The Fisher Effect and The Long–Run Phillips Curve
--in the case of Japan, Sweden and Italy --

Shigeyoshi Miyagawa and Yoji Morita
Kyoto Gakuen University,
Department of Economics,
Kyoto, 621-6355 Japan
e-mail: miyagawa@kyotogakuen.ac.jp

Working Papers in Economics no 77
Corrected version March 2003

Abstract

The object of the paper is to attempt to assess the two classical long-run neutrality; the Fisherian link between inflation rate and nominal interest rate, and the natural rate hypothesis proposed by Friedman (1968) and Phelps (1967, 1968). We use the quarterly data for Japan, Sweden and Italy. In order to investigate the classical long-run neutrality, we use the non-structural bivariate autoregressive methodology King and Watson (1997) developed to avoid the Lucas-Sargent critique. They showed that long-run neutrality can be tested with limited structural information when nominal variables are integrated.

We pay close attention to the unit root properties of the data, since it takes very crucial role in applying their methodology. Our test results show that all data of Japan, Sweden and Italy we use here do not have unit root and cointegration. The empirical evidences of the Fisherian link and the long-run Phillips curve in Japan, Sweden and Italy are consistent with those of United States by King and Watson (1997). The classical Fisherian link which means that permanent shift in inflation rate will have no effect on real interest rate would not be accepted. On the contrary, we could find little evidence against the vertical long-run Phillips curve. A long-run trade off between inflation and unemployment was rejected.

Key words: long-run neutrality, unit root, cointegration

JEL classification: E44, E52.E58

1. Introduction

The Fisher effect and the long-run Phillips curve are still very controversial topics among macroeconomics researchers even today. The positive effect of inflation rate on nominal interest rate is called Fisher effect as Irving Fisher pointed out more than seventy years ago. Fisher stressed the difference between nominal interest and real interest in theory of fluctuation in investment. The Fisher effect means that an increase in money growth causes price hike and anticipation of inflation eventually leads to a discrepancy between nominal interest rate and real interest rate. Nominal interest rate, real interest rate and anticipation of inflation are linked by the equation.

nominal interest rate = real interest + anticipation of inflation

The Fisher effect suggests that nominal interest rate changes one for one with inflation in the long-run, that is to say, the real rate is constant to permanent changes in the inflation rate.

It is New Zealand economist A. W. Phillips working at the London School of Economics, who showed the stable and negative relationship between the unemployment rate and the nominal wage growth rate. After that many economists found that there exists a similar negative relationship between inflation rate and unemployment rate. A curve showing the negative relationship between inflation rate and unemployment rate is called a Phillips curve. However Edmond Phelps and Milton Friedman proposed the natural rate hypothesis independently in the mid-1960s. Friedman (1968) and Phelps (1967, 1968) suggested that the trade off between inflation rate and unemployment rate vanishes in the long-run when the actual inflation rate equals the anticipated inflation rate. The long-run Phillips curve is vertical at the natural rate of unemployment.

So much evidence is available regarding the Fisher effect and the long-run Phillips curve. However, Lucas and Sargent criticized the traditional long-run neutrality test using the reduced form. They argued that the model has to be fully anticipated. Recently King and Watson (1997) has proposed a new statistical method not to subject to the Lucas-Sargent critique.

They indicated that long-run neutrality should be tested in the framework of the structural model. They proposed that long-run neutrality can be tested with limited structural information when nominal variables are integrated. They tested neutrality by using a priori knowledge of one of the structural impact multipliers or one of the structural long run multipliers. They applied this method to the postwar U.S. data. Their estimation result of the Fisher effect denied the long run Fisherian relationship between nominal interest rate and inflation rate. They found that nominal interest rates change less than one for one with inflation in the long run. Their conclusion about the long-run Phillips curve suggests there is no or very little long-run trade off between inflation and unemployment. Koustas and Serletis (1999) also applied the bivariate vector model by King and Watson to estimate the Fisher effect. They report the evidence on the Fisher effect for several countries. So we also take their results into consideration to analyse the Fisher effect.

In this paper we estimate both the Fisher effect and the long-run Phillips curve by applying the King and Watson methodology to the data for Japan, Sweden and Italy. We will pay close attention to the unit root properties of the data, because this estimation critically depends on the degree of integration of data and cointegration.

The remainder of the paper is organized as follows. The empirical methodology is discussed in section 2. Section 3 investigates the properties of the data for Japan, Sweden and Italy. Section 4 presents the empirical results. Section 5 concludes.

2. Bivariate Autoregression Model

We consider the dynamic simultaneous equation following by King and Watson (1998). The model with order p is expressed in the first difference of variables. We use π (inflation rate) and R (nominal interest rate) to estimate the Fisher effect, while we use π (inflation rate) and u (unemployment rate) to estimate the long-run Phillips curve. We begin with the model to estimate the Fisher effect. We also use this model to estimate the Phillips curve with R_t replaced by u_t.

$$\Delta\pi_t = \lambda_{\pi R}\Delta R_t + \sum_{j=1}^{p}\alpha_{\pi R}^{j}\Delta R_{t-j} + \sum_{j=1}^{p}\alpha_{\pi\pi}^{j}\Delta\pi_{t-j} + \varepsilon_t^{\pi} \qquad (1)$$

$$\Delta R_t = \lambda_{R\pi}\Delta\pi_t + \sum_{j=1}^{p}\alpha_{RR}^{j}\Delta R_{t-j} + \sum_{j=1}^{p}\alpha_{R\pi}^{j}\Delta\pi_{t-j} + \varepsilon_t^{R} \qquad (2)$$

where $\lambda_{\pi R}$ and $\lambda_{R\pi}$ indicate the contemporaneous effect of nominal interest rate on inflation rate, and the contemporaneous response of nominal interest rate to inflation rate, respectively and the structural shock ε^{π}, ε^{R} are unexpected exogenous change of inflation rate and unexpected exogenous change of nominal interest rate, respectively.

This set of dynamic simultaneous equations can be written in a vector form as follows.

$$\alpha(L)X_t = \varepsilon_t \qquad (3)$$

where $\alpha(L) = \sum_{j=0}^{p} \alpha_j L^j$, $X_t = \begin{bmatrix} \Delta\pi_t \\ \Delta R_t \end{bmatrix}$, $\varepsilon_t = \begin{bmatrix} \varepsilon_t^{\pi} \\ \varepsilon_t^{R} \end{bmatrix}$, $\alpha_0 = \begin{bmatrix} 1 & -\lambda_{\pi R} \\ -\lambda_{R\pi} & 1 \end{bmatrix}$

$$\alpha_j = -\begin{bmatrix} \alpha_{\pi\pi}^{j} & \alpha_{\pi R}^{j} \\ \alpha_{R\pi}^{j} & \alpha_{RR}^{j} \end{bmatrix} \quad j = 1,2,\ldots\ldots, p$$

We have an econometric identification problem, which will be treated in the following method shown by King and Watson. The reduced form of Eqs.(1) and (2) is

$$X_t = \sum_{j=1}^{p} \phi_j X_{t-j} + e_t \qquad (4)$$

where $\phi_j = -\alpha_0^{-1}\alpha_j$ and $e_t = -\alpha_0^{-1}\varepsilon_t$.

The matrix α and Σ_ε are determined by the following Eqs.(5) and (6).

$$\alpha_0^{-1}\alpha_j = -\phi_j \quad j = 1,\ldots, p \qquad (5)$$

$$\alpha_0^{-1}\sum\nolimits_\varepsilon (\alpha_0^{-1})' = \sum\nolimits_e \qquad (6)$$

Equation (5) determines α_i as a function of α_0 and ϕ_i. Equation (6) determines both α_0 and Σ_ε as a function of Σ_e. Σ_e is a 2×2 symmetric matrix with only three unique elements. Therefore we can estimate only three unknown parameters of the remaining parameters var(ε^π), var(ε^R), $\lambda_{\pi R}$, $\lambda_{R\pi}$ with the assumption that cov(ε^π, ε^R) = 0. Thus we need one additional identifying restrictions in order to estimate the Fisherian relationship between inflation rate and nominal interest rate. King and Watson suggest one of the following identifying assumptions in their money-output model, X_t=(α, β).

