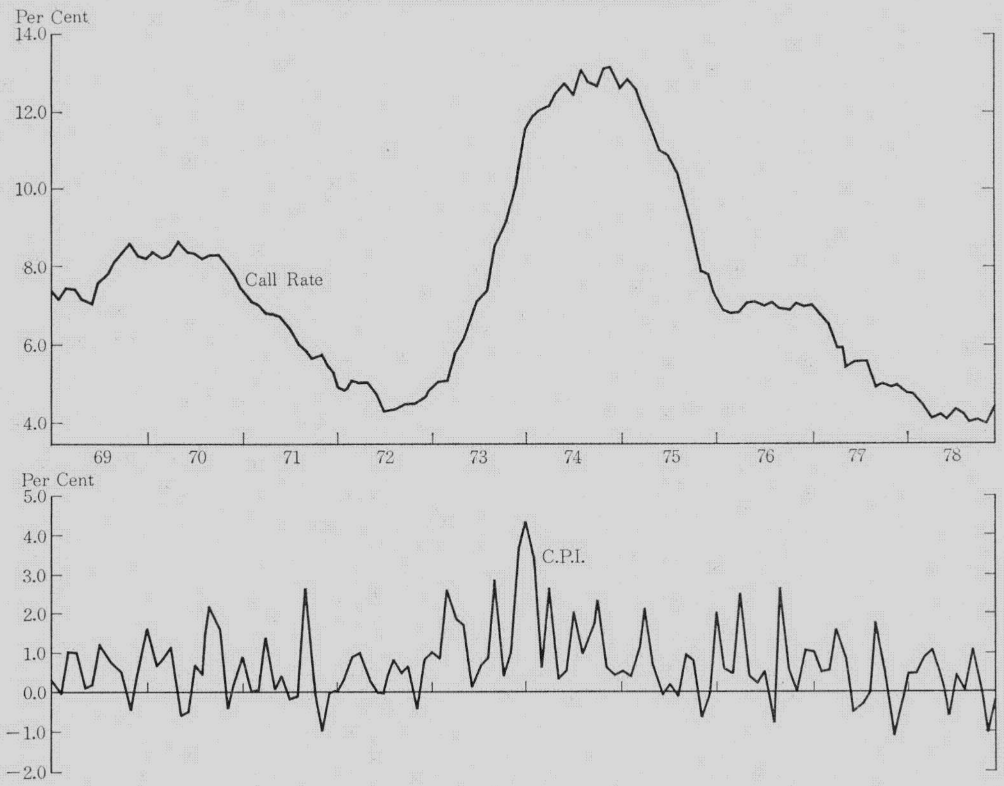
$$i_t=\alpha+\sum_{i=0}^{n} w_i \frac{\Delta p_{t-i}}{p_{t-i}}+u_t. \tag{5}$$

In this section we report the results of estimation of equation (5). In the following section the simple model (4) is modified such that the real interest rate depends on money supply and real income.

As mentioned above, data for the period 1967–1978 were used to test the hypothesis about the effect of price expectations on the level of the nominal interest rate. The price variables used to calculate the inflation rates are the consumer price index (C. P. I.) and the wholesale price index (W. P. I.). All of the results suggest a much shorter time horizon for the price expectations formation than had been found in the U. S. except for Yohe and Karnosky's results.

Before proceeding to the results, it will be useful to show the movements of interest rate and inflation over the sample period. Figure 1 indicates the call rate and inflation measured by changes in C. P. I. from previous month for January 1969- December 1978. Bond rate's movement resembles closely that of call rate. The whole period falls broadly into three parts. In the first period, though we faced the big external shocks (revaluation of yen brought about by the New Economic Policy in the United States), the inflation was mild and the economy still kept high growth rate. The second period 1973–1975 is very interesting for the purposes of this study. At the end of 1973, the economy was struck by the Arab oil embargo and oil price increase. Real GNP growth became negative in the last quarter of 1973 and recorded negative growth for four consecutive quarters. Though already there was temporary bulge in the inflation rate, as measured by the C. P. I., the inflation rate increased abruptly to a higher level in 1973/III. As a result of the higher inflation, interest rates rose sharply toward the end of 1973, and stayed high through the first half of 1975. After 1975, the economic recovery staggered and induced the slow down of inflation, which caused interest rates move down to a

Figure 1. Movement of Call rate and Inflation



very low level.

II-A. Interest Rates and Expected Inflation

Using monthly observations for the period January 1967 to December 1978, equation (5) was estimated. I first used the ordinary least-squares procedure, and the results indicated very strong positive correlation in error terms. Then all equations reported below were estimated by the Almon technique, with an adjustment for serial correlation by the Cochrane-Orcutt iteration procedure.

