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EXPLAINING DEVALUATION EXPECTATIONS IN THE EMS*

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This paper is an attempt to explain devaluation expectations in the ERM with macroeconomic fundamentals. Two different measures of devaluation expectations are used; expectations estimated using the drift-adjustment method of Bertola and Svensson (1993), and the directly observable interest rate differential. The interest rate differential seems more closely connected to macroeconomic fundamentals than the estimates stemming from the drift-adjustment method. For the ERM as a whole, an expanded monetary model of exchange rate determination explains a considerable part of the devaluation expectations, whereas for individual countries additional variables are important, but the relationships are ambiguous and country-specific. (JEL E43, E44, F31)

1. Introduction

The European currency crises of 1992 and 1993 have made clear that the European Monetary System is far from a completely credible exchange rate system. Expectations on the financial markets about realignments have proven to trigger speculation and eventually force realignments. In such a setting, it would be interesting to know what drives these devaluation expectations. In theory, exchange rates should be ultimately determined by macroeconomic fundamentals, such as inflation rates, money growth, and real output. However, additional factors, such as foreign exchange reserves, government finances, and unemployment could also have some impact on exchange rates via policy makers' reaction functions, and consequently on devaluation expectations. This paper is an attempt to explain devaluation expectations in the Exchange Rate Mechanism of the European Monetary System, using macroeconomic fundamentals. The study covers 3-month devaluation expectations of the initial ERM currencies[1] relative to the German mark, during the

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[1] *Initial members of the ERM were Belgium, Denmark, France, Germany, Ireland, Italy, and the Netherlands.*

time from the establishment of the ERM on March 13, 1979, until the end of 1992.

Measuring devaluation expectations, one approach would be to simply observe the interest rate differential between two countries, which, if uncovered interest rate parity holds, reflects the expected rate of depreciation of one currency relative to the other. In a target zone system such as the ERM, however, the interest rate differential may be misleading as a measure of devaluation expectations, since it includes expectations of exchange rate movements *within* as well as *outside* the exchange rate band. Therefore, Bertola and Svensson (1993) suggest adjusting the interest rate differential for the expected rate of depreciation within the band, thereby reaching an estimate of the expected rate of devaluation, defined as the jump of the exchange rate at a realignment. This »drift-adjustment method» has been used in several empirical studies of devaluation expectations (e g Chen and Giovannini, 1992; Lindberg et al, 1993; Rose and Svensson, 1994b). Nevertheless, although this method is attractive, the interest rate differential may be more appropriate in practice, if the assumptions made in the Bertola-Svensson procedure are not fulfilled.

A different approach to devaluation expectations is taken by Edin and Vredin (1993), who estimate devaluation probabilities in the Nordic countries, studying macroeconomic fundamentals. These estimates can be regarded as objective devaluation expectations, being based on fundamentals, whereas the former estimates are more subjective, based on expectations on the financial markets.

Since the scope of this paper is to explain devaluation expectations formed on the financial markets with macroeconomic fundamentals, we will study estimates of devaluation expectations obtained through the drift-adjustment method as well as interest rate differentials, and the results are then compared.

The linkages between devaluation expectations and macroeconomic fundamentals have recently been subject to several studies, but with inconclusive results. Koen (1991) estimates yearly devaluation expectations for several European currencies and compares the estimates with yearly, cross-sectional macroeconomic panel data. Significant coefficients with predicted signs are found for gross public debt, the primary budget deficit, the inflation rate, and a dummy for the adoption of a »hard currency policy». Caramazza (1993) uses the drift-adjustment method to estimate monthly devaluation expectations for the French franc relative to the German mark, and finds a significant impact on devaluation expectations from the change in foreign reserves, the relative government financing requirement, the inflation differential, the rate of real depreciation, and the unemployment rate. Chen and Giovannini (1993) compare devaluation expectations for the French franc and the Italian lira (relative to the German mark) with a number of variables, and find that expected parity changes are significantly related to the length of time since the last realignment and the exchange rate's deviation from the central parity.

Holden and Vikøren (1994) estimate regressions for the devaluation expectations of the four major Nordic countries, and find a significant impact of the Swedish unemployment rate, trade balance and the rate of real depreciation of the exchange rate. For the other countries, most of the coefficients have the predicted sign, but are not significant. Siklos and Tarajos (1994) compare the methodology of Bertola and Svensson (1993) with a simpler version of the Bertola-Svensson method, known as the »simplest test» (Svensson, 1991), and the method of Edin and Vredin (1993), and find that the method proposed by Edin and Vredin performs better in predicting the timing and actual size of devaluations in the ERM than the simplest test.

The study most closely related to the present one is the paper by Rose and Svensson (1994a). They study devaluation expectations for the six original ERM members, but do not find any tight links between realignment expectations and macroeconomic determinants, the only significant variable being the inflation rate. They also find that many movements in realignment expectations are common to all ERM countries, suggesting that credibility is shared by all members.

To anticipate the results of the present study, we find that an extended monetary model of exchange rate determination, including money growth, the domestic and foreign inflation rates, real exchange rate depreciation, real output growth, foreign interest rates, and the change in foreign exchange reserves, performs fairly well in explaining the expected rate of devaluation for all countries, and the interest rate differential seems more closely related to fundamentals than the estimates from the drift-adjustment method. The coefficients of money growth, domestic inflation, the rate of real depreciation, and the change in foreign exchange reserves are consistently (for a panel of all countries as well as for individual countries) significant with predicted signs. For individual countries, other variables, such as government finances, the trade balance, and the unemployment rate, are important, but the relationships are ambiguous and country-specific.

The paper is organised as follows: a simple monetary theory of exchange rate determination is presented in section 2, and is extended to cover the existence of devaluation expectations. In section 3 alternative methods of estimating devaluation expectations are discussed. In section 4 the empirical study of the estimated devaluation expectations and interest rate differentials is presented, after which our results are summarised and conclusions drawn in section 5.

2. Exchange rate theory

Consider the following simple model of an economy:

(1) $m_t - p_t = y_t - \gamma i_t^{\tau}$

(2) $q_t = s_t + p_t^* - p_t$

(3) $i_t^{\tau} = i_t^{*\tau} + \dfrac{Et[ds_{t+\tau}]}{\tau dt}$

Equation (1) is the money market equilibrium condition, where m, p, y and i^{τ} are nominal money supply, the domestic price level, domestic output, and the domestic interest rate (for maturity τ), respectively, and γ is a parameter. Equation (2) defines the real exchange rate; q, s, and p^* are the real exchange rate, the nominal exchange rate, and the foreign price level. Equation (3) is the uncovered interest parity condition, where $i^{*\tau}$ is the foreign interest rate, $ds_{t+\tau} = S_{t+\tau} - S_t$, i e the rate of depreciation of the exchange rate during time period τ, and E_t is an expectations operator, conditional on information available at time t. $E_t[ds_{t+\tau}]/\tau dt$ is thus the expected rate of depreciation, as of time t, of the exchange rate during time period τ (in annual terms).[2] All variables are denoted in logarithms except interest rates (which are denoted in annual rates of return).