1. the impact elasticity of α with respect to β is known (i.e., $\lambda_{\pi R}$ is known in our framework)
2. the impact elasticity of β with respect to α is known (i.e., $\lambda_{R\pi}$ is known in our framework)
3. the long-run elasticity of α with respect to β is known (i.e., $\gamma_{R\pi}$ is known in our framework)
4. the long-run elasticity of β with respect to α is known (i.e., $\gamma_{\pi R}$ is known in our framework)

In our framework the long-run multipliers are interpreted as $\gamma_{R\pi} = \alpha_{R\pi}(1)/\alpha_{RR}(1)$ and $\gamma_{\pi R} = \alpha_{\pi R}(1)/\alpha_{\pi\pi}(1)$ which represent the long-run response of R_t to permanent shift in πt and the long-run response of π_t to permanent shift in R_t, respectively.

The classical Fisherian relationship between inflation rate and nominal interest rate, which means that permanent increase in π_t have no effect on real interest rates, is accepted when $\gamma_{R\pi} = 1$. The vertical long-run Phillips curve, which suggests that inflation has not any long-run effect on unemployment, is accepted when $\gamma_{u\pi}$ =0.

3. The properties of the data

Data and sample period

We use the quarterly data of Japan, Sweden and Italy. To begin, we have to investigate the properties of the data, since the unit root properties of the data are the critically important element of the analysis. The data we employ here are inflation rate, nominal interest rate and unemployment. Each data must follow an I (1) processes (integrated of order one) and must not cointegrate. So we need to be very careful to choose the sample period.

The Japanese data sample, the Swedish data sample, and the Italian data sample consists of quarterly observations from 1976:1 through 1989:4, from 1963:1 through 2001:1 and 1975:1 through 1998:2, respectively in the estimation of Fisher effect. On the contrary, the sample period we use to estimate the Phillips curve are from 1971:1 through 2000:4 in Japan, from 1963:1 through 2001:2 in Sweden and from 1971:1 through 1995:4 in Italy.

Interest rate and inflation rate in Japan are call rate and consumer price index, respectively. Interest rate and inflation rate in Sweden are bond rates and GDP deflator, respectively. Interest rate and inflation rate in Italy are bond rate and GDP deflator, respectively. The data for unemployment are unemployment rate in three countries.

All data are obtained from OECD data base.

Unit-Root test

First, we perform the unit-root test to investigate the time series process of the long-run component of inflation rate and nominal interest rate. The augmented Dickey-Fuller (1981) test is performed with and without time trend.

The test results are reported in Tables 1, 3, 5 on inflation rate and nominal interest rate, and Tables 7, 9, 11 on inflation and unemployment rate. We determined the optimal length by the Akaike information criterion (AIC). The ADF statistics show that the unit roots cannot be rejected at the 5 percent level for inflation rate, nominal interest rate and unemployment rate in these three countries.

Cointegration Test

Next, we have to investigate the two variables whether they share any common stochastic trends or not, since they are determined to have the stochastic trends. The statistical method we use here to check it is a cointegration test. Recently various tests of cointegration have been proposed, including Philips (1987), Engle-Granger (1988) and Johansen (1988). We employ here Johansen's cointegration test[1]. The results of the Johansen's test are shown in Tables 2, 4, 6 on inflation and nominal interest rate and in Tables 8, 10, 12 on inflation and unemployment rate. We use the Log Likelihood to test the null hypothesis of no cointegration. The results indicate that the null hypothesis of no cointegration between inflation rate and nominal interest rate cannot be rejected. The null hypothesis of no cointegration between inflation and unemployment rate cannot be rejected either. Such properties of the data satisfy the necessary condition to estimate both the Fisher effect and the vertical Phillips curve.

4 Estimation Results

A. Evidence on the Fisher effect

---

[1] King and Watson(1997) and Koustes and Serletis(1999) used the Engle and Granger’s two step approach to investigate the cointegration.

Firstly we have estimated the Fisher effect by using $X_t = (\Delta\pi_t, \Delta R_t)$, a framework proposed by King and Watson. Under the framework, if both the inflation rate and the nominal interest rate are I (1) and not cointegrated, then this hypothesis can be investigated.

The model is estimated by the simultaneous equations method. The relevant variables have six lags in all of the models. The details of the estimation procedures are shown in the appendix of King and Watson (1997).

Our estimation results are shown in Figures 1, 2 and 3 for a wide range of values of the parameters, $\lambda_{\pi R}$, $\lambda_{R\pi}$, and $\gamma_{\pi R}$. This model has six lags of each variable. Figure 1 shows the results of Japan, while Figures 2 and 3 show ones of Sweden and Italy, respectively. In the King and Watson' s framework, the Fisherian link, the proposition that interest rates respond to inflation rates point-for-point holds when $\gamma_{R\pi} = 1$. That is to say, $\gamma_{R\pi}$ has to be exactly one in order to get the evidence for the Fisherian link between inflation rate and nominal interest rates. Panel A of Figure 1 indicates that $\gamma_{R\pi}$ is significantly less than 1 when $\lambda_{\pi R}$ takes a positive value. Panel C also indicates that $\gamma_{R\pi}$ is significantly less than 1 when $\gamma_{\pi R}$ is positive. On the contrary, we need some caution to interpret the evidence of Panel B.

Figure 2 shows the Swedish case. Panel A and Panel C show that Fisherian link can be rejected since $\gamma_{R\pi}$ is significantly less than 1 when both $\lambda_{\pi R}$ and $\gamma_{\pi R}$ take the positive value. However Panel B suggests that Fisher effect cannot be rejected since $\gamma_{R\pi} =1$ is included in the 95% confidence interval when $\lambda_{R\pi}$ is larger than 1.1. Figure 3 indicate that a positive value of $\lambda_{\pi R}$ on the Panel A or $\gamma_{\pi R}$ on the Panel C leads to an estimate of $\gamma_{R\pi}$ which is significantly less than one. However the evidence of the Panel B is not clear here either.

From Figures 1, 2 and 3, the long –run Fisher effect seems to be rejected as far as one believe that the contemporaneous effect of nominal interest rate on inflation is positive or that the long-run effect of nominal interest rate on inflation is positive. King and Watson (1997) gives a mechanical explanation of this findings. They indicate that the VAR model implies substantial volatility in trend inflation. So to reconcile the data with $\gamma_{R\pi} =1$, a large negative effect of nominal interest rates on inflation is required[2]. The estimated standard deviation of the inflation trend and nominal interest rate for our three countries seems to be consistent with their explanation[3].

How should we interpret the evidence of Panel B for the Fisherian link between inflation and nominal interest rate ? King and Watson (1997) and Koustas and Serletis (1999) also have encountered the same problems. King and Watson suggest that $\gamma_{R\pi} = 1$ cannot be rejected for a value of $\lambda_{R\pi}$, >0.55. Koustas and Serletis get the values of $\lambda_{R\pi}$ >0.5 in all cases except for the UK which cannot reject the Fisherian link.

They interpret the $\lambda_{R\pi}$ parameter as follows. They try to decompose the impact effect of inflation on nominal interest rates into an expected inflation effect and an effect on real rates. When inflation has no impact on real interest rates, only the expected inflation appears. Therefore they think 0.5 is more

---

[2] See King and Watson (1997), p.89

[3] The estimated standard deviation of the inflation(σ_π) and nominal interest rate(σ_R) are as follows.

	σ_R	σ_π
Japan	0.7665	0.7804
Sweden	0.3677	1.4222
Itraly	0.6341	1.8731

plausible value as far as the impact effect of inflation on real interest rate is zero. If inflation has the negative impact effect on the real interest rate, the value in excess of 0.5 is less plausible. So they consider that the evidence of Fisherian link between inflation and nominal interest rate depend critically on one's belief about the impact effect of a nominal disturbance on the real interest rate. If this effect is negative, then there is signficant evidence in the data against this neutrality hypothesis[4]. For example, Lucas (1990), Fuerst (1992), and Cristiano and Eichenbaum (1994) imply that real rate fall in their models with liquidity effects.

The evidence from Panel B of Figure 1 clearly shows that the Fisher hypothesis can be rejected for values of $\lambda_{\pi R} < 0.6$. Panel B of Figures 2 and 3 also indicate that $\lambda_{\pi R} = 1$ can be rejected for values of $\lambda_{\pi R} < 1.1$ and $\lambda_{\pi R} < -0.1$, respectively.