Table 1 and table 2 show the pattern of lag coefficients on past inflation and the summary statistics for call rate and bond rate, each using alternative two measures of inflation to form inflationary expectations proxy. The individual lag coefficients were assumed to lie on a second, third, or sixth-degree polynomial and no initial and end-point constraints were imposed. I tried the maximum length of 54 lag, but the coefficients tended to be small and statistically insignificant beyond a 30 month lag. Increasing the length of the lag beyond 30 months had little effect on the lag distribution. In contrast with the previous U. S. findings, these results suggest that the influence of past inflation on price expectations formation dies out rather quickly. In regard to this finding, we note that most of the works used quarterly or annual observations. To explore the possibility of disaggregation bias in the present results, the original data were changed to a quarterly basis and regressions were run. The patterns of lag coefficients are almost

Table 1. Distributed Lag Coefficient (Call rate)

	C.	P.	I.	W.	P.	I.
−0	6.02(2.12)	4.24(1.41)	3.15(1.19)	10.38(3.24)	11.24(3.78)	9.77(3.42)
−1	9.61(3.16)	9.14(3.27)	7.39(2.32)	10.45(4.14)	12.28(5.17)	12.47(5.27)
−2	12.78(3.48)	13.06(4.13)	10.44(2.77)	10.87(4.63)	13.33(6.37)	14.78(7.13)
−3	15.52(3.74)	16.08(4.43)	13.08(3.21)	11.57(4.80)	14.37(7.05)	16.71(8.59)
−4	17.83(4.08)	18.26(4.57)	15.77(3.63)	12.49(5.00)	15.38(7.35)	18.29(9.46)
−5	19.69(4.54)	19.69(4.69)	18.68(4.05)	13.55(5.37)	16.35(7.55)	19.54(9.87)
−6	21.11(5.09)	20.42(4.82)	21.78(4.54)	14.68(5.93)	17.26(7.81)	20.47(10.04)
−7	22.07(5.68)	20.54(4.96)	24.92(5.15)	15.82(6.60)	18.08(8.16)	21.12(10.11)
−8	22.58(6.14)	20.12(5.10)	27.86(5.90)	16.89(7.27)	18.81(8.60)	21.49(10.15)
−9	22.64(6.24)	19.23(5.20)	30.30(6.69)	17.82(7.77)	19.42(9.10)	21.61(10.19)
−10	22.22(5.92)	17.94(5.18)	31.98(7.33)	18.55(7.98)	19.88(9.57)	21.50(10.21)
−11	21.34(5.31)	16.33(4.96)	32.64(7.56)	19.00(7.92)	20.20(9.93)	21.17(10.19)
−12	19.99(4.64)	14.46(4.46)	32.10(7.28)	19.10(7.71)	20.34(10.08)	20.66(10.11)
−13	18.15(4.03)	12.41(3.72)	30.27(6.62)	18.78(7.45)	20.28(9.97)	19.97(9.92)
−14	15.83(3.51)	10.25(2.90)	27.13(5.76)	17.98(7.21)	20.02(9.63)	19.14(9.60)
−15	13.02(3.06)	8.06(2.12)	22.78(4.81)	16.62(6.90)	19.53(9.14)	18.17(9.14)
−16	9.72(2.61)	5.90(1.46)	17.43(3.77)	14.64(6.23)	18.79(8.58)	17.09(8.55)
−17	5.92(1.95)	3.86(0.91)	11.35(2.59)	11.95(4.72)	17.78(8.00)	15.92(7.86)
−18	1.62(0.58)	1.99(0.46)	4.93(1.20)	8.50(2.63)	16.49(7.44)	14.68(7.13)
−19		0.38(0.09)	−1.42(−0.36)		14.89(6.86)	13.40(6.38)
−20		−0.91(−0.22)	−7.23(−1.86)		12.98(6.19)	12.08(5.67)
−21		−1.79(−0.49)	−12.05(−2.97)		10.72(5.25)	10.75(5.00)
−22		−2.21(−0.69)	−15.47(−3.58)		8.11(3.86)	9.43(4.39)
−23		−2.08(−0.74)	−17.18(−3.76)		5.11(2.14)	8.15(3.84)
−24		−1.34(−0.45)	−17.00(−3.62)		1.73(0.58)	6.91(3.33)
−25			−14.99(−3.22)			5.75(2.85)
−26			−11.46(−2.54)			4.68(2.36)
−27			−7.08(−1.66)			3.72(1.87)
−28			−2.98(−0.76)			2.89(1.36)
−29			−0.78(−0.24)			2.21(0.92)
−30			−2.74(−0.99)			1.71(0.59)
Constant	4.47(2.51)	4.83(2.35)	4.98(2.82)	6.05(5.61)	5.67(6.08)	5.52(6.14)
Mean lag	8.6	7.5(2.45)	4.2(1.19)	9.43(8.84)	11.18(8.96)	11.85(6.78)
Sum	2.98(6.31)	2.44(4.46)	2.74(4.87)	2.80(8.94)	3.84(10.20)	4.26(9.09)
S. E.	0.30	0.31	0.28	0.27	0.25	0.25
R^2	0.984	0.983	0.987	0.987	0.989	0.989
D. W.	1.49	1.53	1.72	1.70	1.97	1.89
ρ.	0.99(72.7)	0.99(77.5)	0.99(74.2)	0.98(57.5)	0.98(56.3)	0.98(59.9)
Degree of Polynomial	3	3	6	3	3	3

