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DETERMINATION OF INTEREST RATES IN SMALL OPEN ECONOMIES: A REVIEW OF RECENT EVIDENCE

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ABSTRACT

This paper examines the determination of interest rates in small open economies. We use the classical interest rate parity relationships as a starting point in developing a test procedure which allows us to evaluate the importance of various domestic shocks (in particular, monetary and fiscal shocks). This, in turn, gives us some estimates of the degree of monetary autonomy in the respective countries. The empirical analysis covers seven small European countries; the sample period is 1980M1 - 1987M12. The general result of this study is that the uncovered interest parity relationship is not sufficient to explain the movement in domestic interest rates, particularly in short-term rates.

CONTENTS

1 INTRODUCTION

A standard procedure when analyzing the determination of interest rates is to make use of the classical Fisher parity or the Keynesian IS/LM model. In the former case only expected inflation is focussed on while in the latter case a reduced-form interest rate equation is derived so that, in addition to expected inflation, the list of explanatory variables includes money supply, the government deficit and some other (exogenous) demand distributions. A great number of empirical analyses have been carried out, particularly in the U.S., using one of these alternative approaches. It is not the intention here to discuss the results of these studies; the interested reader is referred to e.g. Levi and Makin (1979) and Makin (1983). This is mainly because the closed economy setting used in these studies is not very realistic for most (European) countries. In this paper, by contrast, we are concerned with trying to model the behavior of interest rates in small open economies only.

An attractive alternative to the above-mentioned models in an open-economy setting is the classical interest rate parity relationship. This relationship implies that domestic interest rates are completely determined by foreign interest rates and expected rates of change in exchange rates. Thus, domestic factors do not play any role: they can affect domestic interest rates only via exchange rate expectations!

Clearly, from the policy perspective it makes a vast difference whether or not domestic interest rates follow the interest rate parity relationship. If they do, that means the absence of monetary autonomy. The question of monetary autonomy, in turn, is generally of crucial importance for small countries, and its importance has increased considerably during recent years owing to deregulation of banking and capital movements.

When evaluating the current situation it is worth bearing in mind that even though prices are now fully flexible and agents can efficiently exploit market arbitrage opportunities, this does not imply the existence of the interest rate parity relationship (and the absence of monetary autonomy). In a setting characterized by uncertainty and risk aversion the parity relationship will ultimately fail and, at least in principle, monetary policy can affect domestic interest rates.[1)]

A central theme in our review is not, however, uncertainty itself. That is partly because there already exists a number of studies focusing on this issue (using the so-called conditional heteroscedasticity model as a point reference); see e.g. Cumby and Obstfeld (1985). Rather, we examine the problem of interest rate determination in a framework which is based instead on a closed-economy model. Given this model we propose and implement a test which is some sort of "non-nested" test in terms of the reduced-form interest rate equation à la standard closed-economy IS/LM model and the (uncovered) interest rate parity.

The paper is organized as follows. Section 2 reviews the basic elements of the above-mentioned theories and derives the test procedure. Section 3 first presents some stylized facts on the data and then carries out the econometric tests. The data used in our analyses are derived from seven small European countries: Austria, Denmark, Finland, Iceland, Norway, Sweden and Switzerland. The sample period in these analyses is (with some exceptions) 1980M1 - 1987M12. Finally, Section 4 offers some conclusions.

2 FORMULATION AND DISCUSSION OF THE HYPOTHESES

The purpose of this section is first to set out a conventional macroeconomic model of interest rates and then to use this model as a basis for tests of monetary autonomy. The model can be derived from the following Keynesian-type setting:

(1) $$y_t = \alpha(R_t - E_t(p_{t+1})) + \beta' Z_t$$

(2) $$(M_t - P_t) = \gamma R_t + \theta y_t,$$

where t is an index of time, R_t an interest rate on one-period bonds, y_t real income, p_t the inflation rate, E_t the expectations operator conditional on information known at time t, M_t money supply, P_t the price level and Z_t a vector of all other variables that affect aggregate demand. In particular, Z_t includes measures of the real government deficit, G_t, and real net exports, X_t. y_t, Z_t, M_t and P_t are expressed in logs.

Conventional macroeconomic theory suggests that a country's nominal interest rate should be a decreasing function of the domestic real money supply and an increasing function of the domestic inflation rate and of the positive demand shift variables (i.e. both real deficits and real net exports).

