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INTEREST RATE AND INFLATION EXPECTATIONS IN FINLAND 1987–1994: A CASE FOR THE INVERTED FISHER HYPOTHESIS

MIKA LINDEN

Department of Economics, P.O.BOX 54 (Unioninkatu 37),
FIN-00014 UNIVERSITY OF HELSINKI, Finland

The relationship between interest rates and the rate of inflation is analyzed with cointegration methods in the context of the inverted Fisher hypothesis. The hypothesis is not rejected. The results indicate that the main reasons for the interest rate behaviour in the period 1987/I–1995/III were positive and over reacting dependence on foreign interest rates and negative dependence on the exchange rate. Real interest rates react to the inflation rate with a coefficient value of close to –1, and the inflation effects on the nominal rates are insignificant. One step recursive predictions of inflation process support the existence of a negative price expectations effect on the real interest rates. (JEL E37, E43, F41)

1. Introduction

The connection between interest rates and the rate of inflation has been one of the cornerstones of macroeconomic theory and policy. The real interest rate is an economic variable that affects all intertemporal decisions and as such influences both aggregate consumption and investment decisions. Fisher (1930) argued that any changes in the expected inflation rate will be reflected in the nominal interest rate and, hence, *ceteris paribus* the real *ex ante* interest rate will be constant over time. However, the validity of the Fisher effect has been questioned many times both empirically (see Holden et al. 1985, Mishkin 1991 and 1988) and theoretically (see Wray 1992, Carmichael and Stebbing 1983). One to one correspondence between nominal interest rates and inflation expectations or non- significant inflation coefficients in real interest rate regression have seldom been found in the literature.

Since the liberalization of the Finnish loan and financial markets in 1986, commercial interest rates have been determined on the markets. The overvalued Fmk (Finnish Markka) and the overheated economy of the late 1980s led to a major recession in the 1990s with a devaluation of the currency in September 1991, and to the floating of the currency in October 1992. Although these incidents had their own impact on the interest rates, the announced target of the Bank of Finland has also lately been a downward trend in the inflation rate and lower inflation expectations in order to boost the economy with low interest rates. This type of policy is a direct outcome of attachment to the strong version of the Fisher effect, i.e. inflation expectations drive nominal interest rates with a unit value.

In this article, the effects of inflation expectations on interest rates are analyzed using a linear time series model when the effects of foreign interest and exchange rates are controlled. Irrespective of the dependent variable (a 3- or 36-month interest rate) and sample period, the inflation expectations variable has a significant *negative* impact on real interest rates and an *in-*

significant effect on nominal rates. The results question the validity of the basic Fisher effect and the policy based on it.

2. Econometric Specification

The (expected) nominal rate of interest for a one-period asset can decomposed as

(1) $E(i) \equiv E(r) + E(\dot{p})$

i.e. the 'Fisher' identity, where i is the nominal interest rate, E(r) is the expected real rate and and $E(\dot{p})$ is the expected inflation rate. However, the definition of the (ex post) real interest rate is

(2) $r \equiv i - \dot{p}$.

The following two basic assumptions are made:

a) inflation expectations are unbiased, $\varepsilon \sim (0, \sigma^2_\varepsilon)$

$$\dot{p} = E(\dot{p}) + \varepsilon$$

b) the nominal interest rate is known at the date of the financial transaction

$$E(i) = i$$

Combining these with (1) and (2) yields

(3) $r - E(r) = E(\dot{p}) - \dot{p} = -\varepsilon$.

This means that the actual deviation of the real rate from the expected rate will be the inflation forecast error with a minus sign. Naturally, if actual inflation is above expected inflation, the actual real interest rate is adjusted downwards. Thus, the expected real return or interest rate (or the inverted Fisher hypothesis, see Carmichael and Stebbing 1983) is defined as

(5) $E(r) = \alpha_o - E(\dot{p}) + \mu$, or, (5') $i = \alpha_o + \mu$,

where α_o is the constant premium of a financial asset and μ is a random variable with $E(\mu) = 0$. It is assumed that ε and μ are independent. The model in (5) or (5') is based on the implicit assumptions that financial assets and money are close substitutes, financial assets and capital are poor substitutes, and the nominal rate of return of money is regulated to zero. The approach is reasonable considered the turmoil in the Finnish financial markets in the post-1986 period. This framework allows for constancy of nominal interest rates. The nominal interest rate should be independent of $E(\dot{p})$ or $(\dot{p})$:

(6) $i = \alpha_o + \alpha_1 \dot{p} + \mu$.

