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Satake, Mitsuhiko

(出版者 / Publisher)
Institute of Comparative Economic Studies, Hosei University / 法政大学比較経済研究所

(雑誌名 / Journal or Publication Title)
Journal of International Economic Studies / Journal of International Economic Studies

(巻 / Volume)
19

(開始ページ / Start Page)
63

(終了ページ / End Page)
75

(発行年 / Year)
2005-03

(URL)
https://doi.org/10.15002/00002501

Journal of International Economic Studies (2005), No. 19, 63–75

An Empirical Study on Testing the Fisher Hypothesis in Japan

Mitsuhiko Satake
Faculty of Economics, Ryukoku University

Abstract

The objective of this paper is to conduct an empirical study on testing the Fisher hypothesis in Japan. There are few studies centering on testing the Fisher hypothesis in Japan. There are several techniques that can be used to test the Fisher hypothesis. The developments in the time series analysis have led to several new tests of the Fisher hypothesis. Thus, we utilize a cointegration approach and apply two testing methods based on the VAR approach in order to examine the robustness of the results for the Fisher hypothesis in Japan. The main finding of the paper is that the partial Fisher effect, which partially supports the Fisher hypothesis, is detected in Japan. The period for this study contains 1990s, i.e. the period for the development of IT industry, which does not affect this result.

I. Introduction

The Fisher hypothesis is one of the key concepts in macroeconomics. It proposes a one-for-one relationship between the nominal interest rate and inflation rate, i.e. a 1% change in the inflation rate induces a 1% change in the nominal interest rate. The definition of the Fisher equation is that nominal interest rate = real interest rate + expected inflation rate. Under a constant real interest rate and the rational expectations, it is possible to forecast the future inflation rate, on average, using information contained in the nominal interest rate, based on the Fisher equation. In order to predict future inflation, it is useful to examine whether or not the Fisher hypothesis is supported.

Since the seminal work by Fama (1975), there have been many empirical studies on the Fisher hypothesis in the U.S., other OECD countries, and developing countries[1]. However, there are few recent empirical studies centering on testing the Fisher hypothesis in Japan.

Early tests of the Fisher hypothesis in Japan have been carried out based on Fama's method, e.g. Kuroda (1982) and Yamada (1991), and more recent ones based on Mishkin's (1990) method, e.g. Yamada (1991) and Bank of Japan (1994). Fama (1975) estimates the regression equation of the inflation rate on nominal interest rate by OLS, then tests whether the coefficient of the slope is one. The evidence suggests that in short-term money markets in Japan, the Fisher hypothesis is not supported. Mishkin (1990) estimates the regression equation expressed as the relationship between the term structure of nominal interest rates and the difference of inflation rates. The evidence also suggests that the Fisher hypothesis is

Email: satake@econ.ryukoku.ac.jp
[1] See Cooray (2002) as a brief survey.

not supported, though for shorter maturities, the interest rate spread has information that can be used for the prediction of the inflation rate[2].

In accordance with recent developments in the time series analysis, the method for testing the Fisher hypothesis has changed, and the cointegration analysis and VAR approaches are mainly applied. Engsted (1995) uses a VAR model based on the restriction of the present value model and finds that the long-term nominal interest rate reflects expectations of the long-term inflation rate in Japan, i.e. the Fisher hypothesis is supported. Kamae (1999) applies a cointegration approach to Japanese data, and also obtains the result that the full Fisher hypothesis is supported. However, the result of this test is not robust, and is sensitive to the sample period or method.

The Fisher hypothesis is closely related to financial markets' efficiency, which is considered to be affected by the development of information technology (IT) since 1990s. The existing literature for Japan does not contain the period for the development of IT industry. This paper examines the robustness of the Fisher hypothesis in Japan using a cointegration approach and two VAR approaches, extending the period to 2002. The outline of the paper is as follows. In Section II, we briefly explain the testing methods applied in the paper. In Section III, the methods referred to above are applied to Japanese quarterly data during the period between 1971 and 2002, and two sub-periods, in order to test whether or not the Fisher hypothesis is supported. Finally, our summary and conclusions are described in Section IV.

II. Methodology

II-1 The basic idea of the test

Fama (1975) indicates that future inflation can be predicted by testing the hypothesis that the market should predict future inflation rates exactly as stochastic expectations if short-term financial markets are efficient in the sense of using all information available.