Note: Numbers in parentheses are t-values. All coefficients are multiplied by 10^2. Unit of mean lag is month. Sum is a sum of coefficients. *S. E.* is a standard error of the regression. ρ is a estimate of serial correlation in error terms. The sample period is January 1967 through December 1978. Call rate is seasonally adjusted percent per annum. C. P. I. is seasonally unadjusted change from previous month. W. P. I. is seasonally unadjusted change from previous month.

the same as in the monthly data. However, in general, the average of lag coefficients decreased. Thus the difference in the time unit used cannot explain the short mean lags found in the present study. It is possible that institutional changes such as the greater publicity given to price level movements and the more rapid processing of data produced such discrepancy. If this is correct, mean lags depend on the specific period under inves-

Table 2. Distributed Lag Coefficient (Bond rate)

	C.	P.	I.	W.	P.	I.
−0	6.43(2.10)	9.77(3.09)	5.77(1.89)	16.84(4.99)	24.25(6.70)	23.17(6.56)
−1	6.82(2.45)	6.43(1.73)	4.13(1.13)	14.55(5.54)	13.43(5.14)	12.98(4.93)
−2	7.10(2.58)	8.12(1.83)	5.12(1.19)	12.85(5.32)	9.18(3.39)	8.81(3.25)
−3	7.26(2.52)	12.25(2.48)	7.55(1.63)	11.63(4.72)	8.87(3.34)	8.28(3.06)
−4	7.31(2.36)	16.93(3.18)	10.50(2.14)	10.83(4.25)	10.53(4.06)	9.64(3.71)
−5	7.25(2.18)	20.89(3.76)	13.33(2.56)	10.35(4.03)	12.78(4.87)	11.65(4.57)
−6	7.07(2.00)	23.36(4.20)	15.59(2.88)	10.11(4.02)	14.73(5.55)	13.50(5.24)
−7	6.78(1.84)	24.01(4.45)	17.02(3.13)	10.01(4.13)	15.88(6.06)	14.72(5.61)
−8	6.38(1.69)	22.82(4.41)	17.50(3.30)	9.98(4.26)	16.01(6.31)	15.08(5.74)
−9	5.86(1.54)	20.02(3.98)	17.03(3.36)	9.92(4.30)	15.16(6.12)	14.59(5.67)
−10	5.23(1.39)	16.03(3.21)	15.69(3.22)	9.75(4.16)	13.51(5.46)	13.37(5.36)
−11	4.49(1.23)	11.35(2.27)	13.61(2.82)	9.38(3.86)	11.34(4.52)	11.64(4.78)
−12	3.63(1.05)	6.52(1.32)	10.99(2.22)	8.73(3.46)	8.97(3.55)	9.64(3.99)
−13	2.66(0.83)	2.09(0.44)	8.02(1.56)	7.71(2.30)	6.93(2.69)	7.63(3.13)
−14	1.57(0.53)	−1.49(−0.32)	4.89(0.92)	6.24(2.44)	4.90(1.99)	5.84(2.36)
−15	0.37(0.14)	−3.86(−0.85)	1.79(0.33)	4.21(1.71)	3.68(1.50)	4.44(1.79)
−16	−0.94(−0.36)	−4.79(−1.03)	−1.11(−0.21)	1.56(0.65)	3.20(1.27)	3.54(1.43)
−17	−2.37(−0.87)	−4.26(−0.87)	−3.68(−0.74)	−1.81(−0.68)	3.45(1.33)	3.17(1.30)
−18	−3.91(−1.28)	−2.43(−0.47)	−5.82(−1.25)	−5.98(−1.76)	4.32(1.64)	3.28(1.37)
−19		0.32(0.06)	−7.48(−1.70)		5.59(2.13)	3.74(1.55)
−20		3.38(0.65)	−8.63(−1.97)		6.92(2.66)	4.38(1.77)
−21		5.91(1.21)	−9.28(−2.03)		7.88(2.96)	4.99(1.95)
−22		6.85(1.56)	−9.49(−1.95)		7.97(2.93)	5.33(2.03)
−23		4.89(1.33)	−9.31(−1.81)		6.65(2.54)	5.21(1.97)
−24		−1.46(−0.46)	−8.81(−1.67)		3.39(0.93)	4.50(1.72)
−25			−8.05(−1.53)			3.20(1.22)
−26			−7.07(−1.39)			1.46(0.55)
−27			−5.86(−1.21)			−0.28(−0.10)
−28			−4.34(−0.97)			−1.31(−0.48)
−29			−2.33(−0.62)			−0.50(−0.19)
−30			0.46(0.14)			3.76(1.06)
Constant	7.76(9.53)	6.93(9.40)	7.87(10.20)	7.76(14.67)	7.42(14.82)	7.47(14.82)
Mean lag	4.86(0.96)	7.11(1.98)	−9.74(−0.75)	5.82(3.13)	9.25(4.69)	9.43(2.94)
Sum	0.79(1.60)	2.04(3.72)	0.78(1.26)	1.57(5.04)	2.39(6.44)	2.29(4.95)
S. E.	0.32	0.31	0.32	0.29	0.27	0.27
R^2	0.947	0.953	0.950	0.959	0.964	0.962
D. W.	1.57	1.83	1.65	1.71	1.93	1.88
ρ	0.97(46.0)	0.96(41.3)	0.96(41.1)	0.95(38.4)	0.95(38.0)	0.95(37.0)
Degree of Polynomial	2	6	6	3	6	6