As far as we follow their interpretation of $\lambda_{R\pi}$, the evidences shown in Panel B of Figures 1, 2, and 3 indicate that we cannot accept the Hypothesis of Fisherian relationship between inflation and nominal interest rate. Thus, our estimation results shown in Figures 1, 2, and 3 are thought to provide the evidence against the proposition that nominal interest rate respond to inflation rates one for one as Fisherian link suggests.

B. Evidence on the long-run Phillips Curve

We also applied the same methodology to estimate the long-run Phillips curve with R_t replaced by u_t. Figures 4, 5 and 6 show the point estimates and 95 percent confidence intervals for $\gamma_{u\pi}$ in which Panel A, B and C indicate $\gamma_{u\pi}$ for various values of $\lambda_{\pi u}$, $\lambda_{u\pi}$ and $\gamma_{\pi u}$ respectively. The Phillips curve which shows the relationship between inflation and unemployment is drawn with inflation on the vertical axis and unemployment on the holizontal axis. So the vertical long-run Phillips curve holds when the restriction $\gamma_{u\pi} = 0$.

Figure 4 shows the evidence on Japan. It indicates that estimates $\gamma_{u\pi}$ for various ranges of values on the short-run impact of unemployment rate on infation, $\lambda_{\pi u}$ (panel A), the short-run impact of inflation on unemployment, $\lambda_{u\pi}$ (panel B) and the long-run impact of unemployment on inflation rate, $\gamma_{\pi u}$ (panel C) at the 95 percent confidence level. Graphical outputs of panel A and C clearly indicate that a vertical Phillips curve is acccepted for a wide range of $\lambda_{\pi u}$ and $\gamma_{\pi u}$ at 95 percent confidence interval. On the contrary, $\gamma_{u\pi} = 0$ cannot be accepted when $\lambda_{u\pi} < -0.07$. Since $\gamma_{u\pi}$ can be interpreted as the slope of the short-run Phillips curve, long- run neutrarity depends on the slope of the short – run Phillips curve. If short –run neutrality is maintained, the estimated value of $\gamma_{u\pi}$ is almost zero. King and Watson take several values which had already been estimated in the United States. Sargent (1976) finds an estimate of $\lambda_{u\pi} = -0.07$ in the United States. Even if $\lambda_{u\pi}$ in the area less than –0.07 reject the long-run neutrality, the slope of long-run Phillips curve would be very steep. For example our results show that $\gamma_{u\pi}$ would be –0.069 when $\lambda_{u\pi} = -0.1$. It means very steep long-run Phillips curve which has a slope of $-14.5 = (\gamma_{u\pi}^{-1})$. Thus we conclude there is no long-run trade off between inflation and unemployment in Japan.

Figure 5 and 6 indicate the graphical evidence on Sweden and Italy, respectively. A long-run vertical Phillips curve can be rejected only when $\lambda_{\pi u} > 1.9$ (Sweden) and $\lambda_{\pi u} > 1.0$ (Italy). However the

---

[4] See King And Watson (1997), p.89

estimates of $\lambda_{\pi u}$ in this range implicate that unemployment rate have a large positive impact on inflation.

The Panel B of Figures 5 and 6 show that the long-run Phillips curve has a vertical or very steep slope. $\lambda_{u\pi}$ is interpreted as the slope of the short- run Phillips curve. A vertical Phillips curve ($\gamma_{u\pi} = 0$) can be accepted in the range of $\lambda_{u\pi} > -0.13$ from Panel B of Figure 5 in Sweden. $\gamma_{u\pi} = 0$ is rejected in the range of $\lambda_{u\pi} < -0.07$ in the case of Italy. However a vertical Phillips curve has a very steep slope even when $\lambda_{u\pi} < -0.07$. For example, the values of –0.1 and –0.2 of $\lambda_{u\pi}$ correspond to the point estimates of $\gamma_{u\pi} = -0.12302$ and $\gamma_{u\pi} = -0.19142$, respectively, which means a long- run Phillips curve with a very steep slope shown by $(\gamma_{u\pi}^{-1})$. Panel C of Figures 5 and 6 support the evidence for a vertical Phillips curve.

5. Conclusion

We estimated the classical long-run Fisher effect and the long-run Phillips curve by using the Japanese, Swedish and Italian data. We followed the bivariate autoregression method proposed by King and Watson, paying close attention to the unit root properties of the data, because the properties of the data take very important role in applying their method. We carefully chose the data which satisfy the necessary condition to apply the King and Watson' methodology. All data we used here do not have unit root (ie, they follow the I(1) process) and not cointegrate in all countries.
Unrestricted VARs tends to give misleading results. We used a wide range of values of three parameters, $\lambda_{\pi R}$ ($\lambda_{\pi u}$), $\lambda_{R\pi}$ ($\lambda_{u\pi}$) and $\gamma_{\pi R}$ ($\gamma_{\pi u}$) to identify our model following King and Watson.
The evidence suggests that nominal interest rate do not respond to inflation rates point-for-point and a long-run Phillips curve is vertical or has a steep slope which means a very steep long-run trade off between unemployment and inflation.

Our empirical results of Japan, Sweden and Italy are consistent with those of United States by King and Watson (1997). Thus our conclusion comes as follows.
The classical Fisherian link between inflation rate and nominal interest rate would be denied and inflation would reduce real interest rate even in the long run, i.e., nominal interest rate do not adjust fully to sustained inflation. On the contrary our evidence of a long-run Phillips curve suggests the natural rate hypothesis proposed independently in the mid-1960s by Edmund Phelps and Milton Friedman holds.

Acknowledgements

This paper was written while the first author was visiting the department of Economics, Gotheborg University, Sweden, in the summer of 2002. Many thanks go to Professor Lennart Hjalmarson, Head of department, Professor Goran Bergendahl, Professor Arne Bigsten, Professor Lars-Goran Larsson, Dr. Eugenity Nivorzhkin, Dr. Ola Olsson, Ms. Eva Jonason, Ms.Neth Eva-Lena, for their hospitality and informative discussion.

References

Bernanke, B., 1986. Alternative Explanations of the Money-Income Correlation. *Carnegie-Rochester Series on Public Policy*, 25, 29-100.
Blanchard, O., Quah, D., 1989. The Dynamic Effects of Aggregate Demand and Supply

Disturbances, *American Economic Review*. 79. Dec. 655-73.

Christiano, L., Eichenbaum, M., 1995. Liquidity Effects, Monetary Policy and the Business Cycles. *Journal of Money, Credit, and Banking* 27, 1113-1136.

Dicky, D.A., Fuller, W.A., 1981. Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica* 49,1057-1072.

Fisher, I., 1896. Appreciation and Interest , *Publications of the American Economic Association*.

Fisher, I., 1930. *The Theory of Interest*, New York:Macmillan.

Furest. T., 1992. Liquidity, Loanable Funds and Real Activity, *Journal of Monetary Economics* 29, 3- 24.

Feldstein M., SummersL., 1978. Inflation, Tax Rules, and the Long-Term Interest Rates, *Brooking Papers on Economic Activity* I.

Friedman, M. The Role of Monetary Policy, *Presidential address* delivered at the Eightieth Annual Meeting of the American Economic Association, December 29, 1967. Reprinted in the M. Friedman, *The Optimum Quantity of Money and Other Essays*, Aldine Publishing Company, Chicago, 95-110.

Granger , C.W.J. ed. 1992. *Long-Run Economic Relationships*, Oxford

Karnosky D., Yohe, W. 1965. Interest Rates and Price Level Changes, *Review*, Federal Reserve Bank of St. Louis , Dec.

King, R.G., Watson, M.W., 1992. Testing Long-Run Neutrality, *working paper* 4156, National Bureau of Economic Research, September, Boston.

King, R.G., Watson, M.W., 1997. Testing Long-Run Neutrality. *Economic Quarterly*, Federal Reserve Bank of Richmond, 69-101, 83/3 summer.

Koustas, Z., Serletis, A. 1999. On the Fisher Effect. *Journal of Monetary Economics*, 44, 105-130.

Lucas Jr., R.E., 1990. Liquidity and Interest Rates. *Journal of Economic Theory* 50, 237-264.

Miyagawa, S. 1983. Money Supply and Monetary Policy, in K. Furukawa ed. *Financial Market and Policy in Japan*, Shouwado 277-324.

Phelps, E.S. 1967. Phillips Curves, Expectations of Inflation and Optimal Unemployment Over Time, *Economica*, 34, 254-281.