These considerations suggest the following reduced form for the nominal interest rate:

(3) $$R_t = a_1 E_t(p_{t+1}) - a_2(M_t - P_t) + a_3' Z_t,$$

where all coefficients, a_i, are positive (notice that a_1 is not necessarily unity so that the Fisher parity may not hold in this setting). Because the expected inflation rate is not observable, we cannot really test these coefficient restrictions unless some assumptions are made about how agents in securities markets form expectations. Obviously, this is the hot pot of the whole analysis. If agents form expectations as least squares predictions from the right-hand-side variables (M_t - P_t), G_t, X_t (and so on), the final operational equation precisely includes these variables (not, however, $E_t(p_{t+1})$) but we cannot really estimate it and test the implied coefficient restrictions.[2)]

If, however, we close the model using some weaker form of rational expectations, (3) may still be used a basis for the estimating equation. Unfortunately, to obtain this result, highly restrictive assumptions must be made about, for instance, economic policy (it is hard to believe that possible error term in (3) could be uncorrelated with the all right-hand-side variables).

So far, we have proceeded as though we had a closed economy in terms of the financial sector. Clearly, this assumption is not valid - at least for the countries we intend to scrutinize. But what happens if there is some degree of capital mobility between countries? That is something we do not know. We only know that in the case of perfect capital mobility the following uncovered interest rate parity (UIP) condition holds:

$$(4) \qquad R_t = R_t^f + E_t(S_{t+1} - S_t),$$

where R_t^f is the foreign interest rate and $E_t(S_{t+1} - S_t)$ the expected rate of depreciation of the (log) exchange rate. Condition (4) must hold when bonds differing only in their currencies of denomination are perfect substitutes in investors' portfolios.[3)]

Now, how do we test (4) against (3)? The standard procedure is to use the UIP as the maintained hypothesis and interpret a failure to reject this hypothesis as rejection of the "closed-economy model" model (3). But the problem is that (4) is crucially dependent, inter alia, on assumptions about the nature of uncertainty and agents' behavior towards risk. Therefore we prefer not to fix the maintained hypothesis but to treat both the hypotheses in the same way and arrange the test in the "non-nested" test framework so as to be able to compare the performance of the alternative hypotheses. For instance, we would like to see whether it is specifically domestic money supply disturbances which "break" the UIP relationship. In practice this means estimating the following composite models for R_t:

(5) $$R_t = b_0 + b_1 R_t^f + b_2 s_{t+1}^e + b_3 p_{t+1}^e + b_4 m_t + b_5' Z_t + u_t,$$

and/or

(6) $$R_t = c_0 + c_1 R_t^f + c_2 s_{t+1}^e + c_3 \hat{R}_t + v_t,$$

where s_{t+1}^e and p_{t+1}^e denote the expected rates of change in the exchange rate and the price level, respectively, $m_t = (M_t - P_t)$, and $\hat{R}_t$ is the predicted value of R_t given by p_{t+1}^e, m_t and Z_t. (For details of the test procedures see e.g. Mizon and Richard (1986) and Davidson and MacKinnon (1981)). Now, the test boils down to testing the parameter restrictions $b_1 = b_2 = 0$ and $(b_0 =)$ $b_3 = b_4 = b'_5 = 0$ and/or $c_3 = 1$.4)

3 EMPIRICAL RESULTS

3.1 The Data

The data used in this study are derived from seven small European countries: Austria, Denmark, Finland, Iceland, Norway, Sweden and Switzerland. These countries have been chosen because they represent a fairly homogenous entity both in terms of economic development and institutional framework. The sample period is (19)80M1 - (19)87M12. The period has not been extended back to the 1970s because there were no market-determined (domestic) interest rates in most of these countries at that time. By contrast, the 1980s represent a period in which most of the controls on interest rates and capital movements have been removed, and so testing of various economic hypotheses starts to make sense.

Some idea of the behavior of interest rates can be obtained by scrutinizing the sample averages of the national and the Euro rates which (together with the data for inflation) are presented in Table 1.[5] On the basis on these data one can readily conclude that there are noticeable differences between the sample countries (both in terms of the nominal interest rates and the rate of inflation) and between the domestic and Euro rates of interest. This also suggests that the hypotheses which were discussed above may be of different relevance for different countries.[6]

3.2 Regression Estimates

Before we can think about estimating (5) we have to derive the values for p^e_{t+1} and s^e_{t+1}. As pointed out earlier, this is not very easy. The standard way of doing this is to use the forecasts from some time series models, typically from univariate ARIMA models. But the problem is that the differences of the log price level and the log exhange rate can approximated fairly well by the random walk process. This is particularly true with respect to one-month log differences (see the sample autocorrelation functions reported in Table 2). The three-month log differences, however, differ somewhat from random walk and given these data we can derive the expected values of s_{t+1} and p_{t+1} by means of ARIMA models.