Note: See note to table 1. Bond rate is yield on the interest-bearing Telegraph and Telephone Bond and unit is percent per annum.

tigation. While testing this hypothesis is interesting, it would require a longer time series.

There are a number of interesting observations about the results.

1) For both call rate and bond rate, the mean lags of W. P. I. are longer than those of C. P. I. One reason would lie in the fact that W. P. I. had more volatile fluctuations than C. P. I. did.

2) The sums of coefficients are greater for W. P. I. than for C. P. I. It should be noted that inflation is measured by change from previous month, whereas call rate and

bond rate are measured by percent per annum. The regression for call rate using 18 lags of C. P. I. implies that, if the monthly rate of change in the consumer price index increased by one percent in a given month (this corresponds to annual rate of 12.68%) and prices continued to rise at that rate, the call rate would have risen by 0.24 percentage points after 18 months. In the long run, therefore, the nominal interest rate does not rise by the full amount of the change in price expectation.

3) Constant term corresponds to real interest rate and results suggest that bond rate's real rate is higher than that of call rate. Robert Mundel (1963) has presented an analysis suggesting that the real rate falls when the expected rate of inflation rises. We can interpret the fact that the sums of coefficients for call rate are greater than those for bond rate as evidence of greater inflationary expectations in call market. Thus difference in real rates is consistent with Mundel's argument.

4) Fisher hypothesized that the time horizon in forming price expectations is related to the term to maturity of the security. Buyers and sellers of long-term debt would tend to look further into the past than would those people who were dealing in short-term securities. The results in this study contradict this view, since the mean lags of call rate are longer than those of bond rate for both C. P. I. and W. P. I.

5) The fit of the equations is very good, though R^2 is marginally higher for W. P. I. versions.

6) The pattern of coefficients is different for C. P. I. and W. P. I. The shape of lag distribution of W. P. I. is consistent with the adaptive expectations hypothesis, that is, they are generally declining as time lag increases. The coefficients of C. P. I. forms a bell-shaped pattern and becomes negative in the tail of the distribution. This would represent the negative regressive effects in the expectations formation.

7) The estimates of the autoregressive coefficient are nearly unity, which suggests the possibility of some systematic variables being omitted. Section III below explores this possibility by allowing the real interest rate to depend on money supply and real output.

II-B. Structural Change Test

The present study covers from 1967 to 1978. In the first half of the period, the Japanese economy maintained high growth rate and on an average inflation was mild compared with the latter half. However, after 1973 big "innovations" such as the oil curtailment, a change of the exchange rate system, struck the economy and caused unprecedented prolonged depression. In order to investigate the stability of equation (5) during this period, the whole sample period was divided into two subperiods, 1976–72 and 1973–78, and equations were reestimated for each period by the Almon technique with the Cochrane-Orcutt procedure. Tables 3A, B present the sum of the coefficient and the coefficient of determination as summary statistics. Figure 2 illustrates the shift in the lag pattern for the selected equations.