The hypothesis is $\alpha_1 = 0$.

Alternatively, it is possible to test a model in Eq. (5). Eq. (3) is used to eliminate the unobservable E(r) in (5), i.e. the ex post real interest rate is obtained in the form of testable model (the inverted Fisher hypothesis)

(7) $r = \alpha_o + \alpha_2 E(\dot{p}) + \mu - \varepsilon$
$= \alpha_o + \alpha_3 \dot{p} + \mu - (1 + \alpha_3)\varepsilon$,

The hypothesis is now that $\alpha_2 = -1$ or $\alpha_3 = -1$. All these hypotheses rest on the assumption that $\text{cov}(i, \dot{p}) = \text{cov}(\mu, \dot{p}) = 0$. This means that the (expected) rate of inflation is an *exogenous* variable in the above models, and the OLS estimation is consistent.

These equations are evidently too simple to reveal the observed movements of interest rates. In order to test the hypotheses, the effects of other variables have to be controlled. The following structural equations, which add the exchange rate (exr) and foreign interest rates (fi) as explanatory variables in equations (6) and (7), are estimated

(8) $i = \beta_o + \beta_1 \dot{p} + \beta_2 fi + \beta_3 exr + \mu$.

(9) $r = c_o + c_1 \dot{p} + c_2 fi + c_3 exr + \mu - (1 + c_1)\varepsilon$

The testable hypotheses are now:

in (8) $\beta_1 = 0$, $\beta_2 = 1$, in (9) $c_1 = -1$, $c_2 \leq 1$

Hypotheses $\beta_1 = 0$ and $c_1 = -1$ test the inverted Fisher hypothesis. The other tests concern interdependence among international capital markets. Hypothesis $\beta_3 = 1$ stems from interest rate parity. The same reason is valid for hypothesis $c_2 \leq 1$. However, inequality is used because Eq. (9) is specified for real interest rates and fi is nominal foreign rates. At this moment no hypothesis are specified for β_3 and c_3 because different approaches imply contradictory results concerning the relationship between interest rates and exchange rates. The Frenkel-Dornbusch approach implies $\partial r/\partial exr < 0$, but some monetarist approach gives $\partial r/\partial exr > 0$ (for more details, see Cuthbertson and Taylor 1987, p. 196–215). Notice that equation (9), or (7) when the inverted Fisher hypothesis is true, does not have the errors in variable problem often found in expectation models. Both equations (8) and (9) contain only observable variables.

3. Data

Monthly observations from the time period January 1987 to March 1995 we used (99 observations). Both the short-term interest rate, the 3-month Helibor rate $R3_t$ (the bid rates quoted daily at 1 p.m. by the five largest banks in Finland), and the long-term interest rate, the 36-month long-term reference rate $R36_t$ (the monthly averages of the bid rates quoted daily by the five largest banks and based on the market rates for taxable, fixed-rate bullet bonds issued or guaranteed by banks), are analyzed. The exchange rate, EXR_t, is measured with the trade-weighted currency index (1982 = 100) calculated by the Bank of Finland. fi_t is measured with 12-month ECU interest rates, $ECU12_t$ (average Euromarket rates weighted by the respective weights of the currencies making up the ECU basket). For the long-term interest models, the long-term (bond) interest rates in Sweden and Germany were used instead of $ECU12_t$, but the results were very close to the models that include $ECU12_t$. The inflation rate is defined as $INF_t = \Delta \ln(P_t - P_{t-12})$, where P_t is the consumer price index (1990 = 100). The real interestrates are defined as $RR3_t \equiv R3_t - INF_t$ and $RR36_t \equiv R36_t - INF_t$.

4. Results

Unit root test

If the basic series in the analysis are integrated at different degrees, the proposed framework is not motivated. For example, if the inflation rate is a I(1) series and the interest rates are I(0) series, the Fisher hypotheses are without solid ground (see Rose 1988). In the following, the augmented Dickey-Fuller test (ADF) is used as unit root test, and the KPSS-test (see Kwiatkowsky et al. 1991) as a stationary test. This joint testing gives a firmer basis to the inference (see Linden 1995).