Combining these three equations, we can derive the following expression for determination of the exchange rate in the economy:

(4) $s_t = f_t + \gamma \dfrac{E_t[ds_{t+\tau}]}{\tau dt}$

where f_t is a fundamental given by

(5) $f_t = m_t - p_t^* + q_t - y_t + \gamma i_t^{*\tau}$

The exchange rate is thus determined by macroeconomic fundamentals, including money supply, the foreign price level, the real exchange rate, domestic output and the foreign interest rate, and by expectations of future exchange rate movements. Moreover, the exchange rate's dependence on the expected rate of depreciation is determined by γ, the semi-elasticity of money demand with respect to the interest rate.

Solving equation (4) forward, assuming away bubbles, we get (see e g Bertola, 1994):

(6) $s_t = \dfrac{1}{\gamma} \int_t^{\infty} E_t\left[e^{-\frac{v-t}{\gamma}} f_v \right] dv$

The exchange rate can thus be seen as the discounted sum of present and expected future values of the fundamental.

In a fixed exchange rate regime (or a target zone regime), equation (4) could be interpreted as the »shadow exchange rate», i e the exchange rate that would prevail in a flexible regime. In the basic model of speculative attacks and »balance of payments crises», the exchange rate is kept fixed until the level of foreign exchange reserves reaches some minimum level, when the

2 *Throughout this paper, interest rates will be of 3 month maturity, consequently τ is equal to 3/12.*

exchange rate is set equal to the shadow exchange rate (see e g Garber and Svensson, 1995). Expected rates of devaluation would then be proportional to the level of the shadow exchange rate, and the fundamentals of equation (5) could be used to explain such expectations. In these models, the level of foreign exchange reserves is steadily decreasing due to domestic credit expansion, which is presumed to finance government deficits. Consequently, variables related to government finances should also be expected to affect expected rates of devaluation.

3. *Estimating devaluation expectations in a target zone*

Estimating devaluation expectations in a target zone, we use the »drift-adjustment method», proposed by Bertola and Svensson (1993). The expected rates of devaluation are calculated deducting an estimate of the expected rate of depreciation within the band from the interest rate differential, which if uncovered interest parity holds reflects the total expected rate of depreciation of the exchange rate. This way, the existence of the exchange rate band is explicitly taken into account.

However, the distribution of exchange rate movements within the band are difficult to model explicitly, leading to econometric difficulties when estimating the expected rate of depreciation within the band. In the original target zone model of Krugman (1991), the central bank was assumed only to use infinitesimal interventions when the exchange rate reached the edge of the band, leading to a U-shaped distribution of the exchange rate within the band. In reality, however, central banks often intervene also when the exchange rate is inside the band, yielding a hump-shaped distribution of the exchange rate (see Lindberg and Söderlind, 1994a,b). To overcome this problem, Rantala (1992) shows that the exchange rate can be modelled as a continuous-time stochastic diffusion process.

Considering these problems with the basic target zone model and the Bertola-Svensson procedure, the pure interest rate differential can be seen as an alternative measure of devaluation expectations, being directly observable on the financial markets.

The assumption of uncovered interest parity is certainly not trivial either, if there is an exchange rate risk premium on the financial markets, included in the interest rate differential. Most empirical studies (e g Froot and Thaler, 1990; Hodrick, 1987) reject the hypothesis of uncovered interest parity in a floating exchange rate regime, suggesting that a time-varying risk premium exists. On the other hand, Svensson (1992) argues that the risk premium is likely to be considerably smaller in a target zone than in a flexible exchange rate regime, since the risk from exchange rate movements within the band is insignificant (in narrow target zones), and the devaluation risk is small in relation to the expected rates of devaluation. Consequently, uncovered interest parity should hold approximately in target zones. Also, Holden and Vikøren (1994) point out that the risk premium is increasing in the variance of the exchange rate, which, in a fixed exchange rate regime, is likely to be an increasing function of the expected rate of devaluation. If both the risk premium and the expected rate of devaluation are positive, the risk premium will be a strictly increasing function of the expected rate of devaluation. Thus, the interest rate differential may be a satisfactory measure of depreciation expectations even if the risk premium is non-negligible.

To estimate the expected rate of depreciation within the band, Bertola and Svensson (1993) suggest regressing the realised rates of depreciation on the current exchange rate within the band, and although this relationship is likely to be non-linear, a simple linear OLS regression may be an acceptable approximation. Following Svensson (1993), the domestic and German interest rates are included, since they prove to be significant, and intercepts are allowed to vary between exchange rate regimes, that is between realignments. Thus, the following model is estimated, using Newey-West (1987) standard errors to allow for serial correlation and heteroskedasticity:

$$(7)\quad (x_{t+\tau} - x_t)/\tau = \sum \beta_{0j} d_j + \beta_1 x_t + \beta_2 i_t^{\tau} + \beta_3 i_t^{*\tau} + \varepsilon_{t+\tau}$$

where x_t is the exchange rate deviation from the central parity, the d_j's are intercept dummies for regimes $j = 1,2,\ldots,$ and $\varepsilon_{t+\tau}$ is an error term. This estimate is then deducted from the interest rate differential to reach an estimate of the expected rate of devaluation.[3]

Our data on log exchange rates and interest rate differentials (relative to the German mark) are shown in figures 1 and 2, and the estimated expected rates of devaluation from the drift-adjustment method are depicted in figure 3.[4] The vertical lines in figures 2 and 3 represent realignments relative to the German mark. Note that interest rates were not available for Ireland before November 1981, and that Italy left the ERM on September 17, 1992, why there are no estimates for these periods. We conclude from figures 2 and 3 that there have been quite large devaluation expectations on the financial markets. Several realignments seem to have been anticipated by market agents, and the expected rate of devaluation often falls abruptly after a realignment (e g the French franc in 1981–1983).

4. *Explaining devaluation expectations*

Following the discussion in section 2 above, we will begin by examining the links between devaluation expectations and the macroeconomic fundamentals from equation (5). We would then predict the same relationship between these variables and devaluation expectations as for the exchange rate, i e domestic money supply, the real exchange rate, and the foreign (German) interest rate should have a positive effect, while the foreign price level and domestic real output is expected to have a negative effect on devaluation expectations.

Inspired by the balance of payments literature, we also test the effects of foreign exchange reserves, and we include the domestic price level as an additional explanatory variable. Here, foreign exchange reserves is expected to have a negative effect whereas the domestic price level should affect devaluation expectations positively.

To capture the effects of government finances on devaluation expectations, we test the government deficit, debt, and financing requirement, as well as the trade balance (as a proxy for the total savings of the economy). We also include the unemployment rate, to catch the impact of the business cycle on devaluation expectations. We would expect the government deficit, debt, and financing requirement, as well as the unemployment rate to affect devaluation expectations positively, and the trade balance to affect devaluation expectations negatively, although there is no obvious theoretical relationship to rely upon.