The results indicate several interesting points. First, in general the estimated sum of the coefficient becomes larger in the 1973–78 period. Second, R^2 of the call rate equations increases for all cases in the second period. By contrast, it decreases without exception for the bond rate equations. Third, though tables do not report, the estimates of the serial correlation of error terms become smaller in the second period. For example, in the bond rate equation with 30 month lags C. P. I., ρ reduces from 0.99 to 0.67. For formal test of the stability of the equations, the Chow-test (Chow, 1960) was conducted, and the results are contained in the last columns of the tables. F-values are highly significant for all bond rate equations, and suggest structural change of the equations. In the call rate equation, the situation is a tie; three are significant and the other three are insignificant. However, considering the large increase in the sum of the coefficient and F-values, it would be safe to conclude that the call rate equation with C. P. I. as a measure of inflation experienced a structural shift in the second period. As noted above, interest rates have become more responsive to price changes in recent years. In the United States Yohe and Karnosky (1969) did a preliminary test of the hypothesis

Figure 2. Change of Lag Distribution

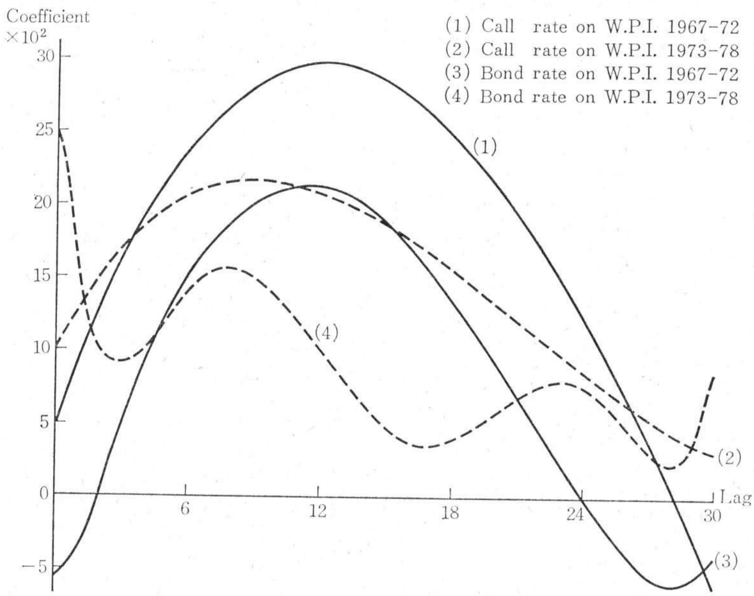


Table 3A. Structural Change Test of Call Rate Equation

	Length of lag	1967–1972	1973–1978	F-statistic
C. P. I.	18	0.60 (0.970)	4.97 (0.988)	$F_{51}^{71}=1.99$*
	24	−0.48 (0.972)	5.97 (0.989)	$F_{45}^{71}=2.11$*
	30	1.75 (0.975)	4.95 (0.989)	$F_{39}^{71}=1.57$
W. P. I.	18	3.70 (0.973)	2.83 (0.989)	$F_{51}^{71}=1.71$**
	24	2.70 (0.971)	4.07 (0.992)	$F_{45}^{71}=1.12$
	30	5.58 (0.975)	4.51 (0.991)	$F_{39}^{71}=1.20$

Table 3B. Structural Change Test of Bond Rate Equation

	Length of lag	1967–1972	1973–1978	F-statistic
C. P. I.	18	−0.83 (0.973)	2.65 (0.942)	$F_{51}^{71}=6.65$*
	24	0.99 (0.973)	3.83 (0.949)	$F_{45}^{71}=5.35$*
	30	0.42 (0.975)	4.14 (0.943)	$F_{39}^{71}=5.34$*
W. P. I.	18	0.90 (0.972)	1.67 (0.954)	$F_{51}^{71}=4.90$*
	24	3.89 (0.977)	2.42 (0.961)	$F_{45}^{71}=4.78$*
	30	2.64 (0.975)	2.76 (0.961)	$F_{39}^{71}=3.96$*

Note: Values in parentheses are R^2 of the regression.
* significant at one percent level.
** significant at five percent level.

that institutional changes both hasten and magnify the effects of price level changes on interest rates. To do so, they divided the total period into two periods, and found a much larger price expectations effect in the latter period. Cargill (1976) reported that interest rates have not responded to anticipated price changes during the 1950's, but that price change coefficients are highly significant in the 1960's. He interpreted this result as reflecting the different variability in anticipated price changes. One possible explanation for our result can be found in the change of monetary policy by the Bank of Japan. The monetary authority began to abolish or relax various restrictions on financial transactions and then interest rates could reflect more easily the market forces than before. This kind of change would enable interest rates to react more freely to the shift in people's anticipated inflation. If we interpret the positively correlated movements in error terms as reflecting the influence of monetary authority's intervention, reduction in the magnitude of serial correlation coefficient provides additional support for the suggested interpretation.