The Fisher equation is expressed by the following equation (1).

$$E_t r_t = R_t - E_t \pi_t \tag{1}$$

where r_t, R_t and π_t are the real interest rate, nominal interest rate, and inflation rate at period t to (t + 1), respectively. E_t expresses the expectation at period t. Under the assumption of a constant real interest rate and the rational expectations, the following equation (2) is derived from equation (1).

$$\pi_t = \alpha + \beta R_t + u_t \tag{2}$$

where $\alpha = -r$, $\beta = 1$, u_t is an error term. We can test whether or not the real interest rate is constant by testing $\beta = 1$, and whether the market is efficient or not by testing whether there is no serial correlation of the residual series. When the above assumptions are satisfied in equation (2), we find that the Fisher hypothesis is completely satisfied, and that nominal interest rates contain complete information about the future rate of inflation.

If the nominal interest rate R_t and inflation rate π_t are stationary, we can test the hypothesis by estimating equation (2) by OLS. However, if these two variables are not stationary, it is not appropriate to directly apply Fama's (1975) method to the OLS estima-

[2] See Satake (1997).

tion. Several methods for testing the Fisher hypothesis are proposed in accordance with the recent developments in modern time series techniques. In the following part, we concisely explain the testing methods that are applied in this paper.

II-2 Cointegration analysis

Most recent empirical studies testing the Fisher hypothesis apply cointegration analysis. On the one hand, they generally analyze the cointegrating relationship between the inflation rate π_t and nominal interest rate R_t in order to test the long-run Fisher hypothesis, when the inflation rate π_t and nominal interest rate R_t are subject to an I (1) process, as they usually are. On the other hand, an error correction model is estimated and the Granger causality test is conducted in order to find the short-run Fisher relationship. As the Fisher hypothesis is generally a long-run relation, we confine our study to the long-run approach, i.e. cointegration analysis.

Equation (2) states that the Fisher hypothesis is supported if $\beta = 1$ under the assumption of that expectations are rational and that α is constant, i.e. the real interest rate is constant. Therefore, in the context of cointegration analysis, if the inflation rate π_t and nominal interest rate R_t are subject to the I (1) process, they are cointegrated, and the values of the cointegrating vector are $(1, -1)$, then the long-run Fisher hypothesis is supported. In this case, the relationship where the nominal interest rate R_t moves one-for-one with the rate of inflation π_t is called the 'full Fisher effect.' However, the result of testing the Fisher hypothesis is useful from the perspective of forecasting the inflation, even if $0 < \beta < 1$. This relationship is called a 'partial Fisher effect' if the cointegrating vector is $(1, -\beta)$ and $0 < \beta < 1$, Moreover, if the nominal interest rate R_t and inflation rate π_t are I (1), and they are not cointegrated, then this relation implies the absence of a long-run Fisher effect.

II-3 Tests using the VAR model

There are many studies using the VAR model to test the Fisher hypothesis. We explain two methods — Engsted (1995) and Olekalns (1996) — which are applied in this paper.

II-3–1 Testing method of Engsted (1995) using a present value model

Engsted (1995) tests the long run Fisher hypothesis imposing the restrictions derived from the present value model of Campbell and Shiller (1987). Let $S_t = R_t - b\pi_t$, where R_t is nominal interest rate and π_t is inflation rate, and b is the discount rate, which is equal to $e^{-r} \approx (1 + r)^{-1}$. r is the real interest rate. If R_t and π_t are subject to I (1), S_t and $\Delta\pi_t (= \pi_t - \pi_{t-1})$ are stationary, i.e. I (0). Then consider the following VAR (p) model.

$$\begin{bmatrix} \Delta\pi_t \\ S_t \end{bmatrix} = \begin{bmatrix} a(L) & b(L) \\ c(L) & d(L) \end{bmatrix} \begin{bmatrix} \Delta\pi_{t-1} \\ S_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \tag{3}$$

Adding the constraint of the present value model to the parameters in (3), the following relation is obtained.

$$\begin{aligned} \Delta\pi_t &= a_1\Delta\pi_{t-1} + \ldots + a_p\Delta\pi_{t-p} + b_1 S_{t-1} + \ldots + b_p S_{t-p} + u_{1t} \\ S_t &= -a_1\Delta\pi_{t-1} - \ldots - a_p\Delta\pi_{t-p} + (b^{-1} - b_1)S_{t-1} - b_2 S_{t-2} - \ldots - b_p S_{t-p} + u_{2t} \end{aligned} \tag{4}$$

Moreover, adding the two regression equations in VAR model (4), the following relation is obtained.

$$X_t = S_t - b^{-1}S_{t-1} + \Delta\pi_t = u_{1t} + u_{2t} \tag{5}$$

Based on the present value model, X_t is an innovation and is uncorrelated with the information known at period $(t-1)$. If X_t is regressed on $\Delta\pi_{t-j}$ and S_{t-j}, $j = 1, \ldots, p$, and all of the coefficients are zero, the constraint of the present value model holds, i.e. the Fisher hypothesis is supported. This test can be conducted using the F-statistic test under the constraint that all coefficients are zero, using the results of the OLS estimation.