4.1 Data

Since data on macroeconomic variables are mostly published on a monthly basis, the estimated devaluation expectations and interest rate differentials have been transformed to monthly averages, the period covered being March 1979 through December 1992. The macroeconomic data used have been compiled from various publications (IMF International Financial Statistics, OECD Main Economic Indicators and Eurostat). The choice of variables has been constrained by availability; data on government debt and government financing requirement for Denmark and Ireland, as well as government deficit for Denmark, were only available on a yearly basis, and are therefore not included. Also, data on Irish consumer prices and Italian unemployment were only available on a quarterly basis, but are nevertheless included.

The data are expressed either in natural logarithms or logarithmic differences, except interest rates, denoted in annual rates of return, fiscal variables, which are normalised by output (GNP), and thus expressed in percentage ratios, and the unemployment rate, which is expressed in percentage of the labour force. Following Caramazza (1993), yearly data on GNP (GDP for France) have been interpolated on the industrial production index, to approximate monthly

[3] *For details and a thorough discussion of estimation procedures, see Svensson (1993).*

[4] *We are highly indebted to Lars E O Svensson for letting us use his data, collected from BIS, Basle. Data definitions and sources are found in appendix A.*

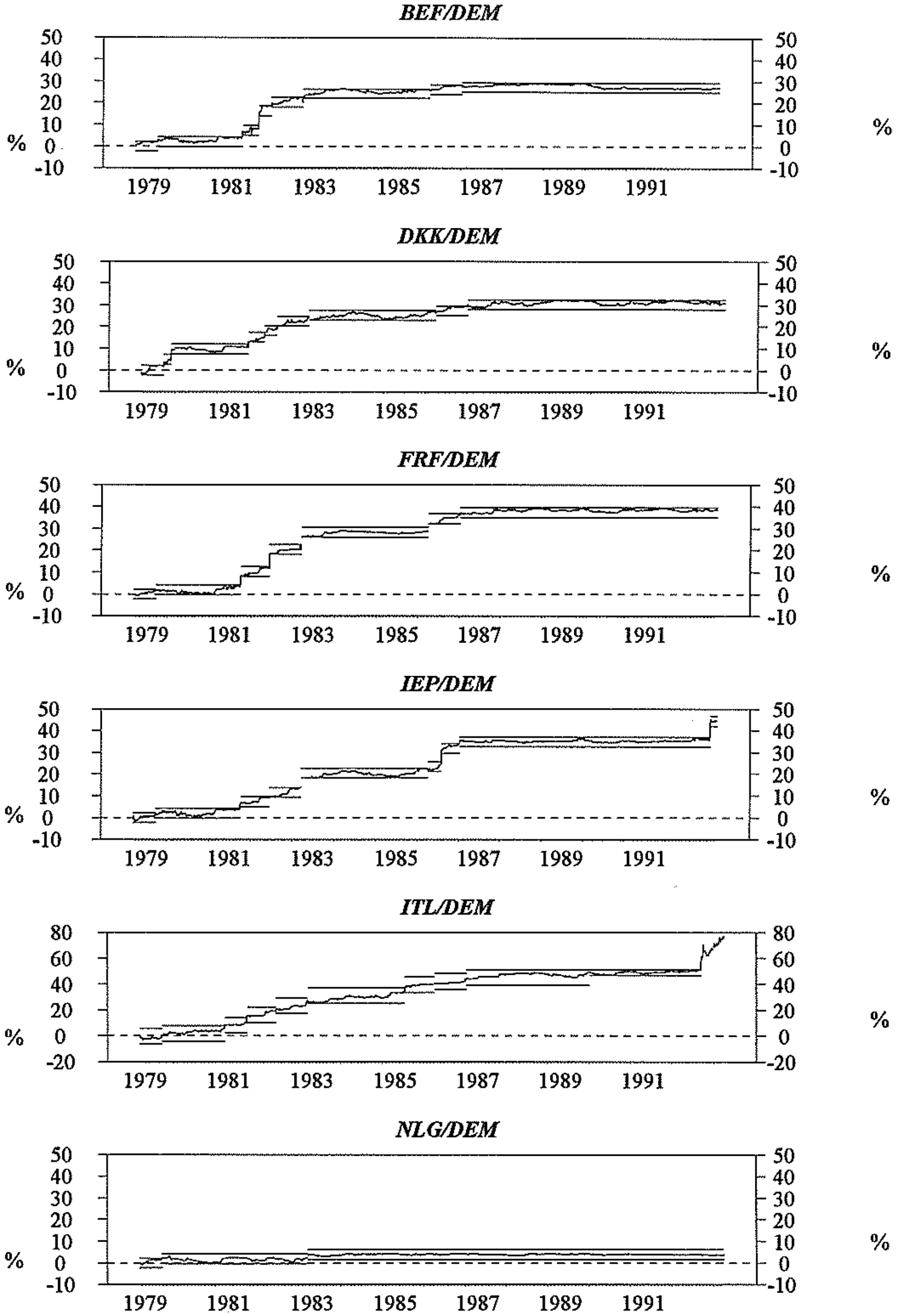

Figure 1. Log exchange rates, % deviation from original central parity.