III. Liquidity Preference

So far our estimating equations assume equation (4) as a determination of real interest rate. In this part the basic equation (4) is replaced by the Keynesian liquidity preference theory. According to this theory, the interest rate is determined in the money market by the equilibrium condition for demand and supply of money. If no inflation is expected, this nominal rate is identical with real rate. Empirical studies have generally analyzed the liquidity preference function as a demand for money function. However, since the money supply has been regarded as a exogenous variable in the conventional Keynesian models, the causality interpretation of the assumed relationship between the quantity of money, the level of income, and the bond rate of interest would require to treat interest rate as a "dependent" variable. We regard the liquidity preference function as defining the bond rate at which investors are satisfied to hold the quantity of money supplied. Thus our empirical equation takes the form:

$$i_t=\alpha+\beta y_t+\gamma\left(\frac{M}{p}\right)_t+\sum_{i=0}^{n} w_i\frac{\Delta p_{t-i}}{p_{t-i}}+u_t. \quad (6)$$

The nominal money supply used in this study is the sum of currency plus demand deposits. The real money supply was obtained by dividing M_1 by the consumer price index. As monthly data of real GNP are not available, the index of industrial production published by the Ministry of In-

Table 4. Bond Rate Equation including Real Income, Money Supply and Expected Inflation

Expected Inflation	Constant	Income	Money	Sum	R^2	S. E.	D. W.
C. P. I (18)	34.270 (1.84)	0.294 (0.65)	−2.154 (−1.44)	0.72 (1.44)	0.947	0.32	1.60
C. P. I (24)	40.280 (3.79)	0.116 (0.27)	−2.714 (−3.09)	2.40 (5.64)	0.953	0.31	1.83
C. P. I (30)	32.363 (2.03)	0.023 (0.05)	−1.988 (−1.53)	1.04 (1.80)	0.950	0.32	1.68
W. P. I (18)	33.977 (2.77)	0.039 (0.10)	−2.120 (−2.13)	1.62 (5.81)	0.959	0.28	1.76
W. P. I (24)	37.565 (4.65)	0.053 (0.14)	−2.441 (−3.66)	2.37 (9.46)	0.965	0.26	1.94
W. P. I (30)	40.713 (5.42)	0.183 (0.48)	−2.713 (−4.34)	2.52 (9.25)	0.964	0.27	1.90

Note: The sample period is 1976 through 1978. Income data are seasonally unadjusted index of industrial production (1970=1.0). Real money supply is seasonally adjusted end of month M_1 deflated by the C. P. I. deflator. Values in parentheses are t-ratios.

ternational Trade & Industry was used as a proxy for real GNP.

Table 4 reports the results for the bond rate equation. In the call rate equation, the estimates of coefficients of income and money variables turned out to have the wrong sign and to be insignificant for most equations. Thus the hypothesis that the real interest rate depends on liquidity preference is undoubtedly rejected. The results in table 4 indicate that the coefficients of real money supply are significantly different from zero. Though the coefficients of income variable have correct sign, they are insignificant at conventional level. In addition, the lag patterns of past inflation do not change substantially from those reported earlier in tables 2. If the liquidity preference theory is correct, then our results suggest that the economy has been on the "Keynesian liquidity trap" region of the *LM* curve. But roughly speaking, the economy has maintained full employment over the period under consideration and presumably has been on the "classical" region. Consequently, our results are not consistent with the liquidity preference theory of real interest determination. Though we got mixed results for the bond rate equation, it would be somewhat interesting to reduce the implied movements in real interest rate from the estimated equations and this experiment will be studied in section V.

IV. Money and Interest Rate

We now return to the original formulation (5), and consider it from a more fundamental point of view. More specifically, we regard it as a "spuruous" relation between interest rate and past inflation reflecting the causal relation between money supply and interest rate.

In his 1967 presidential address before the American Economic Association (Friedman, 1968), Friedman criticized the interest rate pegging policy. He argued that though the monetary authority can reduce interest rates by increasing money supply in the short run, it cannot keep interest rates at a low level for a long period. According to Friedman, "The *initial* impact of increasing the quantity of money at a faster rate than it has been increasing is to make interest rates lower for a time than they would otherwise have been. But this is only the beginning of the process not the end" (p. 6). The increase in money supply shifts the *LM* curve to the right and for some time the interest rate goes down. At the same time the aggregate demand increases and raises prices, which reduces real money supply and interest rate moves back to the initial level. Furthermore interest rate tends to overshoot that level due to the price expectations effect. Quoting again Friedman, "A fourth effect (inflationary expectations effect), when and if it becomes operative, will go even farther, and definitely mean that a higher rate of monetary expansion will correspond to a higher, not lower, level of interest rates than would otherwise have prevailed" (p. 6).

The above discussion suggests to explain the movements in interest rate by the distributed lag of the rate of change in money supply rather than by the that of inflation.