Phelps, E.S. 1968. Money Wage Dynamics and Labour Market Equilibrium, *Journal of Political Economy*, 76, 678-711.

Shapiro, M., Watson, M.W. 1988. Sources of Business Cycle Fluctuations, National Bureau of Economic Research, *Macroeconomics Annual,* 3. 111-56.

Tobin, J. 1965. Money and Economic Growth, *Econometrica,* 33, October , 671-84.

Table 1 Unit root test, Japan

	Inflation Rate			Interest Rate	
	1976Q1-1989Q4			1976Q1-1989Q4	
	with trend			without trend	
	ADF-t	AIC		ADF-t	AIC
n=1	-2.443271	2.065774	n=1	**-2.568788**	2.228762
n=2	-2.251098	2.101454	n=2	-2.399992	2.264001
n=3	-2.259128	2.134146	n=3	-2.353041	2.299379
n=4	**-2.624678**	1.952773	n=4	-2.319262	2.334216
n=5	-2.595264	1.980003	n=5	-2.204886	2.369125
n=6	-2.546919	2.015714	n=6	-2.142293	2.404772
	1%c.value	-4.1281		1%c.value	-3.5501
	5%c.value	-3.4904		5%c.value	-2.9137
	10%c.value	-3.1735		10%c.value	-2.5942

Table 2 Cointegration test, Japan

	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value		
lag=1	None	0.214719	13.53594	18.96	23.65	Log likelihood	-105.4508
	At most 1	0.056434	3.252972	12.25	16.26		
lag=2	None	0.200171	12.50801	18.96	23.65	Log likelihood	-102.2863
	At most 1	0.041343	2.364434	12.25	16.26		
lag=3	None	0.152401	9.259469	18.96	23.65	Log likelihood	-101.5592
	At most 1	3.78E-02	2.159396	12.25	16.26		
lag=4	None	0.171564	10.54009	18.96	23.65	Log likelihood	-95.12586
	At most 1	0.098015	5.776828	12.25	16.26		
lag=5	None	0.18265	11.2945	18.96	23.65	Log likelihood	-94.4903
	At most 1	0.115912	6.899138	12.25	16.26		
lag=6	**None**	**0.227228**	**14.43516**	**18.96**	**23.65**	**Log likelihoo**	**-90.99667**
	At most 1	**0.117774**	**7.017168**	**12.25**	**16.26**		

Table 3 Unit root test, Sweden

	Inflation Rate			Interest Rate	
	1963Q1-2001Q2			1963Q1-2001Q2	
	without trend			without trend	
	ADF-t	AIC		ADF-t	AIC
n=1	-2.208509	3.194348	n=1	-1.743947	1.813841
n=2	-2.468636	3.198783	n=2	-1.764774	1.832482
n=3	-3.269939	3.119782	n=3	-1.749056	1.852413
n=4	**-1.803855**	2.884297	n=4	**-1.402087**	1.841754
n=5	-1.711484	2.898801	n=5	-1.131017	1.817624
n=6	-1.646594	2.919293	n=6	-1.018787	1.831984
	1%c.value	-3.4752		1%c.value	-3.4755
	5%c.value	-2.8809		5%c.value	-2.881
	10%c.value	-2.577		10%c.value	-2.577

Table 4 Cointegration test, Sweden

	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value		
lag=1	None	0.071613	11.29456	14.07	18.63	Log likelihood	-369.7333
	At most 1	0.021461	3.297601	3.76	6.65		
lag=2	None	0.088836	14.04789	14.07	18.63	Log likelihood	-364.8929
	At most 1	0.02818	4.316245	3.76	6.65		
lag=3	None **	0.138285	22.32455	14.07	18.63	Log likelihood	-352.5657
	At most 1	3.07E-02	4.669382	3.76	6.65		
lag=4	None	0.065549	10.10156	14.07	18.63	Log likelihood	-330.2171
	At most 1	0.025314	3.820341	3.76	6.65		
lag=5	None	0.07813	12.03999	14.07	18.63	Log likelihood	-320.2069
	At most 1	0.025667	3.84827	3.76	6.65		
lag=6	None	0.081088	12.43103	14.07	18.63	Log likelihood	-316.8122
	At most 1	0.021711	3.226729	3.76	6.65		
lag=7	**None**	**0.084105**	**12.82663**	**14.07**	**18.63**	**Log likelihood**	**-311.4062**
	At most 1	**0.019072**	**2.811468**	**3.76**	**6.65**		

Table 5 Unit root test, Italy

	Inflation Rate			Interest Rate	
	1975Q1-1998Q2			1975Q1-1998Q2	
	with trend			with trend	
	ADF-t	AIC		ADF-t	AIC
n=1	-4.209891	3.300429	n=1	**-1.984977**	2.194969
n=2	-4.278313	3.309479	n=2	-1.932803	2.216079
n=3	-3.244911	3.298137	n=3	-1.909507	2.237347
n=4	**-1.992305**	3.148002	n=4	-1.673203	2.22402
n=5	-2.030157	3.16708	n=5	-1.638192	2.245127
n=6	-2.061424	3.186383	n=6	-1.634566	2.26617
	1%c.value	-4.0625		1%c.value	-4.058
	5%c.value	-3.4597		5%c.value	-3.4576
	10%c.value	-3.1557		10%c.value	-3.1545

Table 6 Cointegration test, Italy

	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value		
lag=1	None *	0.173801	17.94641	14.07	18.63	Log likelihood	-249.3812
	At most 1	0.015313	1.450546	3.76	6.65		
lag=2	None *	0.167905	17.27801	14.07	18.63	Log likelihood	-248.9449
	At most 1	0.012658	1.197421	3.76	6.65		
lag=3	None *	0.148763	15.14006	14.07	18.63	Log likelihood	-244.1045
	At most 1	1.96E-02	1.860656	3.76	6.65		
lag=4	None	0.116553	11.64884	14.07	18.63	Log likelihood	-233.0231
	At most 1	0.020733	1.96938	3.76	6.65		
lag=5	None	0.119933	12.00915	14.07	18.63	Log likelihood	-232.7677
	At most 1	0.021522	2.045202	3.76	6.65		
lag=6	**None**	**0.101912**	**10.10377**	**14.07**	**18.63**	**Log likelihooc**	**-230.5221**
	At most 1	**0.015378**	**1.456771**	**3.76**	**6.65**		

Table 7 Unit root test, Japan

	Inflation Rate			Unemployment	
	1971Q1-2000Q4			1971Q1-2000Q4	
	without trend			with trend	
	ADF-t	AIC		ADF-t	AIC
n=1	-2.118558	-5.856523	n=1	-0.545559	-1.768703
n=2	-2.616273	-5.88144	n=2	-0.977595	-1.776832
n=3	-3.121893	-5.923013	n=3	**-1.595747**	-1.811815
n=4	**-1.62892**	-6.17043	n=4	-1.197969	-1.797962
n=5	-1.413652	-6.161368	n=5	-1.08935	-1.776383
n=6	-1.44517	-6.148002	n=6	-0.904899	-1.750965
	1%c.value	-3.488		1%c.value	-4.0393
	5%c.value	-2.8865		5%c.value	-3.4487
	10%c.value	-2.5799		10%c.value	-3.1493

Table 8 Cointegration test, Japan

	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value		
lag=1	None	0.083561	10.29666	14.07	18.63	Log likelihood	464.3169
	At most 1	0.003535	0.417887	3.76	6.65		
lag=2	None	0.089367	10.95293	14.07	18.63	Log likelihood	463.2193
	At most 1	0.003532	0.413986	3.76	6.65		
lag=3	None *	0.138112	17.24108	14.07	18.63	Log likelihood	468.8308
	At most 1	3.31E-05	0.00384	3.76	6.65		
lag=4	**None**	**0.05446**	**6.439923**	**14.07**	**18.63**	**Log likelihoo**	**486.302**
	At most 1	**0.002327**	**0.267961**	**3.76**	**6.65**		
lag=5	None	0.055724	6.536334	14.07	18.63	Log likelihood	483.4034
	At most 1	0.000518	0.059069	3.76	6.65		
lag=6	None	0.07822	9.203694	14.07	18.63	Log likelihood	480.8529
	At most 1	0.000458	0.051821	3.76	6.65		