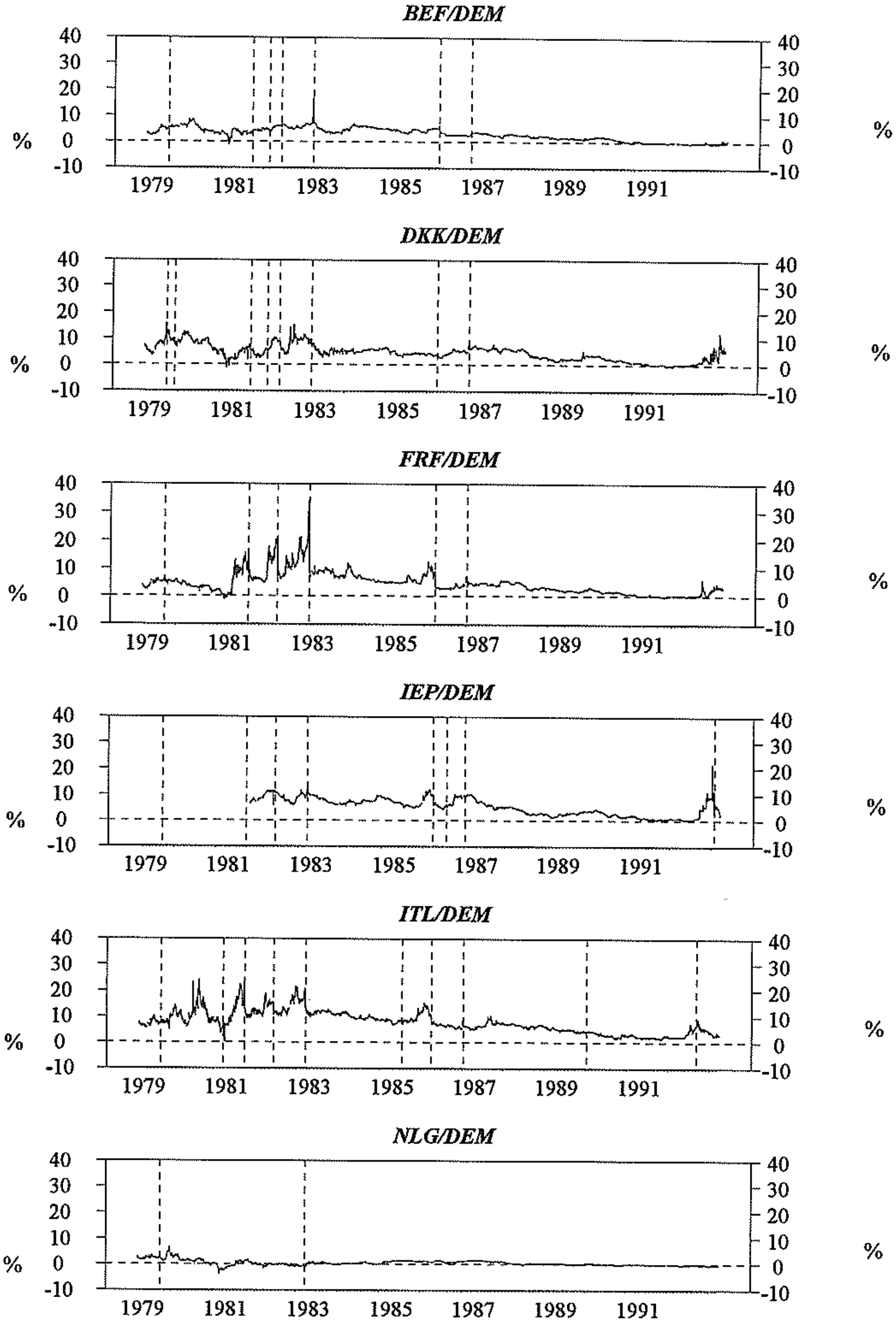

Figure 2. Interest rate differentials.

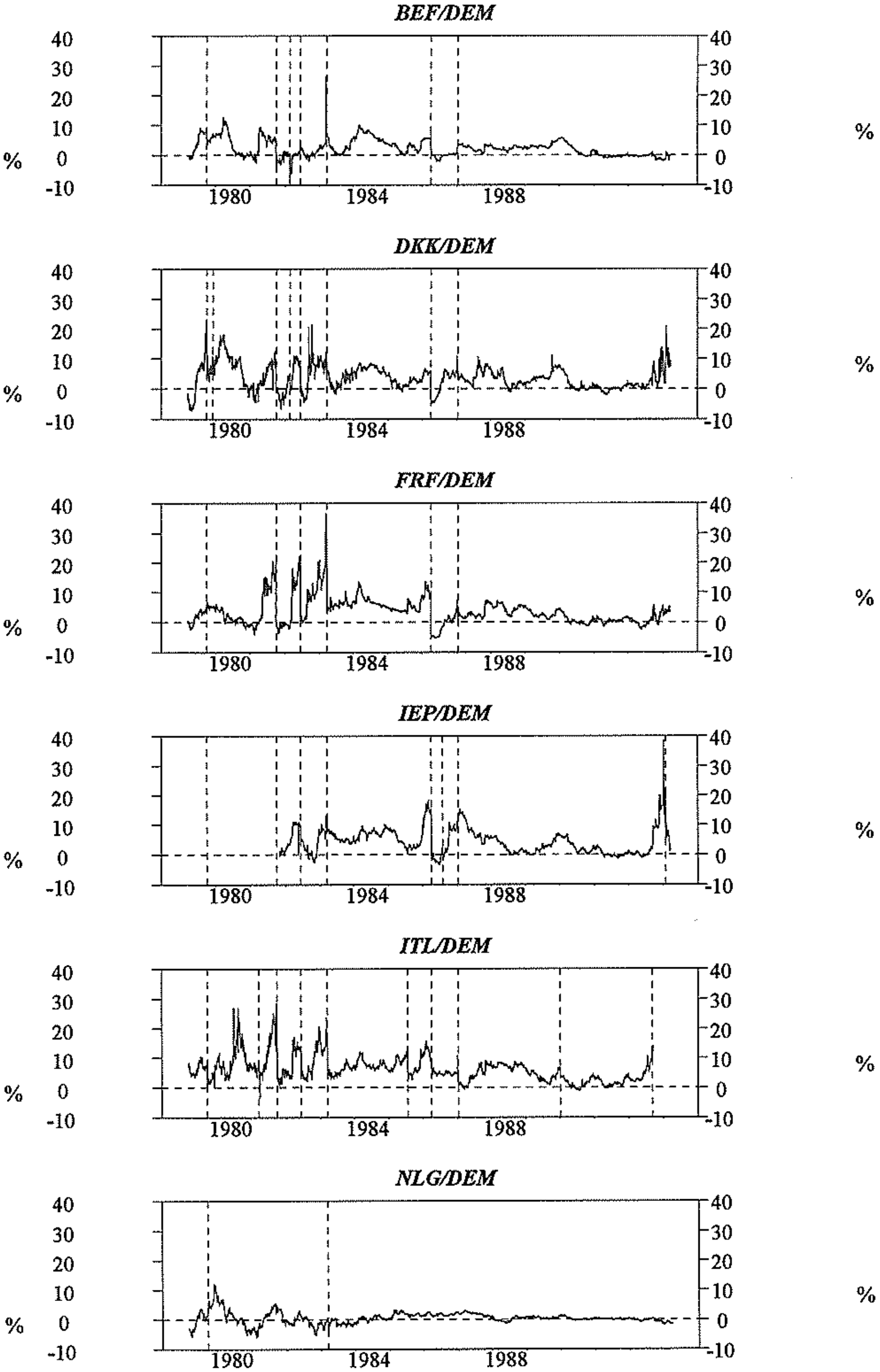

Figure 3. Estimated expected rates of devaluation.

data in the normalisation. Finally, to allow for some time for publication, all our data (except interest rates) have been lagged one period. A complete list of the variables, their sources, and definitions are found in appendix A. Graphs of all variables can be found in appendix B.

4.2 Empirical results

We now proceed as follows: first, the theoretic monetary model coming from equation (5) is tested for a panel of all six countries, allowing for different intercepts between countries. Second, foreign exchange reserves and the domestic price level are added, yielding an extended monetary model. Third, the same two versions are tested for each country individually, and finally, additional variables are added, to capture each country's particularities. To avoid problems stemming from trending variables, in the monetary models growth rates are used for all variables (except for the German interest rate), whereas in the final individual models, both levels and growth rates are tested. The different models are estimated by OLS using Newey-West standard errors (to allow for heteroskedastic and serially correlated error terms coming from the overlapping observations problem, see Hansen and Hodrick, 1980, and Newey and West, 1987).