II-3–2 Testing method of Olekalns (1996)

Olekalns (1996) examines the Fisher relationship in Australia using a procedure based on vector autoregressive innovations. This technique yields consistent estimates of structural parameters in models featuring rational expectations. Under the rational expectations, the Fisher hypothesis is formulated as follows:

$$R_t = \rho + \beta E(\pi_{t+1}|I_t) + \varepsilon_t \tag{6}$$

where R_t is the nominal interest rate at period t to $(t+1)$, ρ is the real interest rate, which is assumed to be constant, $E(\pi_{t+1}|I_t)$ is the expected inflation rate of π_{t+1} at period t, conditional on the information for the current period, and ε_t is an error term. The strong form condition of the Fisher hypothesis is that $\beta = 1$. In order to be available to test the Fisher hypothesis, we need to estimate the expected inflation rate. In Olekalns, the expected inflation rate is estimated from the VAR (q) model of the inflation rate π_{t+1} and R_t in the following equation (7).

$$\begin{bmatrix} \pi_{t+1} \\ R_t \end{bmatrix} = \begin{bmatrix} a_{11}^1 & a_{12}^1 \\ a_{21}^1 & a_{22}^1 \end{bmatrix} \begin{bmatrix} \pi_t \\ R_{t-1} \end{bmatrix} + \begin{bmatrix} a_{11}^2 & a_{12}^2 \\ a_{21}^2 & a_{22}^2 \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ R_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} a_{11}^q & a_{12}^q \\ a_{21}^q & a_{22}^q \end{bmatrix} \begin{bmatrix} \pi_{t-q+1} \\ R_{t-q} \end{bmatrix} + \begin{bmatrix} e_t^\pi \\ e_t^R \end{bmatrix} \tag{7}$$

From equations (6) and (7), by calculating the expectations of R_t and the expected inflation rate $E(\pi_{t+1}|I_t)$, the following equation is derived.

$$R_t - E(R_t|I_{t-1}) = \beta[E(\pi_{t+1}|I_t) - E(E(\pi_{t+1}|I_t)|I_{t-1})] + \varepsilon_t \tag{8}$$

As R_t and π_{t+1} are assumed to be I (1), the variables both on the left hand side and in the brackets on the right hand side in (8) are stationary, and can be estimated, because the expected values are estimated from (7). We can test the hypothesis that $\beta = 1$ based on equation (8) using the t-statistic of the coefficient estimated by OLS.

III. Findings

III-1 Data and plots of interest rates and the inflation rate

We apply the tests described above to Japanese quarterly data during the period between 1971: 2 and 2002: 4. CPI, all averaged, is used as a price index. We use the three-month CD rate[3], which is released monthly, as a nominal interest rate. These figures are transformed into quarterly figures by calculating the average. The inflation rate DP is the one-lead difference of the log of the quarterly CPI. In order to accommodate the testing method to the formulation of the Fisher equation, a different calculation than usual is used for the inflation rate. For example, the inflation rate in the first quarter of 2000 is defined as

[3] We also consider the three-month Gensaki rate. Gensaki is repurchase agreement.

the rate of change between the figures for the first quarter and the second quarter of 2000[4].

The plots of two nominal interest rates, i.e. the three-month CD rate (CD) and the three-month Gensaki rate (GEN), and the inflation rate (DP) are shown in Figure 1. As the two interest rates are highly correlated, only the CD rate is applied to the tests. The inflation rate (DP) calculated as a one-period difference of the CPI fluctuates turbulently, appearing to precede nominal interest rates by a few quarters. Figure 2 is a plot of nominal interest rates and the inflation rate (DP4), calculated as the difference between the log of the current CPI and its fourth lag. It is found that DP4 moves smoothly and is coincident to interest rates. Therefore, the future inflation rate can be predicted based on the past inflation rate. We use both DP and DP4 as the inflation rate when performing cointegration tests to examine the Fisher hypothesis, because the movement of DP contains too much noise. However, we do not use DP4 when the two VAR approaches are applied, because their formulations are not based on the difference between the current price level and its fourth lagged one.

Figure 1 and Figure 2 illustrate the movement of the two series. Although the nominal interest rate was volatile in the 1970s because of the two Oil Shocks, it remains at between 0% and 8% in the period overall, with the exception of the period of the Oil Shocks and in the early 1980s. After 'the Bubble era', Japan quickly entered a period of low interest rates. The inflation rate (DP4) is influenced by the two Oil Shocks between the middle of the 1970s and at the beginning of the 1980s. After the second Oil Shock, it declines below 4%. The relationship between the nominal interest rate and inflation rate is peculiar in the 1970s, because of the influence from the Oil Shocks. Therefore, we also conduct the tests for the two sub-periods, i.e. 1978: 1 to 2002: 4 (referred to as period (2)) and 1980: 1 to 2002: 4