Even though it is technically possible to derive the expected values there is no guarantee that the corresponding proxies are "correct". There is an ample amount evidence suggesting that standard procedures of forecasting exchange rates perform rather poorly (see e.g. Frankel and Froot (1986) for details). A similar problem has been encountered with inflation forecasts, and if we intend to test hypotheses which are related to or which encompass the Fisher hypothesis the inflation forecastability is the crucial issue.[7)]

Obviously, the use of the predictions from ARIMA models is not the only way to specify the process of expectations formation. An alternative way is to assume that the expected change rates of the price level and the exchange rate are simply constant (cf. fn. 3). A further alternative is to assume that expectations are formed according to an unrestricted VAR model in terms of the remaining right-hand-side variables of the relevant reduced-form interest rate equation. Thus, the final reduced-form equation does not contain these expectations variables: the coefficients of remaining exogeneous variables only reflect the original direct effect and the induced inflation expectations and/or exchange rate depreciation expectations effect (cf. e.g. Evans (1987b) for details of this approach). Clearly, it very difficult to discriminate between these two latter alternatives and this is surely one of the main problems we face in this study.

We now turn to the estimation results, which are reported in Tables 3 to 9. The estimates correspond to a model which includes either the Eurodollar or the Euro-DM interest rate as an explanatory variable and, in addition, the constant term, expected inflation, p^e_{t+1}, real money supply, m_t, the real trade balance, tb_t, the expected rate of change in the exchange rate, s^e_{t+1} and the government real deficit, def.[8] We also introduced the rate of change in hourly earnings and industrial production (all lagged by one period), but these variables turned out to be systematically insignificant and hence the corresponding estimates are not reported here. (Throughout the empirical analysis it is assumed that the information set consists of variables which are observed at period t-1. The only exception is the foreign interest rate R^f_t.)

The basic results (with the level form data) can be summarized as follows: First, the foreign interest rates affect the domestic rates only marginally, and this is true even though the expected rate of change of the exchange rate is introduced in the model. Correspondingly, the domestic variables are not systematically insignificant. In particular, the (negative) money supply ("liquidity") effect can be clearly discerned. If one scrutinizes the test statistics connected with equations (5) and (6), it appears that uncovered intertest rate parity model does not encompass the "closed-economy model", see Table 3 for details.[9] Moreover, this conclusion seems to be more true with the short-term interest rates than with the long-term rates. (Cf. e.g. Sweden which provides a striking example of this pattern.)

The results reported in Table 3 are reinforced by the results of estimating a simple interest rate parity model of the type:

$$(7) \qquad R_t = d_0 + d_1 R^f_t + d_2 s^e_{t+1} + w_t.$$

The results which are reported in Table 4 indicate that the relationship between the domestic and the foreign interest rates is very weak and very sensitive, particularly in terms of differencing the data. Another result which appears here as well as in the context of estimating equations (5) and (6) is the fact that the time-series proxy variable for the expected change rate of the exchange rate performs very poorly. The corresponding coefficient typically has incorrect sign and it can only be estimated very unprecisely. Thus, we drop the variable from the final estimating equations.

Even though the results in Tables 3 and 4 suggest that the domestic variables are of primary importance, this is not necessarily the final truth. A closer look at the coefficients of the "domestic variables" reveals that the explanatory power is partly due to some spurious relationships. Thus, for instance, the proxy variable for expected inflation has in several cases a negative coefficient. Similar problems also arise in terms of the deficit variable and the trade balance (or current account) variable.[10)]

Thus, the test results presented in Table 3 are in a sense biased upwards. Perhaps a more reliable result is obtained by using a more simple estimating equation as a basis for testing the performance of the competing hypotheses. Such an equation is obtained by regressing the domestic rate against the foreign rate and the real money supply. The corresponding results are presented in Table 5. These results do clearly indicate that both (domestic) money supply and foreign interest rates affect the domestic rates; foreign interest rates again seem to be of more importance for the long than the short rates.

The main problem with these results, and in fact with all estimation results thus far presented, is that the residuals are very much autocorrelated. The first-order autocorrelation coefficient is typically .9 which, of course, means that almost nothing can be said of the true distributions of the computed t- and F-statistics.[11)]

It is not only that the residuals are autocorrelated, the structure of autocorrelation is typically rather complicated. Thus, for example, the assumption of AR(1) residuals can clearly be rejected, and hence residual autocorrelation cannot be substantially reduced by taking first differences of the data. All this means that we face a rather difficult choice in determining which model to use as the framework empirical testing. We have tried to solve the problem by using the following alternatives: 1) we estimated a state space model for the simple interest rate parity model (7) in order to find out the role of the exogenous foreign interest rate in the determination of the domestic rate, 2) we estimated the composite model using ARIMA residuals for RS, RS^f and m (the dimension of the model was reduced to these three variables for the reasons which were mentioned above), and 3) we estimated an unrestricted dynamic model for these three variables. This "general" dynamic model was estimated both by using OLS and by using an ARCH spefication to take into account the time-varying variance of the error term (which, in turn, may reflect the time-varying risk premium).

The results of these exercises are reported in Tables 6 (state space model), 7 (ARIMA residual model), 8 and 9 (general dynamic model). The OLS estimates of the general dynamic model are not reported here: only the F-test statistics for the relevant parameter restrictions are given in Table 8; the coefficient estimates of the corresponding the ARCH specification are reported in Table 9.