Table 1 reports the results of the first and second regressions. In the theoretic model, money growth and the German inflation rate have a significantly positive impact on our estimated

Table 1. Theoretic model: Panel results

	Devaluation expectations Theoretic	Devaluation expectations Extended	Interest rate differential Theoretic	Interest rate differential Extended
Intercepts				
Belgium	3.528**	3.248**	5.411**	4.391**
	(0.950)	(0.821)	(0.867)	(0.473)
Denmark	4.098**	3.660**	5.748**	4.700**
	(1.190)	(1.046)	(1.071)	(0.609)
France	4.901**	3.947**	6.631**	4.736**
	(1.109)	(1.004)	(0.968)	(0.602)
Ireland	5.323**	4.049**	7.659**	5.261**
	(1.211)	(1.157)	(1.126)	(0.669)
Italy	6.897**	4.631**	9.281**	5.671**
	(1.097)	(1.155)	(0.930)	(0.646)
Netherlands	1.550	2.190**	2.392**	2.845**
	(1.091)	(0.903)	(1.001)	(0.541)
Coefficients				
Money supply	0.102*	0.025	0.171**	0.033
	(0.052)	(0.048)	(0.045)	(0.025)
German prices	0.797**	–0.186	1.200**	–0.281*
	(0.249)	(0.289)	(0.203)	(0.153)
Real exchange rate	0.009	0.011	0.079	0.183**
	(0.091)	(0.094)	(0.066)	(0.054)
Industrial production	0.046	0.082**	–0.071**	–0.005
	(0.040)	(0.037)	(0.034)	(0.021)
German interest rate	–0.604**	–0.409**	–0.912**	–0.564**
	(0.197)	(0.180)	(0.164)	(0.099)
Foreign reserves		–0.031**		–0.018**
		(0.009)		(0.005)
Domestic prices		0.501**		0.770**
		(0.085)		(0.059)
Statistics				
Observations	800	800	803	803
Adjusted R^2	0.306	0.414	0.610	0.805
Residual standard error	3.252	2.989	2.342	1.656

Dependent variables: 3-month devaluation expectations and interest rate differentials. Independent variables (except interest rates) are in first log differences. Newey-West standard errors (12 lags) in parenthesis. One asterisk (*) indicates significance at a 10 % level, two asterisks (**) indicate significance at a 5 % level.

devaluation expectations, and the German interest rate has a significantly negative impact. In the extended model, money growth and the German inflation rate lose in significance, but industrial production growth and the domestic inflation rate are now significantly positive, whereas the change in foreign reserves enters significantly negative. The sign of money growth, the rate of real depreciation of the exchange rate, the change in foreign exchange reserves, and the domestic inflation rate consistently carry the predicted sign, whereas the German interest rate consistently carries the »wrong» sign. Adjusted R^2 amount to 0.306 and 0.414 respectively in the theoretic and extended model, and residual standard errors are 3.252 and 2.989.

As for the interest rate differentials, the results are similar, but the growth of domestic output now carries the predicted sign, although the coefficient is significant only in the theoretic model. Adjusted R^2 are now 0.610 and 0.805, and residual standard errors are 2.342 and 1.656, respectively. It thus seems that the interest rate differential is more closely related to macroeconomic fundamentals than our estimated devaluation expectations; more variables are significant and residual standard errors decrease substantially. Also, the relationships are closer to those predicted by theory.

We also note that there are fairly large, statistically significant intercepts for all countries, indicating that a systematic part of the expected rates of devaluation is not captured by the fundamentals. This could be interpreted as a risk premium included in the estimated devaluation expectations and interest rate differentials. A rough comparison of the different intercepts indicates the differences in expected rates of devaluation between countries. In all four models, The Netherlands have the smallest intercept, followed by Belgium, Denmark, France, Ireland, and Italy.

Tables 2a–b report the results from running the theoretic model on the estimated devaluation expectations and interest rate differentials of the individual countries. For the devaluation expectations (table 2a) the results are mixed; coefficients often take different signs in different countries, even when significant in both cases. The rate of money growth and the German inflation rate take both significantly positive and negative signs, depending on country. The rate of real depreciation and the industrial production growth are only significant once, and then with incorrect signs, and the German interest rate is often significant, but with negative sign, contrary to theory. Adjusted R^2 range from 0.094 (Denmark) to 0.291 (Netherlands) and residual standard errors vary between 1.263 and 3.994. For the interest rate differentials, the pattern is similar, although more variables are significant and the fit is better; adjusted R^2 now vary between 0.325 and 0.638, and residual standard errors lie between 0.531 and 2.985. Thus, again the interest rate differential is closer connected to our fundamentals than the estimated devaluation expectations.

When extending the model (see tables 3a–b), the domestic inflation rate »dominates» the rate of money growth, and enters significantly positive, for all countries but the Netherlands (both for devaluation expectations and interest rate differentials), and the change in foreign exchange reserves enters significantly negative in several countries. As for the other variables, the performance is similar to before. Residual standard errors now vary between 1.118 and 3.842 for devaluation expectations and between 0.526 and 2.105 for the interest rate differentials.

Finally, we include our additional variables in the individual countries' regressions. Now, (log) levels as well as growth rates are used as independent variables, since the level of the shadow exchange rate should be sensitive to the level of the fundamentals, which would affect the expected rates of devaluation, and the expected change in the exchange rate should be sensitive to the change in the fundamentals.

For our estimated devaluation expectations (table 4a), the level of the real exchange rate and the level of foreign reserves have a strong significant impact with signs consistent with theory. Some variables consistently enter with »wrong» signs; money supply, the rate of real depreciation, and the unemployment rate. As for the other variables, signs and marginal significance levels vary between countries and no strong conclusions can be drawn. Adjusted R^2

Table 2a. Theoretic model: Devaluation expectations

	Belgium	Denmark	France	Ireland	Italy	Netherlands
Intercept	–0.227	5.954**	5.850*	9.551**	3.103	2.042**
	(1.663)	(2.091)	(3.142)	(1.703)	(3.082)	(0.862)
Money supply	0.713**	0.009	0.271*	–0.364*	0.397**	–0.200*
	(0.219)	(0.068)	(0.144)	(0.213)	(0.170)	(0.121)
German prices	0.790**	0.804*	1.420*	0.863**	1.282**	–0.572**
	(0.388)	(0.453)	(0.817)	(0.384)	(0.383)	(0.150)
Real exchange rate	–0.255**	0.148	0.163	0.213	–0.124	0.347
	(0.087)	(0.122)	(0.152)	(0.165)	(0.153)	(0.217)
Industrial production	0.086	0.006	–0.082	0.109	0.171**	–0.011
	(0.067)	(0.069)	(0.167)	(0.078)	(0.063)	(0.034)
German interest rate	–0.380	–0.716*	–1.123*	–0.831**	–0.775*	0.146
	(0.310)	(0.382)	(0.639)	(0.321)	(0.425)	(0.121)
Statistics						
Observations	150	152	152	45	149	152
Adjusted R^2	0.227	0.094	0.281	0.098	0.279	0.291
Residual standard error	2.205	3.166	3.785	3.994	3.570	1.263

Dependent variable: 3-month devaluation expectations. Independent variables (except interest rates) are in first log differences. Newey-West standard errors (12 lags) in parenthesis. One asterisk (*) indicates significance at a 10 % level, two asterisks (**) indicate significance at a 5 % level.