The test results support the interpretation that all the series are unit root series (see Appendix 1). Notice that the real interest rate series $RR3_t$ and $RR36_t$ are also I(1) series. Thus, nominal interest rate series are not cointegrated with the inflation rate with vector [–1 1], i.e a model such as $R36_t = \alpha + \beta INF_t + \eta_t$ with $\beta = 1$ and stationary η_t is not reasonable. In other words, it is not possible to build stationary real interest-rate expectations based solely on the nominal interest rates and inflation expectations. Notice also it is only assumed that the expectation of a nominal interest rate is constant (see Eq. 6). However, some more complicated structural cointegrated model may be valid for interest rates.

Cointegration

Johansen's canonical correlation method was used to analysis the possible cointegration between the series (for more details, see Johansen 1988, 1992). Johansen's system method is based on the following ECM parametrization of the VAR model for X_t

$$(10) \quad \Delta X_t = \mu + \textstyle\sum_1^k \Gamma_i \Delta X_{t-i+1} + \Gamma_k X_{t-k} + \varepsilon_t, \\ \varepsilon_t \sim NID(0,\Omega)$$

where $\Gamma_k X_{t-k} \sim I(0)$ if cointegration exists. Cointegration tests are derived as solutions to the eigenvalue problem $|\lambda S_{kk} - S_{k0} S_{00}^{-1} S_{0k}| = 0$, where $S_{ij} = T^{-1} \Sigma_1^T R_{it} R'_{jt}$, i,j = 0 or k, and R_{0t} is the vector of residuals from regressing ΔX_t on $\{\Delta X_{t-1},\ldots,\Delta X_{t-k}\}$ and R_{kt} is the corresponding

Table 1. Johansen's Maximum Likelihood Tests for Cointegration. 96 observations from April 1987 to March 1995. Non-trended case, lag in VAR = 3. (*) = significant test value: null alternative, the number of cointegration vectors (r) is rejected).

Variables 1)		[R3, INF EXR, ECU]	[R36, INF EXR, ECU]	[RR3, INF EXR, ECU]	[RR36, INF EXR, ECU]	
Null	Alternative					
Maximal	*Eigenvalue Test*					*95 % Crit. Value*
r = 0	r = 1	31.82*	42.14*	31.82*	42.02*	28.13
r <= 1	r = 2	21.00	19.79	22.50	19.67	22.00
r <= 2	r = 3	8.71	8.54	8.71	8.49	15.67
r <= 3	r = 4	1.75	2.39	1.75	2.15	9.24
Trace Test						
r = 0	r >= 1	63.31*	72.87*	64.78*	72.34*	53.11
r <= 1	r >= 2	31.48	30.73	32.96	30.32	34.91
r <= 2	r >= 3	10.47	10.93	10.47	10.65	19.96
r <= 3	r = 4	1.75	2.39	1.75	2.15	9.24
Cointegration vectors						
		−1	−1	−1	−1	
		0.143	−0.476	−0.856	−1.467	
		0.612	−0.271	−0.925	−0.270	
		1.421	1.496	1.421	1.496	
Model residual diagnostics						
AR(6)		.99	1.37	.39	.52	
		F[6,74]	F[6,76]	F[6,74]	F[6,76]	
Normality χ^2 (2)		2.44	.49	.24	.44	
ARCH(6)		1.12	.30	.19	.74	
		F[6,68]	F[6,70]	F[6,68]	F[6,70]	
White's HET		.74	.67	.69	.79	
		F[24,55]	F[24,57]	F[24,55]	F[24,57]	
Exogeneity tests						
$a_2=a_3=a_4=0$	$\chi^2(3)$	10.89*	3.81	11.14*	3.93	
$a_2=0$	$\chi^2(1)$	0.25	1.57	0.33	1.96	
Tests for economic hypotheses						
$\beta_1=\beta_3=0, \beta_2=1$	$\chi^2(3)$	11.75*	14.77*			
$\beta_1=0, \beta_2=1$	$\chi^2(2)$	5.44	13.01			
$\beta_1=0$	$\chi^2(1)$	0.79	12.19			
$c_1=-1, c_2=1, c_3=0$	$\chi^2(3)$			11.33*	14.03*	
$c_1=-1, c_2=1$	$\chi^2(2)$			5.31	14.26*	
$c_1=-1$	$\chi^2(1)$			0.82	12.36*	