The results from these exercises are not completely different from those obtained by using untransformed level form data and completely static specification. So, most importantly we find that there is no instantaneous one-for-one relationship between domestic and foreign interest rates. Still, one can find a statistically significant effect from foreign interest rate on domestic rates. As far as the money supply effect is concerned the corresponding interest rate effects are not so important as the level form data might suggest (in the dynamic model the short-run money supply effect turns out to be negative while the long-run effect is typically positive; cf. Table 9).[12] But, clearly, the most striking feature in the results are the differences between countries. In the case of Switzerland and Sweden, and to a somewhat lesser extent Austria and Denmark, the interest rate parity relationship more or less encompansses the domestic factors while in the case of Finland, Iceland and Norway the interest rate parity relationship is to very weak or nonexistent. Obviously, this does not mean that with these countries interest rates are determined by domestic factors (only). Rather, one finds the whole interest rate behavior to be an unsolved puzzle which cannot really be explained without a more thorough analysis of the actions, rules and credibility of monetary and exchange rate policy.[13)]

4 CONCLUDING REMARKS

Our analyses have indicated that in the case of seven small European countries domestic interest rates are affected by both domestic and foreign shocks. Thus, it seems that the uncovered interest rate parity relationship is not sufficient to explain movements in domestic rates. Rather, in the short run at least, various domestic measures, particularly, changes in money supply, affect the interest rates. As far the long-run behavior is concerned, there are some signs that the interest rate parity relationship is of more relevance.

FOOTNOTES

1) Strictly speaking, the failure of interest rate parity does not necessarily imply that monetary policy is effective (see, e.g. Obstfeld (1982)). The theoretical foundations of the interest rate parity relationship are discussed more extensively in Roll and Solnik (1979).

2) The situation becomes much more complicated if the expectational implications of the so-called Ricardian equivalance hypothesis à la Barro are taken seriously (see Evans (1987a,b) for details).

3) Notice that in the case of static expectations we would simply have an equivalence between R_t and $R^f{}_t$.

4) See Edwards (1986) who represents a somewhat similar approach.

5) Interest rate and price index data are derived mainly from national sources, i.e. from central banks' publications. The other data are - with a few exceptions - taken from the OECD Main Economic Indicators. A detailed appendix containing the exact definitions and data sources together with a data printout is available upon request from the author. As far as the data in Table 1 are concerned, the domestic interest rate corresponds to treasury bill rates for Austria and Sweden, the short-term business loan rate for Denmark, the interest rate on banks' certificates of deposit for Finland, the interest rate on overdrafts for Iceland, the interbank day-to-day rate and/or the interest rate on banks' borrowing from Norges Bank for Norway and, finally the commercial banks' deposit rate for Switzerland. The Euro-rates for Denmark, Finland, Norway and Sweden are based on the dollar forward selling rate, that for Switzerland on the Euro-franc rate, while in the case of Austria the Euro-DM rate is simply used. The maturity of all these assets (except the domestic rates for Iceland and Norway) is three months. The long rates are in all cases yields on government bonds with a maturity of about five years. All interest rates are period averages. The price level is measured by the consumer price index.

6) For further details, see Virén (1987).

7) Cf. Barsky (1987). Barsky shows that if inflation is not forecastable the Fisher parity ultimately seems to fail in regression with the expected inflation regressed on nominal interest rate even though the parity is, in fact, true.

8) With the government deficit variable (measured by the government net borrowing requirement) we had some difficulties due to lack of data. Reasonably good monthly data were available for

Denmark, Finland, Iceland and Sweden only. For Austria and Switzerland we had to construct the data from quarterly figures. The def variable was not derived for Norway as only annual data were available.

9) The fact that domestic and Euro-rates are only weakly related is not so surprising given the fact that the corresponding time series seem to follow different structures (see the sample autocorrelation functions reported in Table 2).

10) It may be noted that in general the coefficient of the deficit variable turned out in general to be positive (i.e. larger deficits increase interest rates) while no clear sign pattern was found for the trade balance variable. Thus, in terms of the deficit variable our results differed from those of Evans (1987a,b) who found the deficit variable completely insignificant.

11) Some idea of the magnitude of the problem can be obtained by examing the tabulated values of the bounds of the t-and F-statistics for ARMA(1,1) disturbances reported by Kiviet (1980). Kiviet's computations show that, for instance, in the case of $n = 50$, $k = 5$, $r(AR(1)) = .9$ the upper bound for t-values is 17.16. It is obvious that autocorrelation results at least partly from overlapping observations. This is why we also estimated the models by weighting the observations so that only every third observation was included in computations. This did indeed considerably reduce residual autocorrelation while otherwise the results were rather well in accordance with the results reported in this paper (see Virén (1987) for details).