Table 2b. Theoretic model: Interest rate differentials

	Belgium	Denmark	France	Ireland	Italy	Netherlands
Intercept	6.633**	7.101**	5.311**	13.459**	7.932**	2.000**
	(1.362)	(1.297)	(1.881)	(1.577)	(3.306)	(0.503)
Money supply	–0.001	0.077*	0.466**	–0.320**	0.345*	–0.063
	(0.150)	(0.041)	(0.080)	(0.138)	(0.199)	(0.047)
German prices	1.111**	1.077**	1.181**	1.257**	1.969**	–0.086
	(0.259)	(0.350)	(0.376)	(0.305)	(0.565)	(0.092)
Real exchange rate	0.054	0.091	0.300**	0.010	–0.030	–0.017
	(0.062)	(0.119)	(0.085)	(0.167)	(0.122)	(0.075)
Industrial production	–0.069	–0.085**	–0.154	–0.082	–0.038	0.004
	(0.047)	(0.027)	(0.112)	(0.066)	(0.053)	(0.012)
German interest rate	–0.956**	0.916**	–0.960**	–1.296	–1.335**	–0.141**
	(0.213)	(0.222)	(0.347)	(0.264)	(0.478)	(0.069)
Statistics						
Observations	150	152	152	45	152	152
Adjusted R^2	0.506	0.396	0.638	0.325	0.462	0.351
Residual standard error	1.368	1.923	2.307	2.584	2.985	0.531

Dependent variable: 3-month interest rate differentials. Independent variables (except interest rates) are in first log differences. Newey-West standard errors (12 lags) in parenthesis. One asterisk (*) indicates significance at a 10 % level, two asterisks (**) indicate significance at a 5 % level.

now lie in the range from 0.394 to 0.768, and residual standard errors range between 0.921 and 3.393. For the interest rate differentials (table 4b), the pattern is again similar. The rate of real depreciation is now consistent with theory when significant (positive), and the trade balance often enters significantly negative. Adjusted R^2 vary from 0.671 to 0.828, and residual standard errors lie between 0.418 and 2.013. Once again, we conclude that the interest rate differential is more closely related to macroeconomic fundamentals than the estimated devaluation expectations.

4.3 Estimated devaluation expectations versus interest rate differentials

The most striking result when comparing the results for the two alternative measures of devaluation expectations is the large increase in

Table 3a. Extended model: Devaluation expectations

	Belgium	Denmark	France	Ireland	Italy	Netherlands
Intercept	–2.757	4.732**	5.605*	7.340**	6.414**	1.831*
	(1.949)	(1.991)	(2.941)	(2.194)	(2.478)	(0.934)
Money supply	0.743**	–0.051	0.103	–0.305	–0.049	–0.095
	(0.156)	(0.061)	(0.157)	(0.221)	(0.139)	(0.117)
German prices	–0.218	–0.163	0.608	–0.119	0.460	–0.960**
	(0.629)	(0.620)	(1.000)	(0.842)	(0.486)	(0.490)
Real exchange rate	–0.261**	0.238*	0.042	0.155	–0.249	0.468
	(0.086)	(0.136)	(0.140)	(0.172)	(0.192)	(0.339)
Industrial production	0.130**	0.055	–0.088	0.161**	0.244**	–0.020
	(0.055)	(0.072)	(0.176)	(0.068)	(0.065)	(0.032)
German interest rate	0.021	–0.490	–0.922	–0.471	–0.910**	0.090
	(0.358)	(0.387)	(0.642)	(0.319)	(0.311)	(0.116)
Foreign reserves	–0.002	–0.005	–0.047**	–0.047	–0.069**	–0.044**
	(0.018)	(0.013)	(0.024)	(0.037)	(0.018)	(0.021)
Domestic prices	0.571**	0.540**	0.401*	0.308*	0.506**	0.474
	(0.216)	(0.144)	(0.228)	(0.163)	(0.122)	(0.455)
Statistics						
Observations	150	152	152	45	149	152
Adjusted R^2	0.315	0.191	0.312	0.165	0.500	0.444
Residual standard error	2.077	2.990	3.702	3.842	2.974	1.118

Dependent variable: 3-month devaluation expectations. Independent variables (except interest rates) are in first log differences. Newey-West standard errors (12 lags) in parenthesis. One asterisk (*) indicates significance at a 10 % level, two asterisks (**) indicate significance at a 5 % level.

Table 3b. Extended model: Interest rate differentials

	Belgium	Denmark	France	Ireland	Italy	Netherlands
Intercept	3.715**	5.221**	4.993**	8.529**	6.767**	2.056**
	(0.937)	(0.806)	(1.645)	(1.155)	(1.662)	(0.582)
Money supply	0.064	–0.015	0.180**	–0.231**	–0.007	–0.063
	(0.092)	(0.025)	(0.075)	(0.114)	(0.108)	(0.062)
German prices	–0.088	–0.267	0.098	–0.495	0.155	–0.286*
	(0.254)	(0.170)	(0.525)	(0.362)	(0.269)	(0.160)
Real exchange rate	0.008	0.247**	0.219**	0.019	0.158	0.072
	(0.027)	(0.086)	(0.092)	(0.107)	(0.104)	(0.104)
Industrial production	–0.025	–0.007	–0.127	0.018	0.063	0.005
	(0.033)	(0.021)	(0.095)	(0.041)	(0.042)	(0.016)
German interest rate	–0.500**	–0.568**	–0.725**	–0.555**	–0.965**	–0.145**
	(0.133)	(0.122)	(0.339)	(0.147)	(0.201)	(0.072)
Foreign reserves	–0.015	0.001	–0.042**	–0.034*	–0.026**	0.000
	(0.007)	(0.005)	(0.014)	(0.018)	(0.011)	(0.011)
Domestic prices	0.688**	0.745**	0.619**	0.585**	0.853**	0.185
	(0.131)	(0.075)	(0.139)	(0.076)	(0.094)	(0.155)
Statistics						
Observations	150	152	152	45	152	152
Adjusted R^2	0.777	0.726	0.698	0.708	0.772	0.365
Residual standard error	0.919	1.296	2.105	1.700	1.942	0.526

Dependent variable: 3-month interest rate differentials. Independent variables (except interest rates) are in first log differences. Newey-West standard errors (12 lags) in parenthesis. One asterisk (*) indicates significance at a 10 % level, two asterisks (**) indicate significance at a 5 % level.

explanatory power; the adjusted R^2 are consistently higher and residual standard errors lower for the interest rate differential than for our estimated devaluation expectations. When it comes to the different explanatory variables, the results are similar between the models, with the exception of real output growth, which has the predicted effect on the interest rate differentials, but not on the drift-adjusted estimates.