1) Short run interest rate models include dummy variables for observations 1989/5, 1989/12 and 1990/4. Long run interest rate models include dummy variable for observation 1994/6. All models include a constant term. *) significant at 5 % level.

vector for X_{t-k}. The cointegration tests are adjusted by factor (T−nk)/T as Johansen's method is biased in favour of the cointegration alternative in small samples (Reimers 1992). All variables, including inflation, are assumed to be endogenous at this moment. The results show (see Table 1.) that one cointegration vector is valid for all four systems, i.e. series ($R3_t$, INF_t, EXR_t, $ECU12_t$), ($R36_t$, INF_t, EXR_t, $ECU12_t$), ($RR3_t$, INF_t, EXR_t, $ECU12_t$) and ($RR36_t$, INF_t, EXR_t, $ECU12_t$) are each cointegrated.

Cointegration vectors

The estimated cointegration vectors reveal that the short-term nominal interest rate, $R3_t$, is mainly determined by the foreign interest rate, and its impact is well above unity. The inflation effect hypothesis is weak, because inflation variable has a coefficient close to zero. The exchange rate effect is positive with value of 0.612. For the long-term nominal interest rate, $R36_t$, the parity condition is equally strong and the inflation effect is negative. However, the exchange rate effect is negative. Thus, the appreciation of the Fmk (i.e. EXR falls) leads to higher long term interest rates. For real interest rates, the foreign interest rate effects are like above, and the effect of the exchange rate negative. However, the real interest rate effects of inflation are around –1. Note, that this is just what the inverted Fisher hypothesis predicts.

Exogeneity

The Johansen approach allows for testing exogeneity (in a weak sense) for the parameters of interest (in this case, the long-run parameters, i.e. cointegration vectors). The test builds on the restrictions on $-\Gamma_k = ab'$. If some of the vectors of adjustment matrix a are equal to zero, then some long run solution vectors in matrix b do not enter model ΔX_t. The asymptotic χ^2 tests for exogeneity (see Table 1.) support the notion that INF_t is an exogenous series in all cointegration models with short and long term term interest rates ($a_2 = 0$). The test values for $a_2 = a_3 = a_4 = 0$ test indicate that for the long term interest rates INF_t, $ECU12_t$ and EXR_t are exogenous (in weak sense). This result opens a single equation modelling alternative for long term interest rates (see below).

Testing for economic hypotheses

The underlying economic model implied to some precise economic hypotheses (see Eqs. (6), (8) and (9) above). The testing can be done with the Johansen approach by constraining the cointegration vectors in b according the hypotheses. In all tests the inverted Fisher hypothesis is tested: $\beta_1 = 0$ or $c_1 = -1$. In addition, the unit response of foreign interest rates ($\beta_2 = c_2 = 1$) and non-significant exchange rate effects ($\beta_3 = c_3 = 0$) are tested also. Under the cointegration the tests statistics are asymptotically χ^2 distributed. The tests results show that joint hypotheses are rejected. However, the inverted Fisher hypothesis is not rejected for short term models. At same time the parity condition is valid also. The exact hypothesis are rejected for long term interest rates. The strong version of the direct Fisher effect, i.e. inflation expectations drive nominal interest rates with a *positive unit value*, is not supported by the data. Moreover, the weak version, a positive relationship between the inflation rate and interest rates, is not supported either.

Sub-sample results

In October 1992 the Fmk was changed to floating currency. This means that the sample period analyzed consists of two different policy regimes in respect to exchange rate. The possible interest rate effects are analyzed in Table 2. with cointegration approach for sub-sample period starting from September 1992.

The fragile results indicate that inverted Fisher hypothesis is not anymore so strong as in the full sample. Two cointegration vectors are valid for real interest rate models. However, the results in Table 2. are very sensitive to lag length used in VAR-model because of short sample period. Precise economic hypotheses testing was not done.