12) As far as the ARCH model estimation results are concerned one cannot make strong conclusions about the presence of time-varying risk premia in the interest rate equation. The implied ARCH process restrictions can typically be rejected as the following χ^2 statistics indicate (df = 2): Austria 2.14, Denmark 0.03, Finland 2.08, Iceland 2.08, Norway 4.49, Sweden 1.34 and Switzerland 10.47.

13) A further problem is that there seems to be only little or no convergence in the results for different countries. Thus, if we estimate a variable parameter regression (VPR) in terms of RS, RS^f and m the coefficients of the two latter variables do not move to the same direction in all countries, for instance, so that the coefficient of RS^f would increase over time. Some idea of this can be obtained by regressing the coefficient of RS_f against a linear time trend. The respective coefficient estimates turn out to be: Aus. -.003. Den. -.005, Fin. -.005, Ice. -.017, Nor. .001, Swe. -.005, Swi. .002.

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Table 1. Sample Averages of Inflation and Interest Rate Variables

National rates	rs	rl	re	inf
Austria	8.24	8.42	..	3.83
Denmark	16.88	14.78	11.84	6.28
Finland	12.50	9.79	12.94	7.09
Iceland	29.38	30.93	..	34.14
Norway	12.94	12.52	13.53	8.70
Sweden	12.18	12.15	12.23	6.99
Switzerland	4.49	4.63	4.89	3.27
Euro rates	edm	eus	ebdm	ebus
	6.84	10.89	8.34	11.90

rs is the short-term interest rate, rl is the long-term interest rate, re is the short-term Euro rate (which, except for Switzerland, is based on the USD forward rate), inf is the rate of inflation (i.e. continously compounded monthly rate, per cent p.a.), edm is the three-month Euro-DM rate and eus the corresponding USD rate, ebdm is the yield on DM-denominated Euro-bonds and ebus the correspong yield on USD-denominated Euro-bonds. For further details of the data see fn. 5.

Table 2. Sample Autocorrelation Functions of p, r and s.

one-month log differences with respect to the CPI

lag	Aus	Den	Fin	Ice	Nor	Swe	Swi
1	.14	.20	.37	.37	-.19	.13	.20
2	.17	-.04	.33	.37	.14	.04	.19
3	-.03	-.05	.15	.67	.14	.01	.20
4	-.11	.05	.32	.32	.05	-.05	-.05
5	.27	.10	.18	.33	.02	.04	.08
6	.13	.62	.18	.45	.18	.17	.00
7	.29	.09	.19	.19	.06	.03	.06
8	-.10	-.02	.23	.18	.01	.12	-.13
9	-.04	-.07	.19	.31	.11	.10	.20
10	.09	-.07	.18	.05	.04	.07	.18
11	.09	.14	.35	.05	.04	.23	.05
12	.55	.79	.49	.17	.40	.43	.41

three-month log differences with respect to the CPI

lag	Aus	Den	Fin	Ice	Nor	Swe	Swi
1	.74	.71	.84	.94	.63	.73	.82
2	.40	.33	.65	.87	.51	.39	.56
3	.09	.03	.44	.78	.23	.06	.27
4	.09	.21	.41	.72	.32	.04	.14
5	.28	.43	.35	.65	.27	.09	.09
6	.33	.60	.34	.56	.27	.17	.02
7	.30	.41	.33	.47	.24	.20	.04
8	.10	.16	.35	.39	.22	.22	.07
9	.05	-.03	.38	.31	.20	.24	.19
10	.20	.20	.47	.24	.34	.37	.32
11	.41	.52	.59	.18	.44	.50	.38
12	.57	.76	.66	.10	.54	.55	.41

one-month log differnces with respect to the USD (spot) exchange rate

lag	Aus	Den	Fin	Ice	Nor	Swe	Swi
1	.03	.02	.03	.03	-.06	.03	.07
2	.18	.22	.14	.38	.24	.12	.12
3	.07	.08	.08	.15	-.02	.14	.05
4	.11	.12	.17	.17	.10	.18	.08
5	.11	.09	.15	.29	.15	.18	.06
6	.01	.01	-.09	.11	.01	-.05	-.03
7	.24	.24	.20	.32	.16	.17	.16
8	-.07	-.04	.01	.09	-.13	.12	-.14
9	.10	.13	.17	.26	.08	.18	.06
10	.02	.02	-.00	.03	-.17	.10	-.01
11	.16	.23	.05	.10	.09	.06	.18
12	.11	-.08	-.08	.10	-.16	-.09	-.09

three-month log differences with respect to the USD (spot) exchange rate

lag	Aus	Den	Fin	Ice	Nor	Swe	Swi
1	.72	.72	.71	.77	.67	.73	.71
2	.51	.55	.51	.68	.50	.54	.45
3	.25	.28	.29	.46	.20	.35	.18
4	.26	.27	.31	.47	.24	.38	.16
5	.27	.25	.27	.48	.24	.35	.15
6	.24	.23	.19	.46	.17	.27	.09
7	.24	.26	.23	.49	.13	.31	.08
8	.14	.19	.19	.39	-.04	.33	-.02
9	.16	.23	.22	.36	-.06	.35	.04
10	.09	.17	.07	.23	-.18	.22	.03
11	.14	.25	.05	.21	-.09	.18	.11
12	.10	.21	.01	.18	-.11	.14	.08