One explanation could be the estimation of

Table 4a. Individual results: Devaluation expectations

	Belgium	Denmark	France	Ireland	Italy	Netherlands
Intercept	–156.498**	60.159	–58.283	–421.519**	5.793**	43.614**
	(16.746)	(62.747)	(62.149)	(147.791)	(1.532)	(14.662)
Money supply			–10.789	–44.200**		–5.494*
			(7.722)	(21.311)		(2.865)
Δ Money supply	0.877**					
	(0.162)					
German prices		–69.665**	23.725	128.016**		–190.417**
		(22.091)	(21.009)	(48.553)		(42.459)
Δ German prices			–0.873**	–0.960**	0.417	
			(0.422)	(0.407)	(0.489)	
Real exchange rate	57.113**	108.653**		30.588*		188.891**
	(6.021)	(13.293)		(18.101)		(29.814)
Δ Real exchange rate	–0.385**		–0.290**		–0.232	
	(0.071)		(0.139)		(0.162)	
Industrial production				23.268**		
				(8.743)		
Δ Industrial production					0.248**	
					(0.062)	
German interest rate					–0.864**	0.149
					(0.275)	(0.092)
Foreign reserves		–6.101**		–23.370**		–7.362**
		(1.783)		(3.908)		(1.449)
Δ Foreign reserves			–0.086**	0.099**	–0.067**	
			(0.018)	(0.032)	(0.015)	
Domestic prices		40.470**				186.168**
		(10.680)				(39.137)
Δ Domestic prices					0.498**	
					(0.122)	
Trade balance	–1.078**	2.093**	–4.098**			
	(0.167)	(0.501)	(0.746)			
Government deficit	–0.935**		1.053**			–0.236**
	(0.163)		(0.118)			(0.057)
Government debt						0.077**
						(0.035)
Unemployment		–2.721**		–0.496		–0.325**
		(0.501)		(0.529)		(0.125)
Statistics						
Observations	129	164	152	40	149	162
Adjusted R^2	0.394	0.437	0.422	0.554	0.503	0.768
Residual standard error	1.939	2.851	3.393	2.893	2.966	0.921

Dependent variable: 3-month devaluation expectations. Newey-West standard errors (12 lags) in parenthesis. One asterisk (*) indicates significance at a 10 % level, two asterisks (**) indicate significance at a 5 % level.

the expected exchange rate depreciation within the band which was made to calculate devaluation expectations. The drift-adjustment method presupposes that the expected rate of depreciation within the band is possible to estimate consistently, but if this is not the case, e g due to the distribution of the exchange rate within the band (see section 3 above), the resulting devaluation expectations may be biased, and hence not fully reflect macroeconomic fundamentals.

Also, the existence of a time-varying risk premium may affect our estimates of the expected rate of depreciation within the band. As mentioned above, Holden and Vikøren (1994) argue that the interest rate differential may be an acceptable measure of depreciation expectations even if agents are risk averse and uncovered interest parity does not hold. As for the devaluation expectations estimated through the drift-adjustment method, it is more difficult to predict how they would be affected by a risk premium.

Another explanation could be the fact that the interest rate differential is less volatile than the

Table 4b. Individual results: Interest rate differentials

	Belgium	Denmark	France	Ireland	Italy	Netherlands
Intercept	–45.520**	45.223	–27.313	–241.573**	6.683**	10.362
	(13.310)	(48.882)	(59.763)	(67.902)	(1.230)	(6.592)
Money supply			–18.090**	–30.503**		–4.291**
			(7.747)	(10.849)		(1.617)
Δ Money supply	0.223**					
	(0.101)					
German prices		–40.305**	25.903	83.949**		–28.639**
		(17.526)	(20.721)	(23.083)		(11.677)
Δ German prices			–1.049**	–0.817**	0.149	
			(0.361)	(0.181)	(0.274)	
Real exchange rate	16.450**	46.025**		10.398		40.622**
	(4.865)	(9.484)		(8.844)		(8.256)
Δ Real exchange rate	–0.027		–0.018		0.161**	
	(0.040)		(0.109)		(0.079)	
Industrial production				6.298		
				(4.826)		
Δ Industrial production					0.064	
					(0.040)	
German interest rate					–0.958**	–0.239**
					(0.195)	(0.053)
Foreign reserves		–2.028**		–8.999**		–2.504**
		(0.762)		(1.884)		(0.665)
Δ Foreign reserves			–0.075**	0.024*	–0.026**	
			(0.021)	(0.014)	(0.008)	
Domestic prices		23.110**				32.080**
		(8.042)				(10.145)
Δ Domestic prices					0.852**	
					(0.092)	
Trade balance	–0.488**	–0.022	–2.845**			
	(0.109)	(0.335)	(0.577)			
Government deficit	0.013		0.671**			–0.051
	(0.119)		(0.137)			(0.038)
Government debt						0.027
						(0.018)
Unemployment		–0.759**		–0.478		–0.334**
		(0.243)		(0.312)		(0.072)
Statistics						
Observations	129	164	152	40	152	162
Adjusted R^2	0.671	0.706	0.724	0.828	0.774	0.775
Residual standard error	0.937	1.485	2.013	1.255	1.936	0.418

Dependent variable: 3-month interest rate differentials. Newey-West standard errors (12 lags) in parenthesis. One asterisk (*) indicates significance at a 10% level, two asterisks (**) indicate significance at a 5% level.

drift-adjusted estimates, which would lead to a closer statistical relationship with the smooth monthly data of the macroeconomic variables.

5. *Summary and conclusions*

This paper has been an attempt to explain devaluation expectations in the ERM with macroeconomic fundamentals. Two different measures of devaluation expectations have been used; expectations estimated using the drift-adjustment method, and the directly observable interest rate differential. We have seen that macroeconomic fundamentals manage to explain between 39 and 77 percent of the estimated devaluation expectations, but up to 83 percent of the interest rate differential. Thus, it seems that the interest rate differential is more closely connected to macroeconomic fundamentals than the estimates stemming from the drift-adjustment method.

For the ERM as a whole, an extended theoretic model of exchange rate determination explains a considerable part of the devaluation expectations, but for individual countries additional variables are important, although these relationships are ambiguous and country-specific. In our theoretic models, the rate of money growth, the domestic inflation rate, the rate of real depreciation, and the change in foreign exchange reserves seem to be closely liked to expected rates of devaluation, and the relationships often carry the signs predicted by theory.