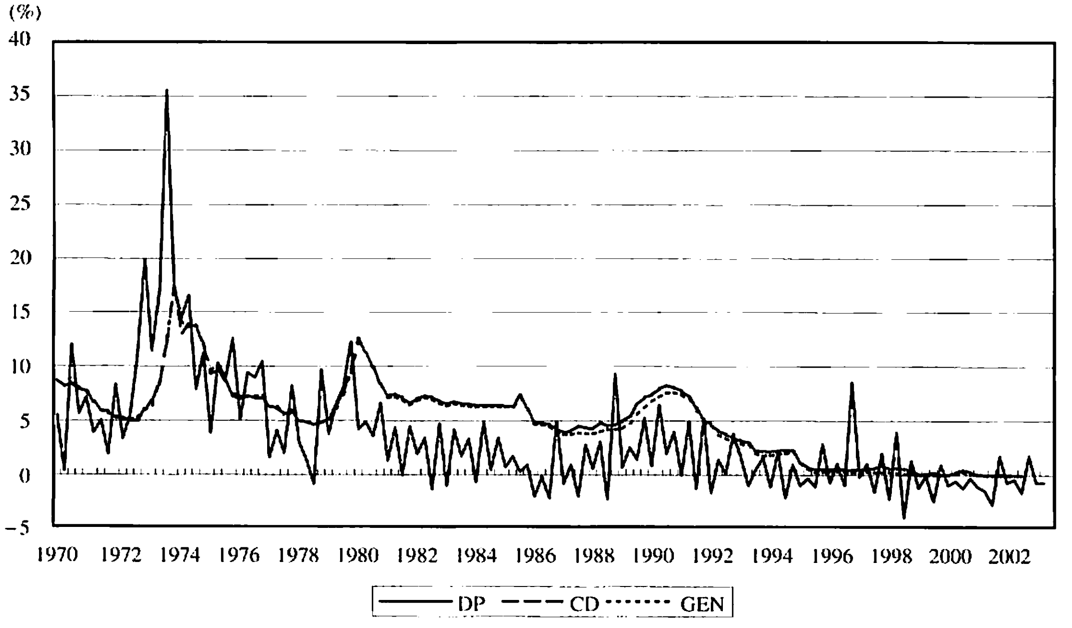

Figure 1. Nominal Interest Rates and Inflation Rate in Japan

[4] The inflation is calculated as the first log diference, and multiplied by 4 in order to adjust it to annual rate.

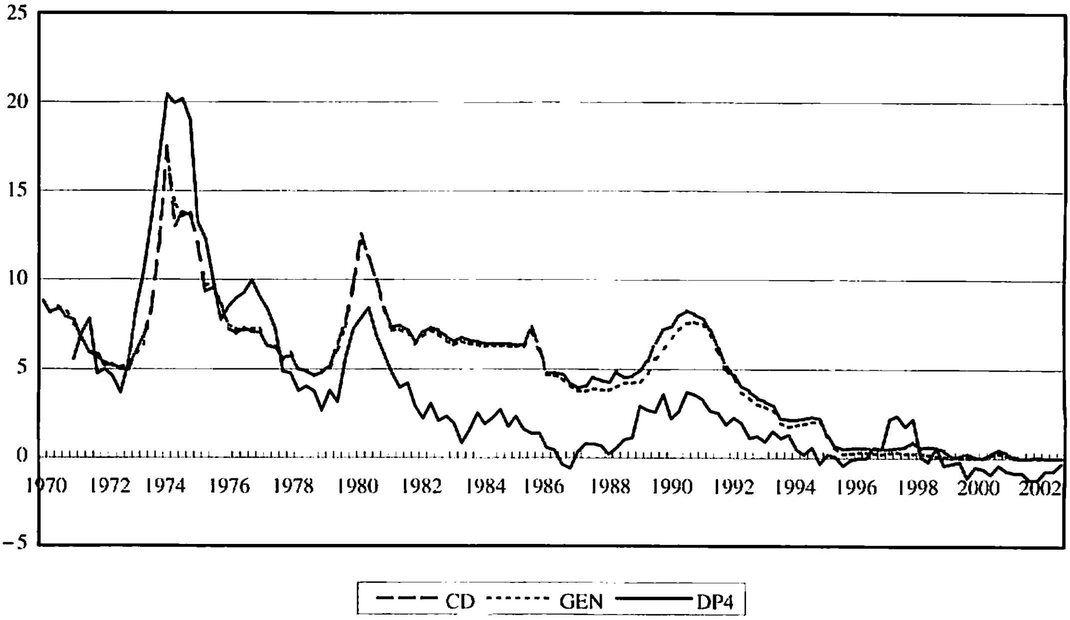

Figure 2. Nominal Interest Rates and Inflation Rate in Japan (case where the inflation rate is calculated as the difference between current and four lag price levels)

(referred to as period (3))[5]. We also refer to the full sample 1971: 2–2002: 4 as period (1).