one-month differences with respect to the short-term interest rate

lag	Aus	Den	Fin	Ice	Nor	Swe	Swi
1	.44	.33	-.31	.49	-.34	.32	.11
2	.45	.15	-.13	.22	-.21	.06	.23
3	.44	.07	.11	.21	-.03	.08	-.09
4	.40	.08	.07	.22	.09	-.10	.21
5	.35	.07	.01	.09	.04	-.18	.09
6	.32	.08	-.15	.07	-.03	-.29	.00
7	.34	-.06	.03	-.07	.10	-.03	-.15
8	.18	-.15	.18	-.14	-.09	-.09	-.09
9	.26	-.13	-.14	-.07	-.10	.10	.06
10	.26	-.16	-.13	-.12	.09	-.01	-.09
11	.29	-.06	.05	-.22	.07	-.01	-.30
12	.02	-.12	.13	-.27	-.09	.05	-.14

one-month differences with respect to the long-term interest rate

lag	Aus	Den	Fin	Ice	Nor	Swe	Swi
30							
1	.38	.30	.25	.50	-.10	.13	.19
2	-.06	.12	.09	.24	.01	-.01	-.12
3	.03	.13	.03	.20	-.15	.04	-.07
4	.11	.03	.03	.19	.15	.15	.06
5	.10	-.16	-.15	.07	-.12	.13	.20
6	.08	.00	-.01	.05	.03	-.07	.03
7	.12	.14	-.04	-.04	-.04	-.01	-.14
8	-.05	-.10	.11	-.09	.06	.03	-.09
9	-.02	-.09	-.09	-.02	-.03	-.17	.08
10	.20	-.03	.09	-.12	.08	-.29	-.14
11	.23	-.02	.02	-.24	.06	.03	-.00
12	.17	-.28	.16	-.27	.18	-.01	-.04

<u>one-month differences with respect to Euro-rates</u>

lag	edm	eus	esf	ebdm	ebus	rs (Nor,m)
1	-.13	.24	-.08	.36	.36	-.82
2	-.07	-.18	.05	-.15	-.13	.62
3	.26	-.18	.16	-.07	-.22	-.69
4	-.04	-.22	-.04	-.05	-.10	.64
5	.02	-.05	.15	-.12	.15	-.64
6	.08	-.12	-.08	-.05	.16	.71
7	-.15	-.11	-.17	-.12	-.01	-.72
8	.06	.19	.25	.18	.03	.66
9	-.13	.25	-.16	-.05	.07	-.58
10	-.08	.05	-.05	-.08	.05	.55
11	.16	.03	-.07	.17	.10	-.57
12	.08	-.34	-.20	.13	-.04	.55

The sample period is in all cases 1980M1 - 1987M12, thus n = 96.

Table 3. Test Statistics for Non-nested Tests

		a:edm	t_a	F	a:eus	t_a	F
Austria	rs	.823	(7.88)	17.81	.846	(8.85)	22.59
	rl	.215	(3.70)	3.73	.500	(6.16)	9.71
Denmark	rs	.781	(8.19)	16.54	.923	(9.60)	22.30
	rl	.744	(7.48)	13.69	.876	(10.17)	25.31
Finland	rs	1.659	(5.84)	23.77	1.391	(4.76)	8.13
	rl	.930	(6.47)	10.15	.482	(4.77)	5.89
Iceland	rs	.915	(12.31)	40.31	.915	(12.09)	39.32
	rl	.838	(12.22)	42.67	.851	(13.15)	62.06
Norway	rs(i)	.876	(3.52)	4.50	.809	(3.14)	3.71
	rl	1.852	(5.74)	11.89	1.531	(5.09)	10.11
Sweden	rs	.737	(6.43)	11.52	.773	(7.50)	16.18
	rl	.300	(1.43)	1.65	.206	(1.15)	3.34
Switzerland	rs	.023	(0.15)	1.71	.374	(2.25)	2.64
	rl	.368	(3.44)	3.36	.411	(3.05)	2.63

a:edm denotes the Davidson-MacKinnon t-test statistic for the parameter c_3 in the context of equation (6) while edm refers to the Euro-DM rate and eus the Euro-USD rate. F denotes the F-statistic for the parameter restriction $b_3 = b_4 = b'_5 = 0$ in the context of equation (5). Because the excpected change rate of the exchange rate variable performed rather poorly in these composite equations it was dropped from the final estimating equation. Needless to say, it had only a very minor impact on the other parameter estimates and test results. Thus, in (5) the right-hand-side variables were: constant, edm/eus, m, tb, p^e, and def. Except for edm/eus these same variables were used in computing the predicted value R in the context of equation (6). rs(i) indicates that the interbank rate is used for the short-term interest rate in Norway; the abbreviation rs(m), in turn, indicates that the marginal borrowing rate is used.