Table 9 Unit root test, Sweden

	Inflation Rate			Unemployment	
	1963Q1-2001Q2			1963Q1-2001Q2	
	without trend			with trend	
	ADF-t	AIC		ADF-t	AIC
n=1	-2.208509	3.194348	n=1	-1.072477	1.348235
n=2	-2.468636	3.198783	n=2	-1.968616	1.13064
n=3	-3.269939	3.119782	n=3	-1.615728	1.114519
n=4	**-1.803855**	2.884297	n=4	-3.270028	0.665666
n=5	-1.711484	2.898801	n=5	**-2.844247**	0.658289
n=6	-1.646594	2.919293	n=6	-2.590507	0.67642
	1%c.value	-3.4752		1%c.value	-4.0224
	5%c.value	-2.8809		5%c.value	-3.4407
	10%c.value	-2.577		10%c.value	-3.1446

Table 10 Cointegration test, Sweden

	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value		
lag=1	None	0.084042	13.34324	18.96	23.65	Log likelihood	-297.2864
	At most 1	0.022165	3.406966	12.25	16.26		
lag=2	None	0.080807	12.72319	18.96	23.65	Log likelihood	-292.5043
	At most 1	0.027041	4.139378	12.25	16.26		
lag=3	None	0.114836	18.29736	18.96	23.65	Log likelihood	-283.3449
	At most 1	2.41E-02	3.663496	12.25	16.26		
lag=4	None	0.077621	12.03902	18.96	23.65	Log likelihood	-240.5932
	At most 1	0.045083	6.873506	12.25	16.26		
lag=5	None	0.072137	11.081	18.96	23.65	Log likelihood	-236.9191
	At most 1	0.050529	7.6739	12.25	16.26		
lag=6	None	0.056563	8.559215	18.96	23.65	Log likelihood	-233.4912
	At most 1	0.045824	6.895292	12.25	16.26		
lag=7	**None**	**0.05792**	**8.711047**	**18.96**	**23.65**	**Log likelihooc**	**-229.0857**
	At most 1	**0.040895**	**6.096251**	**12.25**	**16.26**		

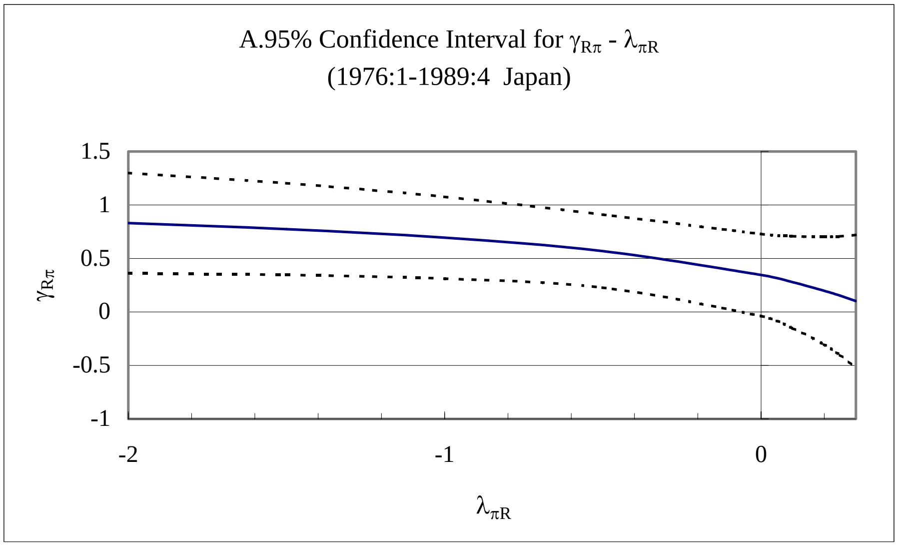
Table 11 Unit root test, Italy

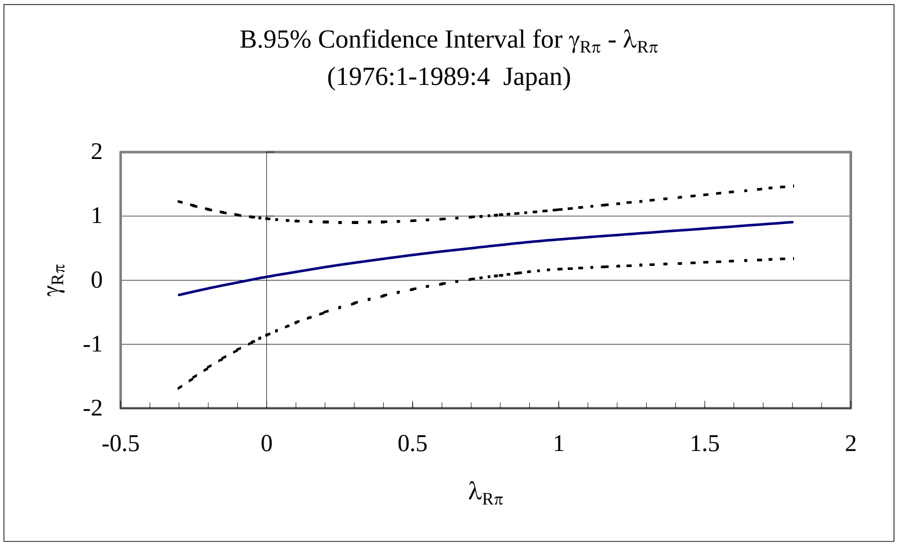
	Inflation Rate			Unemployment	
	1971Q1-1995Q4			1971Q1-1995Q4	
	without trend			with trend	
	ADF-t	AIC		ADF-t	AIC
n=1	-2.24030414	3.643404526	n=1	-1.68831385	0.973656658
n=2	-2.20803659	3.673217485	n=2	-1.72195498	1.002054989
n=3	-1.69327328	3.670564404	n=3	-1.96325896	1.004239155
n=4	-1.22559394	3.636952558	n=4	**-1.42146724**	0.972597055
n=5	**-1.64910179**	3.608492518	n=5	-1.72919821	0.975357571
n=6	-1.70773581	3.639038451	n=6	-1.81804659	1.001243034
	1%c.value	-3.50072942		1%c.value	-4.05698278
	5%c.value	-2.89217367		5c.value	-3.45709145
	10%c.value	-2.58290494		10c.value	-3.15419241

Table 12 Cointegration test, Italy

	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value		
lag=1	None	0.128110522	13.43507563	18.96	23.65	Log likelihood	-215.5195
	At most 1	0.034057195	3.395764107	12.25	16.26		
lag=2	None	0.134554889	14.01759851	18.96	23.65	Log likelihood	-211.3493
	At most 1	0.039683524	3.92776145	12.25	16.26		
lag=3	None	0.106118609	10.7694897	18.96	23.65	Log likelihood	-205.2274
	At most 1	5.22E-02	5.149551697	12.25	16.26		
lag=4	None	0.111290928	11.20860828	18.96	23.65	Log likelihood	-196.208
	At most 1	0.041895899	4.065889985	12.25	16.26		
lag=5	None	0.151422747	15.4342503	18.96	23.65	Log likelihood	-190.7237
	At most 1	0.050897663	4.910433032	12.25	16.26		
lag=6	None	0.183052672	18.80280107	18.96	23.65	Log likelihood	-187.1935
	At most 1	0.05135213	4.902737058	12.25	16.26		
lag=7	None	0.17411684	17.59978107	18.96	23.65	Log likelihood	-184.0036
	At most 1	0.055591294	5.262055438	12.25	16.26		
lag=8	**None**	**0.14706931**	**14.47600597**	**18.96**	**23.65**	**Log likelihoo**	**-180.5159**
	At most 1	**0.059682022**	**5.599883999**	**12.25**	**16.26**		

Figure 1 Evidence on the Fisher effect in Japan


A.95% Confidence Interval for $\gamma_{R\pi}$ - $\lambda_{\pi R}$
(1976:1-1989:4 Japan)


B.95% Confidence Interval for $\gamma_{R\pi}$ - $\lambda_{R\pi}$
(1976:1-1989:4 Japan)