Table 1 shows the basic statistics for the nominal interest rate (R) and inflation rate (DP and DP4). Table 1(1) shows the results for the entire period, 1971: 2 to 2002: 4. The mean of the nominal interest rate is 5.0%, and that of the inflation rate (DP) is 3.3%. Therefore, the average ex post real rate of interest is about 1.7%. The coefficient of the variation for the inflation rate DP (1.60), the standard deviation divided by the mean, is larger than that for the nominal interest rate R (0.71), i.e. the inflation rate is more volatile than nominal interest rate. The correlation coefficient between R and DP is 0.59, and that between R and DP4 is 0.82. The basic statistics of the two sub-samples are shown in Table 1 (2) and (3). The inflation rates are lower than that in the full sample, because these periods do not contain the first Oil Shock. With the exception of this point, the results in the sub-periods (2) and (3) are nearly identical to that in the full sample.

III-2 Unit root tests

We conduct three unit root tests — weighted symmetric (WS) test, Dickey and Fuller (DF) test, and Phillips and Perron (PP) test — using the TSP (Time Series Processor) package. Each test is conducted with regressors, both without and with a trend term. The lag length is selected by the AIC. This criterion is also applied to cointegration tests below.

The results of the unit root tests are shown in Table 2. The values in the table show p-values for each statistic. In the case where a linear trend term is included, some tests on the interest rate R reject the null hypothesis that R has a unit root. However, all of tests on the interest rate R fail to reject the null hypothesis at a 5% significance level in each period, in

[5] In this situation, we should try to detect the structural break points. However, meaningful results are not obtained using some structural change tests. Therefore, we examine the three sample periods above.

Table 1. Basic Statistics

(1) 1971: 2–2002: 4

Variable	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
R	5.03	3.55	0.01	17.52	0.49	0.49
DP	3.34	5.35	−3.53	31.30	1.92	5.71
DP4	3.50	4.58	−1.22	20.45	1.92	3.45

Correlation Coefficient between R and DP = 0.59
Correlation Coefficient between R and DP4 = 0.82

(2) 1978: 1–2002: 4

Variable	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
R	4.15	3.08	0.01	12.59	0.17	−0.82
DP	1.56	3.00	−3.53	11.83	1.02	1.24
DP4	1.68	2.02	−1.22	8.43	1.06	1.31

Correlation Coefficient between R and DP = 0.49
Correlation Coefficient between R and DP4 = 0.82

(3) 1980: 1–2002: 4

Variable	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
R	4.03	3.17	0.01	12.59	0.26	−0.88
DP	1.26	2.72	−3.17	11.83	1.23	2.44
DP4	1.48	1.97	−1.22	8.43	1.35	2.38

Correlation Coefficient between R and DP = 0.50
Correlation Coefficient between R and DP4 = 0.83

the case where a linear trend term is not included. The results on DP, with the exception of the WS tests, indicate that DP is stationary, though DP4 is nearly found to have a unit root in the full sample. The results for the two sub-samples are nearly the same as the full sample. On the other hand, results on the first differences of these variables are considered as stationary from most of the tests. Though some results suggest that DP and DP4 are not I (1), the nominal interest rate R and inflation rates (DP and DP4) are treated as I (1) in all three periods for the subsequent analyses.

III-3 Cointegration tests

The results for the cointegration tests between R and DP are shown in Table 3. First, in the case of no deterministic trend, both the EG (Engle and Granger) and Johansen tests show that there is no cointegration in each sample, as the p-values of the test statistics are far higher than 5%[6]. In the case where a trend term is included, both tests detect cointegration in the full sample (1) and sub-sample (2), though the Johansen test only shows cointegration in sub-sample (3). The conditions for the Fisher hypothesis are that nominal interest rate and inflation rate be cointegrated, and that the cointegrating vector be (1, −1). In the EG tests in

[6] In the Johansen test in Table 3 and Table 4, when p-value of the hypothesis H_0: $r = 0$ is lower than the 5% signicance, the null hypothesis that there is no cointegration is rejected.