Table 4. Coefficient Estimates of d_1 in Equation (7)

	d_0	DW	d_a	d_h	d_Δ
Austria	.251	.06	.193	.249	-.027
Denmark	.734	.15	.826	.776	.053
Finland	-.033	.26	-.105	-.059	-.089
Iceland	1.264	.10	.649	1.145	-.023
Norway (i)	-.195	1.16	-.231	-.219	.463
Sweden	.480	.16	.552	.519	.326
Switzerland	.540	.25	.422	.494	.345

d_0 is the OLS estimate of d_1 in equation (7) in the case of short-term rates and with edm being the short-term Euro rate, DW is the Durbin-Watson autocorrelation test statistics for the same equation. d_a refers to the corresponding least absolute deviations estimator, d_h to Huber's M-estimator and d_Δ the OLS estimator in the case of first differences of the data. The dependent variable is the domestic short-term interest rate, for Norway the interbank rate is used.

Table 5. OLS Estimation Results with Level Form Data

		Constant	m	edm/ebdm	SEE	R2	DW
Austria	rs	8.196	-15.563	.107	.690	.62	.15
		(28.44)	(7.89)	(3.33)			
	rl	3.028	-3.097	.673	.386	.91	.32
		(10.15)	(2.60)	(21.71)			
Denmark	rs	16.848	-7.028	.251	1.176	.78	.14
		(23.71)	(7.95)	(3.32)			
	rl	12.034	-12.661	.770	1.857	.83	.16
		(4.81)	(6.89)	(3.07)			
Finland	rs	20.008	-26.588	-.872	1.292	.47	.86
		(22.65)	(9.06)	(8.29)			
	rl	9.990	-8.094	.039	.587	.67	.26
		(14.20)	(6.10)	(0.51)			
Iceland	rs	24.991	-4.098	.840	6.472	.26	.10
		(10.06)	(2.53)	(2.80)			
	rl	8.851	-3.564	2.974	6.930	.47	.12
		(1.51)	(1.67)	(4.71)			
Norway	rs(i)	12.736	3.696	-.027	1.678	.15	1.24
		(17.16)	(2.69)	(0.30)			
	rl	10.001	5.072	.244	.887	.31	.14
		(10.67)	(5.22)	(2.41)			
Sweden	rs	9.336	-22.612	.482	1.404	.53	.22
		(23.00)	(4.97)	(8.94)			
	rl	8.698	-6.244	.435	.838	.43	.19
		(19.87)	(2.27)	(8.35)			
Switzerland	rs	.635	-3.116	.522	1.004	.68	.26
		(2.09)	(1.41)	(12.84)			
	rl	2.676	-1.184	.224	.273	.70	.28
		(18.36)	(1.74)	(11.17)			

The dependent variable is either the domestic short-term (rs) or the long-term rate (rl). m denotes the real money supply (lagged by one period), edm denotes the Euro-DM rate and ebdm the yield on DM-denominated bonds (the latter rate is used in explaining rl). The model was estimated also by using eus and ebus as explanatory variables. The results were, however, so similar to those presented above that in order to save space they are not reported here. The same is true with an experiment in which the money supply variable (M1) was replaced by a somewhat broader measure (M2) or, alternatively, by the domestic credit (DC).

Table 6. Estimation Results with the State Space Model

	$\hat{a}$	$\hat{b}$	$\hat{c}$	SEE	R2	DW	Q(16)
Austria	.932	-.749	.021	.100	.99	2.07	15.4
Denmark	.884	-.902	.063	.346	.98	1.33	33.3
Finland	-.391	.393	-.013	.889	.75	2.65	30.0
Iceland	.791	-.628	-.017	1.814	.94	1.40	29.6
Norway (i)	.054	-.626	.186	1.562	.22	2.10	18.0
Norway (m)	-.816	-.019	.105	.862	.58	1.96	29.7
Sweden	-.471	.809	.021	.909	.91	1.92	13.5
Switzerland	.394	-.168	.320	.492	.92	2.16	43.5

The estimation results are here presented in the ARMAX form: $\Delta RS = a\Delta RS_{t-1} + u_t + bu_{t-1} + c\Delta RS^f{}_t$. For the sake of comparison, the first order model was here estimated for all countries. As a rule this first order model turned out to be optimal in terms of the information criteria (particularly, in terms of the Schwartz Criterion). As far as the cases in which a higher-order model could be preferred are concerned, particularly Sweden can be mentioned. In her case the coefficients of the exogenous variable (edm) did considerably increase when the second-order model was estimated. Thus, the following set of estimates was obtained for the respective parameters: a_1 = -.689, a_2 = -.012, b_1 = 1.082, b_2 = .194, c_1 = .249, c_2 = .265, SEE = .593, R2 = .92, DW = 2.09 and Q(16) = 11.8.