One-step inflation predictions

The results in Table 1. imply that long-term interest rates may be used as inflation predictors. Since by definition, estimated real rate can be used to generate inflation forecasts,

$$(12) \quad i_t - E(r_t) \equiv E(\dot{p}_t).$$

Thus, subtracting the best prediction for long-term real interest rates $E(r_t) = \widehat{RR36}_t$ from current long term nominal interest rates, $R36_t$ gives a prediction for the expected inflation rate. The efficient and unbiased single equation estimation corresponds to the calculation of the static long run solution of the general autoregressive model $A_1(B)RR36_t = \mu + \beta D_{94/6} + A_2(B)INF_t + A_3(B)ECU12_t + A_4(B)EXR_t + \varepsilon_t$, where $\varepsilon_t \sim NID(0, \sigma^2)$, and $A_i(B)$, $i = 1,..,4$ is a lag polynomial of order 3 normalized at $A_i(0) = 1$. $D_{94/6}$ is a dummy variable for the wider value-add tax base introduced June 1994. The estimated (OLS) long run solution was following

Table 2. Johansen's Maximum Likelihood Tests for Cointegration. 96 observations from September 1992 to March 1995. Non-trended case, Lag in VAR = 1. (*) = significant test value: null alternative, the number of cointegration vectors (r) is rejected).

Variables		[R3, INF EXR, ECU]	[R36, INF EXR, ECU]	[RR3, INF EXR, ECU]	[RR36, INF EXR, ECU]	
Null	Alternative					
Maximal	*Eigenvalue Test*					*95 % Crit. Value*
r = 0	r = 1	37.05*	38.30*	36.95*	38.30*	25.55
r<=1	r = 2	21.58*	25.79*	23.54*	25.79*	19.76
r<=2	r = 3	6.58	8.27	7.36	8.27	13.75
r<=3	r = 4	3.32	6.71	3.34	6.71	7.52
Trace Test						
r = 0	r>=1	68.53*	79.08*	68.21*	79.08*	49.65
r<=1	r>=2	31.48	40.78*	31.25	40.78*	32.00
r<=2	r>=3	9.90	14.99	9.71	14.99	17.85
r<=3	r = 4	3.32	6.71	3.34	6.71	7.52
Cointegration vectors						
		–1	–1	–1	–1	
		0.715	1.412	–0.235	.412	
		–0.535	0.423	–0.558	.423	
		0.240	3.463	0.175	3.463	
			–1		–1	
			42.856		41.271	
			5.925		5.925	
			–23.143		–23.143	
Model residual diagnostics						
AR(3) F(3,15)		.64	.83	1.68	1.66	
Normality $\chi^2(2)$		.66	2.81	4.85	3.44	
ARCH(6) F(3,12)		.68	1.30	4.29*	2.74	
			1.77		2.35	
			6.67*		6.52*	
			2.56		4.42*	

$$\begin{array}{l}\hat{RR36}_t = .069 + .044D_{94/6} - 1.465INF_t \\ \qquad\quad (2.13)\ \ (2.42)\qquad\ (9.37) \\ -.527EXR_t + 1.337ECU12_t \\ \quad (2.40)\qquad\ (8.27)\end{array}$$

Model diagnostics: $R^2 = .949$, SE = .0038
AR(6): F[6,76] = .52
Normality: $\chi^2(2) = .88$
White's HET: F[25,56] = .50

Notice the estimates are close to corresponding cointegration vector result in the Table 1. Figure 1 gives ±2*SE bands for the recursive one-step predictions from OLS model above for RR36 and true inflation process. The inflation process is between the ±2*SE bounds most of the time. Results are similar for the short run interest rates series.

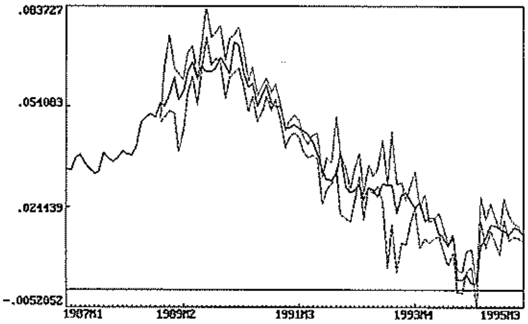

Figure 1. Recursive one-step prediction 2*SE bounds for inflation rate calculated via 'Fisher identity' with long-term interest rates (INF = R36 –$\hat{RR36}$).