Table 2. The Results of Unit Root Tests

(1) 1971: 2–2002: 4

A. Level without Trend

	R	DP	DP4
WS	0.531	0.736	0.486
DF	0.686	0.000	0.606
PP	0.351	0.000	0.234

B. Level with Trend

	DR	DP	DP4
WS	0.031	0.255	0.248
DF	0.004	0.012	0.222
PP	0.089	0.000	0.118

C. First Difference without Trend

	R	DP	DDP4
WS	0.000	0.000	0.093
DF	0.000	0.000	0.000
PP	0.000	0.000	0.000

D. First Difference with Trend

	R	DP	DDP4
WS	0.000	0.000	0.418
DF	0.000	0.000	0.004
PP	0.000	0.000	0.000

(2) 1978: 1–2002: 4

A. Level without Trend

	R	DP	DP4
WS	0.490	0.335	0.448
DF	0.657	0.087	0.124
PP	0.664	0.000	0.229

B. Level with Trend

	DR	DP	DP4
WS	0.027	0.077	0.047
DF	0.004	0.014	0.071
PP	0.216	0.000	0.122

C. First Difference without Trend

	R	DP	DDP4
WS	0.000	0.000	0.000
DF	0.000	0.000	0.001
PP	0.000	0.000	0.000

D. First Difference with Trend

	DR	DP	DDP4
WS	0.000	0.004	0.002
DF	0.000	0.000	0.005
PP	0.000	0.000	0.000

(3) 1980: 1 –2002: 4

A. Level without Trend

	DR	DP	DP4
WS	0.870	0.848	0.794
DF	0.790	0.132	0.104
PP	0.682	0.000	0.193

B. Level with Trend

	DR	DP	DP4
WS	0.142	0.127	0.231
DF	0.155	0.106	0.239
PP	0.369	0.000	0.291

C. First Difference without Trend

	DR	DP	DDP4
WS	0.000	0.001	0.002
DF	0.002	0.000	0.009
PP	0.000	0.000	0.000

D. First Difference with Trend

	DR	DP	DDP4
WS	0.001	0.004	0.012
DF	0.017	0.001	0.043
PP	0.000	0.000	0.000

Table 3. Cointegration Tests

between R and DP

(1) 1971: 2–2002: 4

A. Engle-Granger (tau) Tests
(Explained Variable: R)

	t-stat.	p-value	COINT Vector	Lag Order
without Trend	−1.242	0.847	−0.394	9
with Trend	−3.894	0.037	−0.100	7

B. Johansen (trace) test

	without Trend	with Trend
H_0:r = 0	5.801	22.491
p-value	0.786	0.013
H_0:r ≦ 1	1.207	2.961
p-value	0.670	0.080
Lag Order	7	8

COINT Vector	(without Trend)		(with Trend)	
	1	2	1	2
R	1.000	1.000	1.000	1.000
DP	−1.509	−0.344	0.308	−0.998

(2) 1978: 1–2002: 4

A. Engle-Granger (tau) Tests
(Explained Variable: R)

	t-stat.	p-value	COINT Vector	Lag Order
without Trend	−1.122	0.877	−0.498	9
with Trend	−4.077	0.022	−0.087	4

B. Johansen (trace) test

	without Trend	with Trend
H_0:r = 0	10.821	21.566
p-value	0.373	0.017
H_0:r ≦ 1	1.346	8.154
p-value	0.652	0.004
Lag Order	4	4

COINT Vector	(without Trend)		(with Trend)	
	1	2	1	2
R	1.000	1.000	1.000	1.000
DP	−2.208	−0.222	−2.142	0.050

(3) 1980: 1–2002: 4

A. Engle-Granger (tau) Tests
(Explained Variable: R)

	t-stat.	p-value	COINT Vector	Lag Order
without Trend	−1.095	0.883	−0.578	7
with Trend	−2.343	0.606	−0.133	7

B. Johansen (trace) test

	without Trend	with Trend
H_0:r = 0	13.911	20.072
p-value	0.165	0.023
H_0:r ≦ 1	1.754	7.834
p-value	0.597	0.004
Lag Order	3	3

COINT Vector	(without Trend)		(with Trend)	
	1	2	1	2
R	1.000	1.000	1.000	1.000
DP	−2.668	−0.263	−2.078	−0.023

the case of a deterministic trend included, the cointegrating vectors (they are referred to COINT Vector in Table 3 and Table 4) in sample (1) and (2) are (1, −0.100) and (1, −0.087) respectively, which are not plausible. In the Johansen tests in the case with a trend term, they are (1, −0.998), (1, 0.050) and (1, −0.023)[7] in each sample, respectively. Therefore, only the vector in the full sample (1) is plausible.

The results for cointegration tests between R and DP4 are shown in Table 4. In all three samples, both without trend and with trend, the results from the EG test show that there is no cointegration relation between nominal interest rate R and inflation rate DP4. However, the results of the Johansen test with trend show that there is cointegration between R and DP4 in the full sample (1), and the p-values of the hypothesis H_0: $r = 0$ are 5.5% in sample (2) and 5.9% in sample (3) respectively. The cointegrating vectors are (1, −0.972) in the full sample (1), (1, 0.006) in sample (2), and (1, −1.022) in sample (3), respectively. The vectors for samples (1) and (3) are plausible.