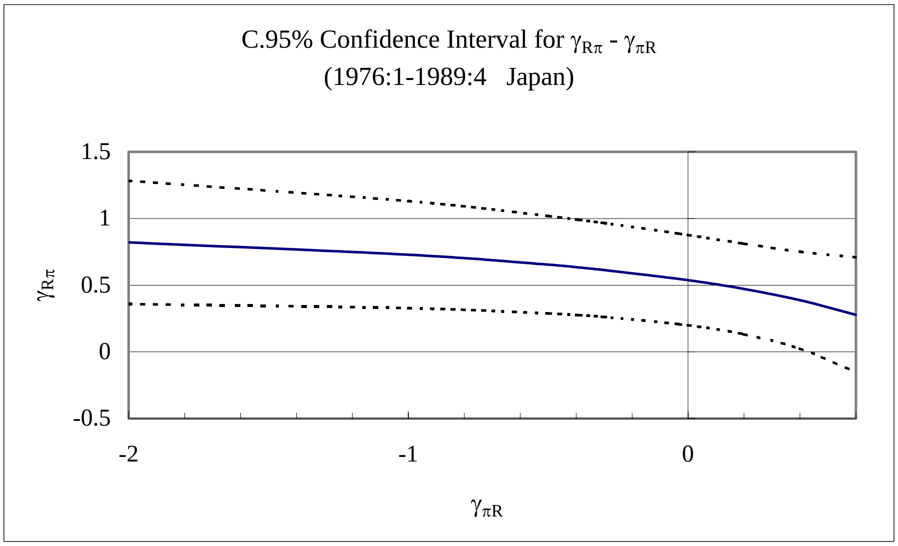
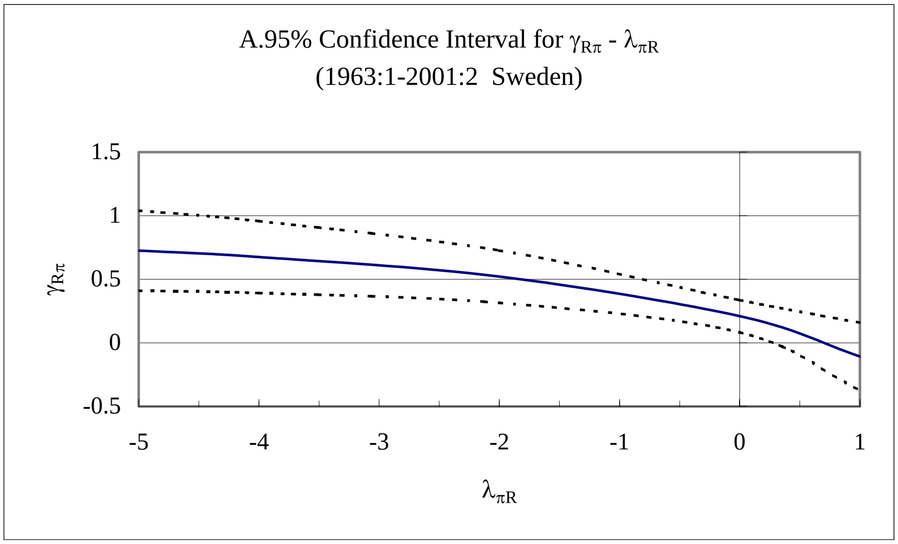
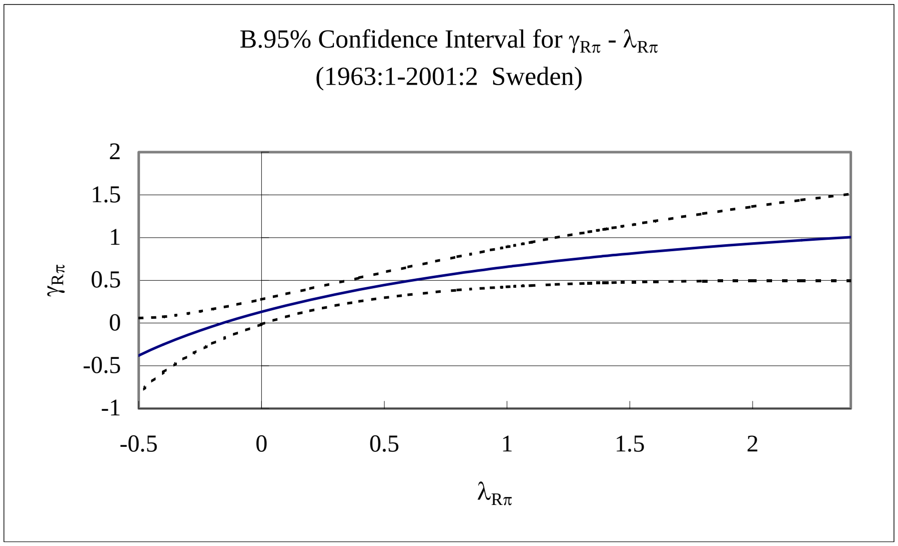

C.95% Confidence Interval for $\gamma_{R\pi}$ - $\gamma_{\pi R}$
(1976:1-1989:4 Japan)

Figure 2 Evidence on the Fisher effect in Sweden


A.95% Confidence Interval for $\gamma_{R\pi}$ - $\lambda_{\pi R}$
(1963:1-2001:2 Sweden)


B.95% Confidence Interval for $\gamma_{R\pi}$ - $\lambda_{R\pi}$
(1963:1-2001:2 Sweden)

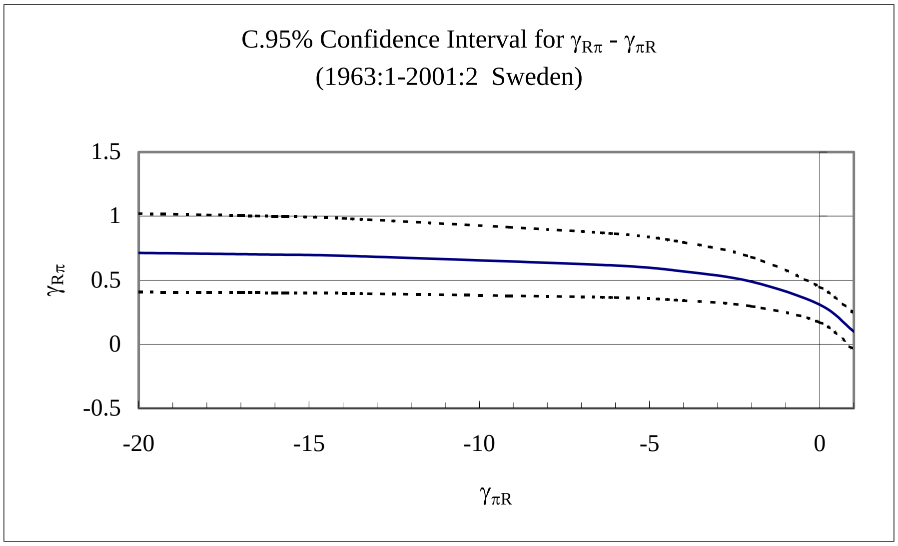
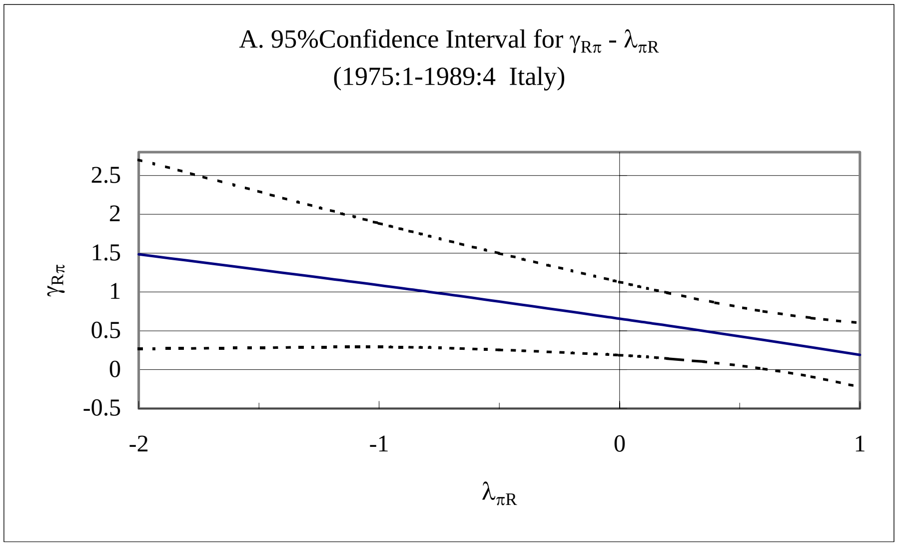
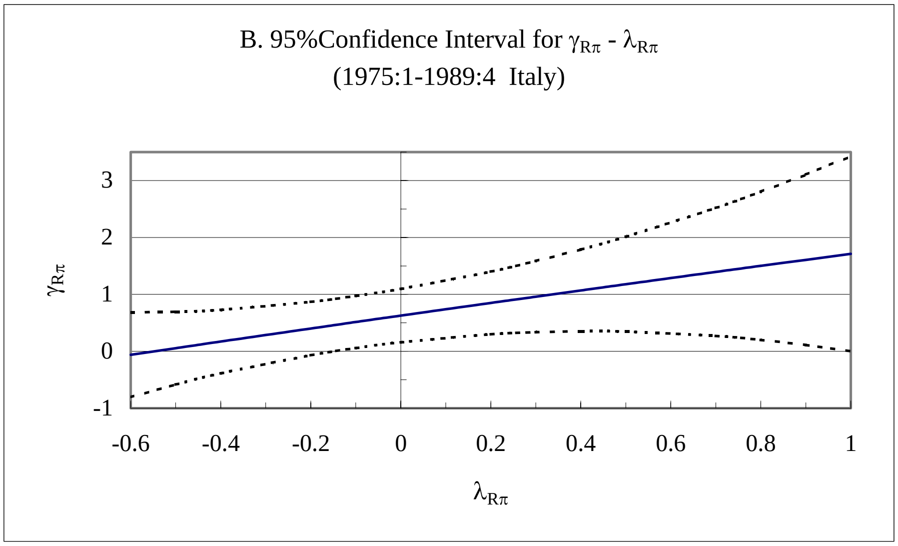