The suggested equation was estimated by the same technique and for the same period as before. As a measure of monetary expansion, seasonally adjusted changes in M_1 (sum of the cash currency in circulation and the deposit money) from previous month

Table 5. Lag Distribution of Money Supply

−0	0.15(0.06)	−3.13(−1.36)
−1	−2.80(−1.21)	−6.50(−1.95)
−2	−5.21(−2.09)	−5.73(−1.57)
−3	−7.12(−2.57)	−3.29(−0.92)
−4	−8.56(−2.81)	−0.70(−0.20)
−5	−9.57(−2.94)	1.20(0.33)
−6	−10.17(−3.01)	2.13(0.61)
−7	−10.40(−3.04)	2.18(0.66)
−8	−10.29(−3.05)	1.63(0.54)
−9	−9.87(−3.03)	0.87(0.30)
−10	−9.17(−2.99)	0.29(0.10)
−11	−8.23(−2.91)	0.20(0.06)
−12	−7.08(−2.79)	0.77(0.24)
−13	−5.74(−2.58)	2.03(0.64)
−14	−4.26(−2.21)	3.81(1.25)
−15	−2.66(−1.60)	5.83(1.92)
−16	−0.98(−0.65)	7.68(2.42)
−17	0.75(0.49)	8.88(2.63)
−18	2.50(1.46)	9.01(2.57)
−19	4.24(2.11)	7.80(2.24)
−20	5.94(2.50)	5.23(1.54)
−21	7.56(2.73)	1.71(0.49)
−22	9.07(2.88)	−1.73(−0.47)
−23	10.44(2.97)	−3.26(−0.95)
−24	11.64(3.03)	−0.04(−0.02)
−25	12.63(3.07)	
−26	13.38(3.10)	
−27	13.87(3.12)	
−28	14.05(3.12)	
−29	13.91(3.11)	
−30	13.39(3.09)	
−31	12.48(3.04)	
−32	11.14(2.95)	
−33	9.34(2.76)	
−34	7.05(2.38)	
−35	4.23(1.61)	
−36	0.85(0.33)	
Constant	5.13(1.47)	7.70(6.06)
Mean lag	59.59(2.93)	22.14(1.94)
Sum	0.67(1.93)	0.37(1.18)
S. E.	0.33	0.32
R^2	0.981	0.947
D. W.	1.16	1.51
ρ	0.99(97.8)	0.98(56.4)
Degree of Polynomial	3	6

Note: The first column corresponds to the call rate equation, the second to the bond rate equation. See also note to table 1.

were used. The results are reported in table 5 for both the call rate and the bond rate. The shape of the distributions shows negative and decreasing values at the outset and change to positive values at 16 month lags for call rate and 4 month lags for bond rate. Lag coefficients become negative once again at the end of the distribution but t-ratios are very low. Thus the estimated lag distributions agree well with the Friedman's implied shape. Note that though general patterns are almost same for both rates, the call rate showed more sensitive and prolonged reactions to changes in money supply than the bond rate did. For formal test of the hypothesis that the current and lagged increase in money supply have no effect on the interest rate, F-values were calculated. The test statistics are $F^{37}_{105}=145.7$ for call rate and $F^{25}_{117}=83.6$ for bond rate and allow one to reject the null hypothesis.

These results provide clear explanation for remarkable movements in call rate and bond rate observed in past ten years. As a first step, we note the average growth rate of money supply per month; 1971: 2.19, 1972: 1.84, 1973: 1.33, 1974: 0.95, 1975: 0.93, 1976: 1.00. During 1971 and 1972 the call rate fell by 3 percent points due to rapid increase in money supply. And in the mid-1972 it reached nearly 4% (See figure 1 above). This is the initial effect of the monetary expansion. Such increase in money supply produced "excess liquidity" and stimulated aggregate demand.

As a natural result, the inflation was accelerated and the situation was further worsend by the oil curtailment and the oil price increase which shifted the aggregate supply schedule to the left. The high inflation produced expectations that prices will continue to rise. This expectations effect pushed the call rate up to 13% in 1974. From 1974 on, the growth rate of money supply returned to the normal level and interest rates declined. Thus the estimated relation between interest rates and monetary expansion can explain the observed movements in the interest rates.

V. Decomposition of Interest Rate Movements

Following Feldstein and Eckstein (1970), we decomposed the movement in the bond rate into the effects of "real" interest rate and price expectations. To do so, the fifth equation in table 4 was used, because it performes best among reported equations. The "real" rate is assumed to be related to the level of industrial production (proxy for GNP) and real money supply. More specifically it is given by $37.565+0.053y_t-2.441(M/p)_t$. The expected inflation is generated by the fixed coefficients distributed lag of past inflation. The fitted value is the sum of the liquidity component and the expectation component.