From the cointegration analysis, we obtain the following results. When a linear trend is incorporated into the model, some of the results from the EG test show cointegration between the nominal interest rate R and inflation rate DP, though not between R and DP4. Using the Johansen tests in this case, we detect cointegration between nominal interest rate R and inflation rates (DP and DP4). The cointegration indicates a stable long-run linear relation between variables. As DP is very volatile, the cointegration test between R and DP is disturbed by the noise of its movements. Therefore, we may be able to conclude that the cointegration is detected by the Johansen test in the case with trend. However, cointegrating vectors in some cases are not close to (1, −1), i.e. $\beta = 1$, and there are some cases where $0 < \beta < 1$. But the cointegration analysis leaves the possibility that the partial Fisher effect is supported in Japan.

III-5 Engsted (1995)'s Method

The results obtained using Engseted's method are shown in Table 5. The results of the test on the constraint of the coefficients are rejected at the 5% significance level for all sample periods[8]. Thus, the constraints from the present value model are not supported, i.e. the Fisher hypothesis is not supported[9]. However, the possibility remains that a partial Fisher effect is supported, because the constraints of the present value model assume the full Fisher effect, and R^2 is not very high.

III-6 Olekalns (1996)'s Method

Table 6 shows the results of the test using Olekalns' (1996) method. In the case of the full sample (1), the coefficient of β is not significantly different from zero; because the estimate of β is 0.059, and the t-value of the null hypothesis $\beta = 0$ is 1.760, which is not significant at the 5% level. However, for the sub-samples, we find that $0 < \beta < 1$, because

[7] There are two cointegrating vectors in the results of the Johansen test like Table 3 and Table 4 in the output of TSP package. This is a two-variable VAR model. When there is a cointegration between the two variables, we have only one cointegration vector. We adopt one vector nearer to (1, −1) as the cointegrating vector here.

[8] In order to conduct the above procedure, we first estimate the VAR model of $\Delta\pi_{t-i}$ and S_{t-j}. The lag length is selected using Schwartz's Baysian information criteria (SBIC). Secondly, the variable X_t is calculated from actual values of S_t, S_{t-1}, and $\Delta\pi_{t-1}$, and b. b is set to 0.97, which is the same as Engsted (1995).

[9] This result is contrary to those of Engsted (1995), as the sample period and the index of nominal interest are different between this study and Engsted (1995).

Table 4. Cointegration Tests

between R and DP4

(1) 1971: 2–2002: 4

A. Engle-Granger (tau) Tests
(Explained Variable: R)

	t-stat.	p-value	COINT Vector	Lag Order
without Trend	−1.322	0.823	−0.633	4
with Trend	−2.420	0.564	−0.395	2

B. Johansen (trace) test

	without Trend	with Trend
H_0:r = 0	3.142	19.354
p-value	0.906	0.033
H_0:r ≦ 1	0.840	1.508
p-value	0.715	0.220
Lag Order	5	4

COINT Vector	(without Trend)		(with Trend)	
	1	2	1	2
R	1.000	1.000	1.000	1.000
DP4	−1.728	−0.424	0.320	−0.972

(2) 1978: 1–2002: 4

A. Engle-Granger (tau) Tests
(Explained Variable: R)

	t-stat.	p-value	COINT Vector	Lag Order
without Trend	−1.552	0.741	−1.252	7
with Trend	−2.593	0.469	−0.652	7

B. Johansen (trace) test

	without Trend	with Trend
H_0:r = 0	6.347	17.904
p-value	0.751	0.055
H_0:r ≦ 1	0.947	4.703
p-value	0.703	0.027
Lag Order	4	4

COINT Vector	(without Trend)		(with Trend)	
	1	2	1	2
R	1.000	1.000	1.000	1.000
DP4	−2.453	−0.627	0.006	−2.377

(3) 1980: 1–2002: 4

A. Engle-Granger (tau) Tests
(Explained Variable: R)

	t-stat.	p-value	COINT Vector	Lag Order
without Trend	−1.493	0.764	−1.341	6
with Trend	−2.384	0.584	−0.627	7

B. Johansen (trace) test

	without Trend	with Trend
H_0:r = 0	9.618	17.662
p-value	0.479	0.059
H_0:r ≦ 1	0.439	6.223
p-value	0.760	0.011
Lag Order	4	4

COINT Vector	(without Trend)		(with Trend)	
	1	2	1	2
R	1.000	1.000	1.000	1.000
DP4	−2.891	−0.700	−1.022	1.960

Table 5. Test Results of the Fisher Hypothesis by the Method of Engsted (1995)

Sample	Test of the Constraint F-statistics	[p-value]	R^2
(1) 1971: 2–2002: 4	5.743	[0.000]	0.210
(2) 1978: 1–2002: 4	7.257	[0.000]	0.242
(3) 1980: 1–2002: 4	6.116	[0.000]	0.220