C.95% Confidence Interval for $\gamma_{R\pi}$ - $\gamma_{\pi R}$
(1963:1-2001:2 Sweden)

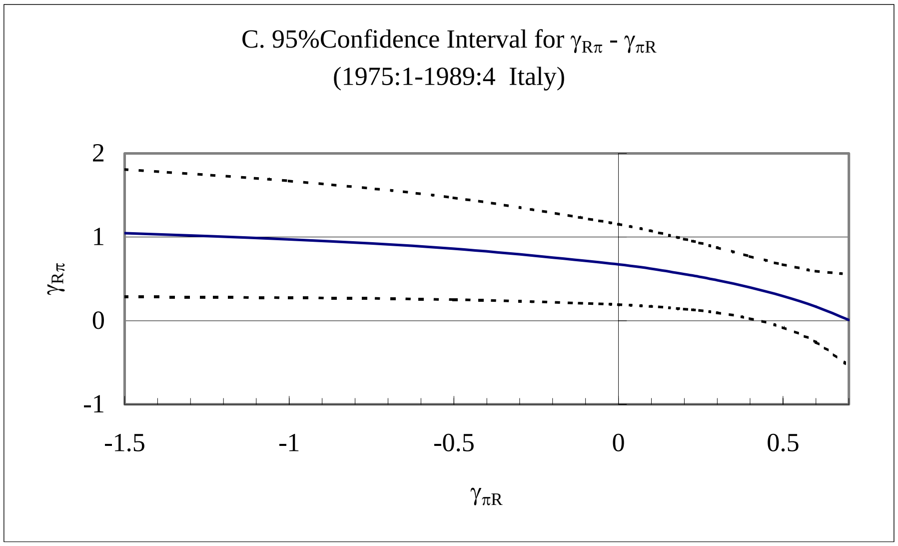
Figure 3 Evidence on the Fisher effect in Italy



A. 95%Confidence Interval for $\gamma_{R\pi}$ - $\lambda_{\pi R}$
(1975:1-1989:4 Italy)



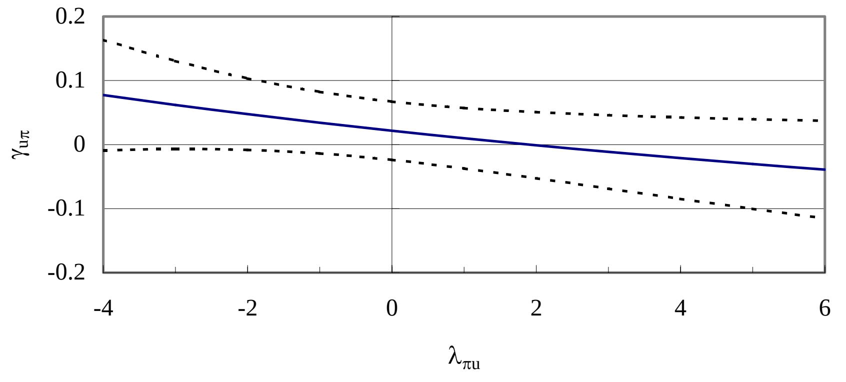
B. 95%Confidence Interval for $\gamma_{R\pi}$ - $\lambda_{R\pi}$
(1975:1-1989:4 Italy)



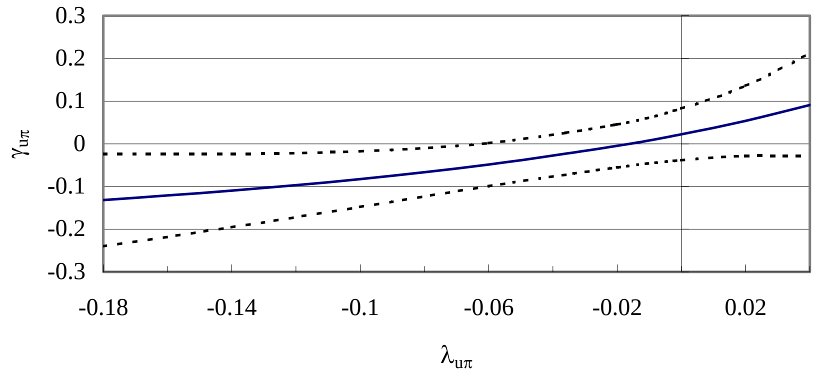
C. 95%Confidence Interval for $\gamma_{R\pi}$ - $\gamma_{\pi R}$
(1975:1-1989:4 Italy)

Figure 4 Evidence on the Phillips curve in Japan

A. 95%Confidence Interval for $\gamma_{u\pi}$ - $\lambda_{\pi u}$
(1971:1-2000:4 Japan)



B. 95%Confidence Interval for $\gamma_{u\pi}$ - $\lambda_{u\pi}$
(1971:1-2001:4 Japan)



C. 95%Confidence Interval for $\gamma_{u\pi}$ - $\gamma_{\pi u}$
(1971:1-2001:4 Japan)

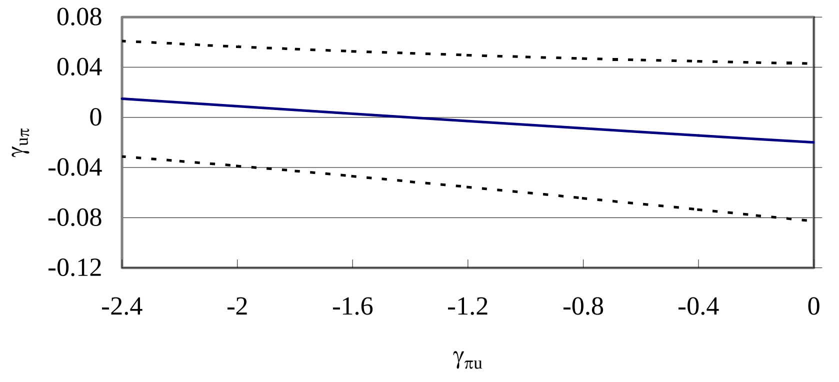
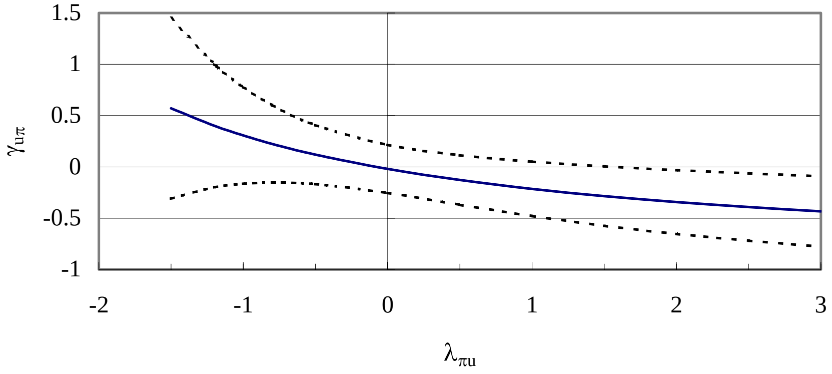
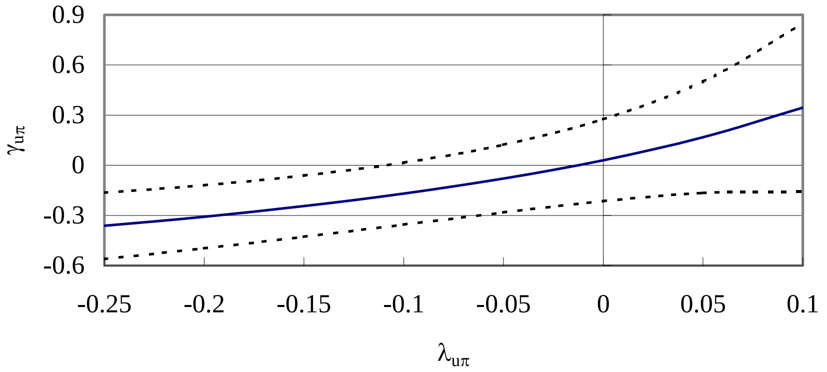