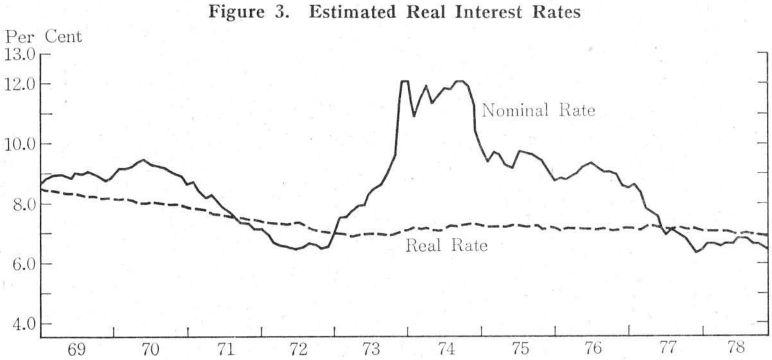
Table 6. Decomposition of the Bond Rate

Period	Liquidity	Expectation	Fitted	Actual
1967: 6	8.919	−0.930	7.989	7.920
1967: 12	8.824	−0.537	8.288	8.300
1968: 6	8.679	0.059	8.739	8.890
1968: 12	8.561	−0.145	8.416	8.370
1969: 6	8.367	0.594	8.961	8.860
1969: 12	8.126	0.824	8.951	8.770
1970: 6	8.006	1.224	9.231	9.450
1970: 12	7.984	0.812	8.796	8.900
1971: 6	7.665	0.468	8.132	8.010
1971: 12	7.449	−0.119	7.330	7.140
1972: 6	7.303	−0.635	6.668	6.500
1972: 12	7.041	−0.219	6.821	6.530
1973: 6	6.923	1.328	8.251	7.940
1973: 12	6.978	4.029	11.015	12.070
1974: 6	7.095	4.709	11.816	11.600
1974: 12	7.260	4.071	11.328	11.130
1975: 6	7.206	2.013	9.219	9.180
1975: 12	7.161	1.953	9.114	9.050
1976: 6	7.117	1.944	9.061	9.260
1976: 12	7.097	1.782	8.879	8.590
1977: 6	7.217	0.278	7.495	7.520
1977: 12	7.099	−0.437	6.662	6.360
1978: 6	7.026	−0.524	6.502	6.670
1978: 12	6.909	−0.310	6.599	6.430
Mean	7.613	0.866	8.496	8.496

Note: The last row shows the average of each variable for total sample period. The sums of Liquidity and Expectation are not exactly equal to Fitted due to rounding errors.

Table 6 lists the values of both components, the fitted and the actual interest rate. To save space, the values corresponding to June and December are given. Figure 3 contains the nominal bond rate from January 1969 to December 1978 and estimated annual "real" rate series. Over this period increase in nominal money supply and relatively stable price level raised real money supply continually and in turn caused "real" rate to decline gradually. Thereafter, though the nominal rate changed very substantially, the "real" rate rose a little bit and stayed almost the same level. Over the period the quantity of money increased steadily but it did not rise by enough to offset the rapid inflation, with the consequence that the real money supply actually fell from May 1973 and returned to its previous peak in

Figure 3. Estimated Real Interest Rates



late 1978. The steady growth of industrial production could not raise "real" rate distinctly because of its insignificant contribution to the equation. It is very clear from the figure that, as suggested in the previous section, the drastic increase in nominal rate from late 1973 until late 1974 can be explained almost by high inflationary expectations. For example in 1974: 6, 41 percent of the level of interest rate consists of the expectation component. The last row of the table implies that the expectations effect explains 11 percent of the interest rate level over the whole sample period.

VI. Conclusions

In this study the hypothesis that the nominal interest rate is a sum of a real rate and the expected rate of inflation was tested for Japanese data from 1967 to 1978. First, the simple model which incorporates a Fisherian distributed lag measure of anticipated inflation was considered. Then the model was extended to take into account the influence of real output and real money supply on the real interest rate. Finally, the relation between money and interest was tested by the one-sided regression of interest rate on change in money supply.

It was found that unlike most of the U. S. studies of the subject, price level changes since 1967 have evidently come to have a prompt and substantial effect on price expectations and nominal interest rate. Considering the rapid inflation over the period on which the present study has been based, this is not puzzling. Most significant finding is that price expectations effect, rather than real rate, accounts for nearly all the variation in nominal rate since 1967. Furthermore, the addition of variables to the equations to account for the real rate component does not appreciably alter these findings. Our results also indicate that there are many differences between the call market and the bond market including the form of lag coefficient, the real rate of return, and the stability of the equation, etc. These results should be no surprise considering the institutional and functional differences between the two. The estimated relation between money supply and interest rate implies, as Friedman (1968) stressed, that the monetary authority can not peg the market interest rate at low level by increasing money supply for a long time. Thus it would not be reasonable for the monetary authority to use the nominal interests as a monetary policy indicator. The danger of using interest rates as a indicator of whether monetary policy is "tight" or "easy" has been stated by Friedman:

> …Paradoxically, the monetrry authority could assure low nominal rates of interest —but to do so it would have to start out in what seems like the opposite direction, by engaging in a deflationary monetary policy. Similarly, it could assure high nominal interest rates by engaging in an inflationary policy and accepting a temporary movement in interest rates in the opposite direction (p. 7).

All in all, our results provide empirical support for Friedman's policy recommendations.

(University of Pennsylvania)

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