These results mean that the expected inflation process can be successfully predicted using the correct model for real interest rates. Thus, the relationship between interest rates and the inflation process is more complex than the standard Fisher identity implies. In (12), the expected inflation process is predicted using real interest rate predictions, not only by nominal interest rates. The results are converse to the standard Fisher identity and to the predictions based on it, that assume that the long-run real rate is nearly constant and nominal interest rates contain all the information about inflation rate expectations.

5. Conclusion

The relationship between interest rates and the rate of inflation is often analyzed in the context of the Fisher hypothesis. One version of this hypothesis, an inverted Fisher hypothesis, is analyzed in the paper using cointegration methods. The results indicate that the main reasons for real interest rate behaviour in the period from January 1987 to March 1995 were the positive and overreacting dependence on foreign interest rates and negative exchange rate dependence. Inflation expectations are not responsible for high interest rates. Results provide support for the existence of a negative price expectations effect on the real interest rates. However, the real interest rates predictions subtracted from observed nominal rates leads to statistically well established expected inflation predictions.

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Appendix 1.

ADF( ) test for series $R3_t$, $R36_t$, INF_t, $RR3_t$, $RR36_t$, EXR_t, and $ECU12_t$ with lag values k = 1,4,12.

	ADF(1)$_{c,t}$	ADF(1)$_c$	ADF(4)$_{c,t}$	ADF(4)$_c$	ADF(12)$_{c,t}$	ADF(12)$_c$
R3	–1.55	–1.29	–1.36	–1.16	–1.05	–1.37
ΔR3		–5.05		–5.07		–4.21
R36	–2.10	–1.93	–2.54	–2.48	–2.27	–2.37
ΔR36		–4.46		–4.51		–2.61
INF	–1.91	–0.42	–1.92	–0.74	–2.71	–1.20
ΔINF		–8.19		–8.15		–3.68
RR3	–1.63	–1.83	–1.65	–1.89	–1.09	–1.65
ΔRR3		–6.48		–4.68		–2.12
RR36	–1.99	–1.77	–2.54	–2.26	–2.36	–1.75
ΔRR36		–6.11		–3.48		–2.19
EXR	–1.90	–0.82	–1.96	–0.99	–1.85	–0.91
ΔEXR		–6.70		–2.89		–2.84
ECU12	–1.03	–0.72	–0.96	–0.62	–1.41	–1.83
ΔECU12		–5.56		–2.90		–2.89

Critical values: 5 % –3.41 (c/t), –2.88 (c), H_0: series with a unit root is rejected if the test values are less than the critical values (c = a test model including a constant term, c/t = a test model including a constant term added with a trend).

KPSS test for series $R3_t$, $R36_t$, INF_t, $RR3_t$, $RR36_t$, EXR_t, and ECU12 with lag values k = 1,4,12.

	KPSS(1)$_{c,t}$	KPSS(1)$_c$	KPSS(4)$_{c,t}$	KPSS(4)$_c$	KPSS(12)$_{c,t}$	KPSS(12)$_c$
R3	0.946	1.065	0.494	0.556	0.202	0.228
ΔR3		0.378		0.298		0.309
R36	0.814	1.104	0.533	0.595	0.206	0.232
ΔR36		0.170		0.122		0.088
INF	0.939	2.673	0.488	1.371	0.191	0.512
ΔINF		0.349		0.415		0.308
RR3	0.698	1.066	0.373	0.566	0.163	0.239
ΔRR3		0.161		0.148		0.189
RR36	0.437	1.058	0.231	0.555	0.103	0.235
ΔRR36		0.124		0.105		0.082
EXR	0.924	2.891	0.479	1.488	0.188	0.547
ΔEXR		0.281		0.251		0.185
ECU12	1.032	1.152	0.533	0.595	0.206	0.232
ΔECU12		0.410		0.344		0.193

Critical values: 5 % 0.146 (c/t), 0.463 (c), H_0: stationary is rejected if the test values are bigger than the critical values.