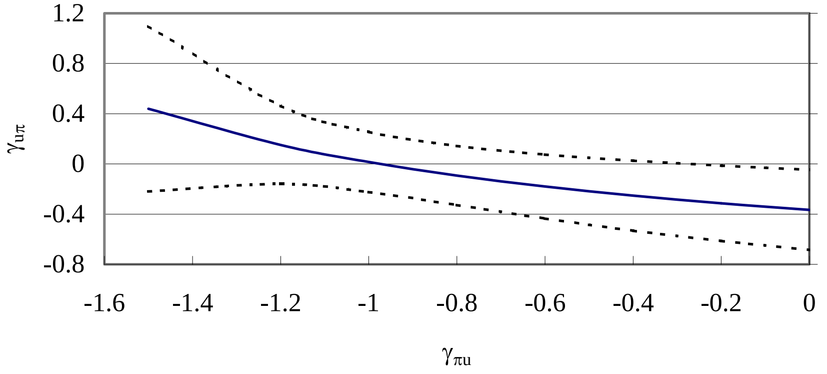
Figure 5 Evidence on the Phillips Curve in Sweden



A. 95%Confidence Interval for $\gamma_{u\pi}$ - $\lambda_{\pi u}$
(1963:1-2001:2 Sweden)

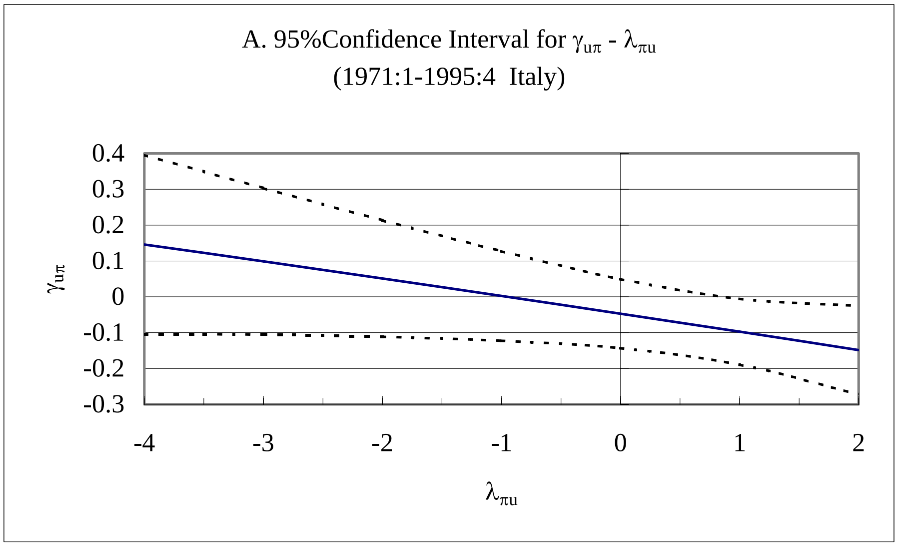


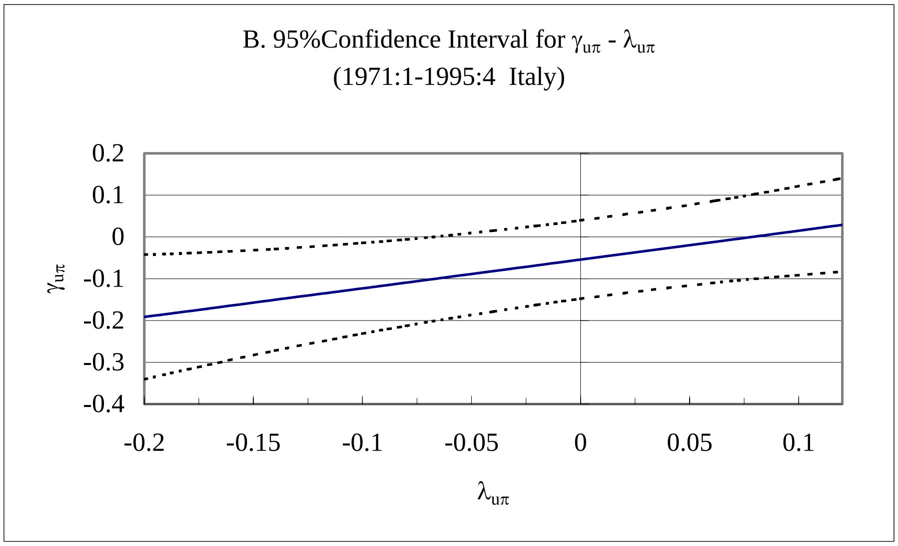
B. 95%Confidence Interval for $\gamma_{u\pi}$ - $\lambda_{u\pi}$
(1963:1-2001:2 Sweden)

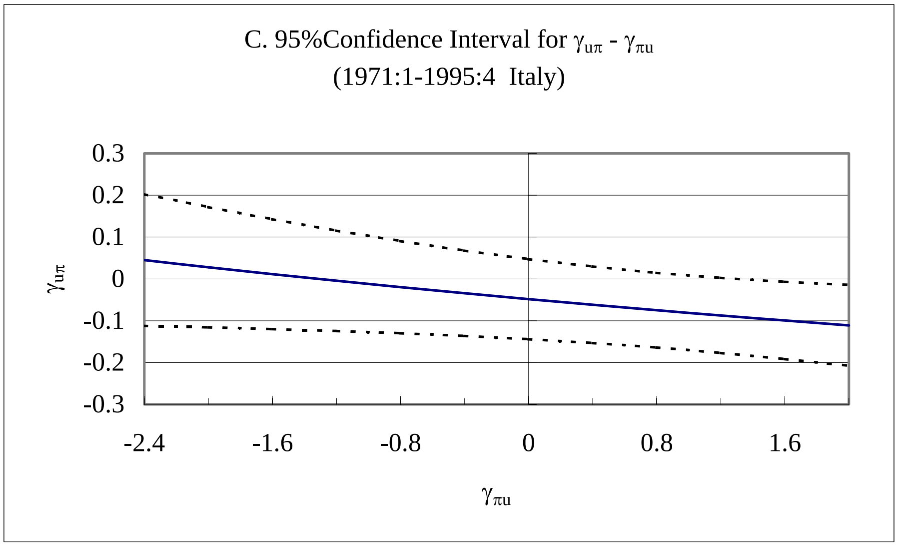


C. 95%Confidence Interval for $\gamma_{u\pi}$ - $\gamma_{\pi u}$
(1963:1-2001:2 Sweden)

Figure 6 Evidence on the Phillips curve in Italy


A. 95%Confidence Interval for $\gamma_{u\pi}$ - $\lambda_{\pi u}$
(1971:1-1995:4 Italy)


B. 95%Confidence Interval for $\gamma_{u\pi}$ - $\lambda_{u\pi}$
(1971:1-1995:4 Italy)


C. 95%Confidence Interval for $\gamma_{u\pi}$ - $\gamma_{\pi u}$
(1971:1-1995:4 Italy)