Table 6. Test Results of the Fisher Hypothesis by the Method of Olekalns (1996)

	(1) 1971: 2–2002: 4 [p-Value]	(2) 1978: 1–2002: 4 [p-Value]	(3) 1980: 1–2002: 4 [p-Value]
β	0.059	0.740	0.556
t-stat ($H_0 = 0$)	1.760 [0.081]	13.778 [0.000]	14.922 [0.000]
t-stat($H_0 = 1$)	−28.079 [0.000]	−4.850 [0.000]	−11.915 [0.000]
R^2	0.017	0.675	0.691
DW	1.657	1.848	1.922

the coefficient of β is found to be 0.740 and 0.556 respectively, and thus the hypothesis that $\beta = 0$ and $\beta = 1$ is rejected. As a result, though we find no Fisher effect from the full sample between 1971: 1 and 2002: 4, the results from other samples show that there is a partial Fisher effect. We can suggest that a partial Fisher effect is supported by Olekalns' method.

IV. Summary and Conclusions

We conduct an empirical study testing the Fisher hypothesis in Japan in order to examine the robustness of the results among different samples, i.e. (1) 1971: 2–2002: 4, (2) 1978: 1–2002: 4, and (3) 1980: 1–2002: 4, different indices of inflation rates, i.e. DP and DP4, and different methods. The results are robust for sample periods with exception with Olekalns' (1996) method.

Then, cointegration tests applied to two inflation indices. DP is the rate of one-period lead change, and DP4 is the rate of the four-period lag change. The movements of DP are very volatile, while DP4 moves smoothly. This may lead to different results between them, as the noise of DP might disturb the cointegration tests. We report the results on the DP4 case below.

The results among the methods are summarized as follows. Looking at the cointegration approach, only the Johansen test detects a cointegaration relation between nominal interest rate R and inflation rate DP4 in the case with trend. However, β is not always one. Engsted's (1995) approach rejects the Fisher hypothesis. However, it only rejects $\beta = 1$, not $0 < \beta < 1$. From Olekalns (1996) method, a partial Fisher effect is supported in sample (2) and (3). Although the Fisher hypothesis, i.e. the full Fisher effect, is certainly rejected, the partial Fisher effect may be supported.

Finally, we compare our results with the existing literature. Engsted (1995) and Kamae (1999) support the Fisher hypothesis, i.e. the full Fisher effect, while we do not find it. The main difference is the sample period, as our sample contains the period for a remarkable development of IT industry since 1990s. This development is considered to make financial market more efficient. However, our results make the efficiency weaker, i.e. we may only support a partial Fisher effect. We will have to carry out further studies on the structural breaks in addition to investigating the reason for the inconsistency.

References

Bank of Japan (1994), "Kinri no kikan supureddo no infure-shihyosei ni-tsuite," (in Japanese) *Monthly Bulletin of Japan Bank*, July, pp. 61–81.

Campbell, John Y., and Robert J. Shiller (1987), "Cointegration and Tests of Present Value Models," *Journal of Political Economy*, Vol. 95, No. 5, October, pp. 1062–1088.

Cooray, Arusha (2002), "The Fisher Effect: a Review of the Literature," *Macquarie University Economics Research Papers*, No. 6, September.

Engsted, T. (1995), "Does the Long-term interest Rate Predict Future Inflation? A Multi-Country Analysis," *The Review of Economics and Statistics*, Vol. 77, pp. 42–54.

Fama, Eugene F. (1975), "Short-Term Interest Rates as Predictors of Inflation," *The American Economic Review*, Vol. 65, No. 3, June, pp. 268–282.

Kamae, Hiroshi (1999), *Nihon no shouken kinyu shijo no kouritsusei*, (in Japanese), Yuhikaku.

Kuroda, Akio (1982), *Nihon no kinri kozo* (in Japanese), Toyokeizai-Shipo-sha, May.

Mishkin, Frederic S. (1990), "What does the Term Structure tell Us about Future Inflation?," *Journal of Monetary Economics*, Vol. 25, No. 1, January, pp. 77–95.

Olekalns, Nilss (1996), "Further Evidence on the Fisher Effect," *Applied Economics*, Vol. 28, No. 7, July, pp. 851 -856.

Satake, Mitsuhiko (1997), "Meimoku kinri no infure yosoku kanousei ni tsuite," (in Japanese) *The Doshisha University Economic Review*, Vol. 48, No. 3, March, pp. 546–558.

Yamada, Yasuhiro (1991), "Kinri no kikan supureddo ni yoru infure yosoku no kanousei ni tsuite," (in Japanese), *Financial Review*, Vol. 20, May, pp. 129–145.