Table 7. OLS Estimation Results with ARIMA Residuals

	Constant	$\hat{m}$	$\hat{edm}$	SEE	R2	DW	Q(15)
Austria	.002	-1.690	-.016	.100	.07	2.15	27.9
	(0.23)	(2.16)	(0.91)				
Denmark	-.000	-7.785	.054	.371	.13	2.19	9.7
	(0.01)	(3.69)	(0.85)				
Finland	.001	-11.737	-.221	.767	.13	2.27	13.4
	(0.02)	(3.69)	(1.64)				
Iceland	.035	.195	-.065	1.974	.00	1.03	89.0
	(0.17)	(0.05)	(0.19)				
Norway (i)	.004	-9.420	.409	1.606	.04	2.17	28.9
	(0.03)	(1.20)	(1.48)				
Sweden	-.000	-3.345	.260	.605	.07	2.00	11.4
	(0.01)	(0.67)	(2.44)				
Switzerland	.000	-3.644	.374	.492	.19	2.37	45.4
	(0.00)	(0.93)	(4.27)				

The dependent variable is the domestic short-term rate; all variables are expressed as ARIMA residuals of the original variables. Q(15) denotes the Box-Ljung autocorrelation test statistic which has been computed for 15 lags, $\chi^2_{.05} = 25.0$.

Table 8. F-test Statistics for Money Supply and Euro Rate Variables

		F:m	F:edm	F:m	F:eus
Austria	rs	3.78	40.32	5.82	29.35
	rl	1.06	20.18	0.43	10.49
Denmark	rs	2.24	6.84	2.85	5.49
	rl	0.71	3.23	0.76	5.55
Finland	rs	2.33	1.37	0.96	0.23
	rl	4.33	1.25	3.86	1.73
Iceland	rs	1.28	0.20	1.26	0.27
	rl	1.76	0.90	2.56	1.67
Norway	rs(i)	2.00	0.14	2.39	0.66
	rl	2.37	1.63	1.19	0.75
Sweden	rs	3.45	4.66	4.11	2.71
	rl	1.28	3.36	1.06	4.94
Switzerland	rs	6.87	8.76	10.12	6.41
	rl	1.45	10.05	2.54	17.67

The test statistics have been computed for the hypotheses H_0: b2 = b3 = 0 (F:m) and H_0: b4 = b5 = 0 (F:edm & eus) in the context of a dynamic model $R_t = b_0 + b_1 R_{t-1} + b_2 m_t + b_3 m_{t-1} + b_4 R^f{}_t + b_5 R^f{}_{t-1} + u_t$. $F_{.05} = 3.11$.

Table 9. Estimation Results with an Unrestricted Dynamic ARCH Model

	Aus	Den	Fin	Ice	Nor(i)	Swe	Swi
Const.	.335	-.033	1.462	.447	6.459	.437	.300
	(3.03)	(0.06)	(0.89)	(0.38)	(4.00)	(0.98)	(2.45)
rs_{t-1}	.931	.945	.904	.977	.510	.934	.833
	(70.65)	(30.65)	(12.51)	(28.95)	(4.32)	(21.23)	(17.51)
m	.373	-1.553	-4.180	-1.499	-8.147	-11.394	-6.447
	(0.59)	(0.83)	(1.28)	(0.34)	(1.14)	(2.13)	(2.51)
m_{t-1}	-1.175	2.357	2.904	2.267	10.343	14.348	6.481
	(1.79)	(1.30)	(0.90)	(0.52)	(1.45)	(2.76)	(2.41)
edm	-.002	.015	-.003	.011	.325	.293	.415
	(0.20)	(0.26)	(0.03)	(0.34)	(1.39)	(3.09)	(6.13)
edm_{t-1}	.040	.089	-.038	.007	-.370	.250	-.343
	(3.09)	(1.48)	(0.30)	(0.02)	(1.60)	(2.61)	(4.64)
$\sqrt{a0}$	.063	.302	.607	1.771	1.095	.511	.064
$\sqrt{a1}$	.601	.287	.736	.385	.630	.557	.955
SEE	.084	.398	.884	1.970	1.581	.610	.480
R2	.99	.98	.76	.93	.27	.91	.93
DW	2.04	1.55	2.58	1.03	2.24	1.51	1.70
Q(12)	17.74	16.6	27.4	89.0	21.2	17.0	44.7
Chow	0.73	0.35	8.01	0.95	0.36	2.11	1.45

The length of the ARCH process is 6, the weights of the lag structure are linearly decreasing. Chow denotes the Chow test statistic for the period 1983M12, $\chi^2_{.05} = 21.0$, $F_{.05} = 2.21$.

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