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Appendix A: Data definitions and sources

Exchange rates: Official spot rates, recorded at 14.30 Swiss time.
Source: Lars E O Svensson, IIES, Stockholm

Interest rates: 3-month Euro-market deposits, annualised bid rates, recorded at 10.00 Swiss time
Source: Lars E O Svensson, IIES, Stockholm

Money supply: M1, 1979:03=100, seasonally adjusted
Source: OECD Main Economic Indicators

Prices: CPI, 1979:03=100, seasonally adjusted
Source: OECD Main Economic Indicators

Real exchange rates: ln(exchange rate) + ln(German CPI) – ln(domestic CPI)

Industrial production: 1979:03=100, seasonally adjusted
Source: Eurostat

Foreign exchange reserves: bSDR
Source: OECD Main Economic Indicators

Trade balance/GNP: % pa
Source: OECD Main Economic Indicators

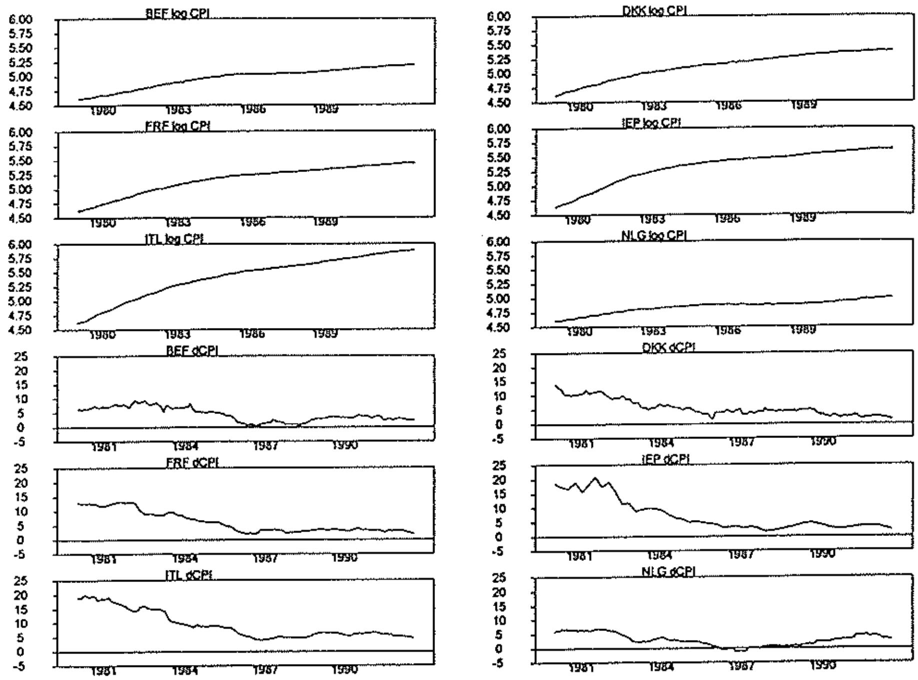
Government deficit/GNP: % pa
Source: IMF International Financial Statistics

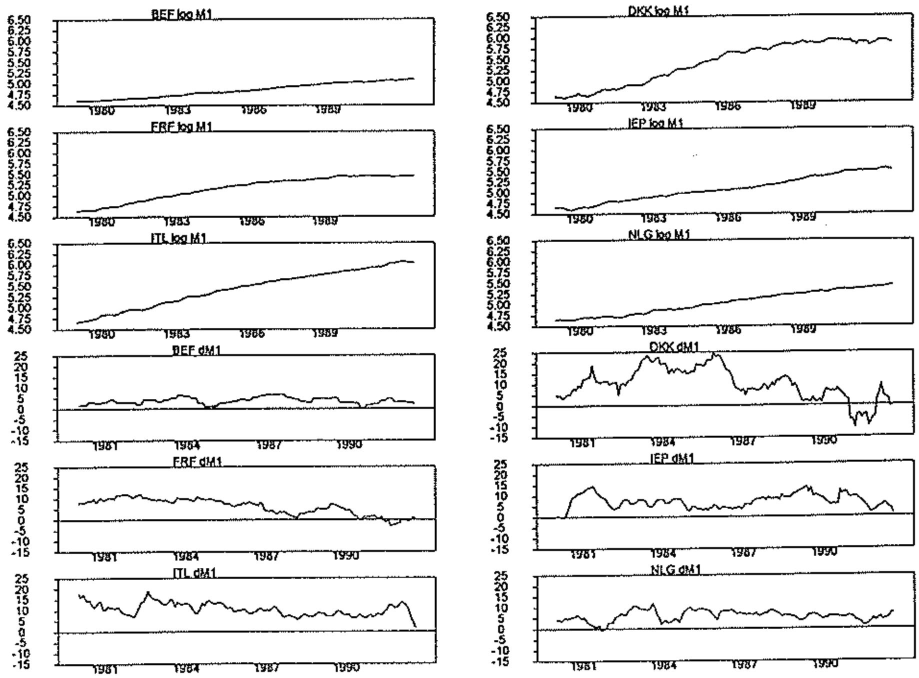
Government debt/GNP: % pa
Source: IMF International Financial Statistics

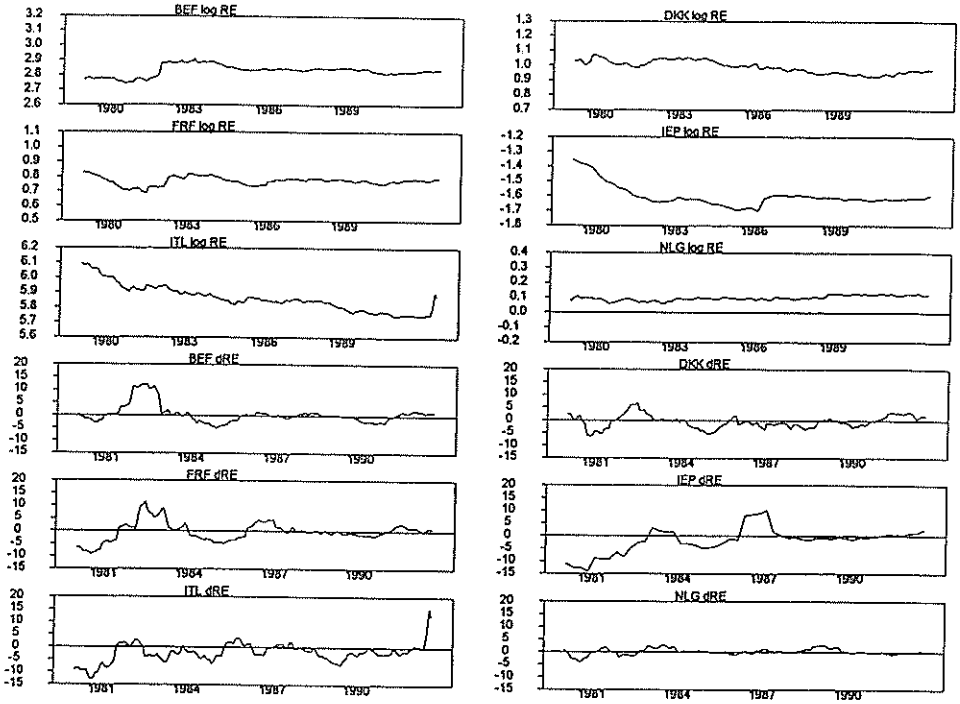
Government financing requirement/GNP: % pa
Source: IMF International Financial Statistics

Unemployment rate: % of labour force, seasonally adjusted
Source: Eurostat

Appendix B. Data Graphs



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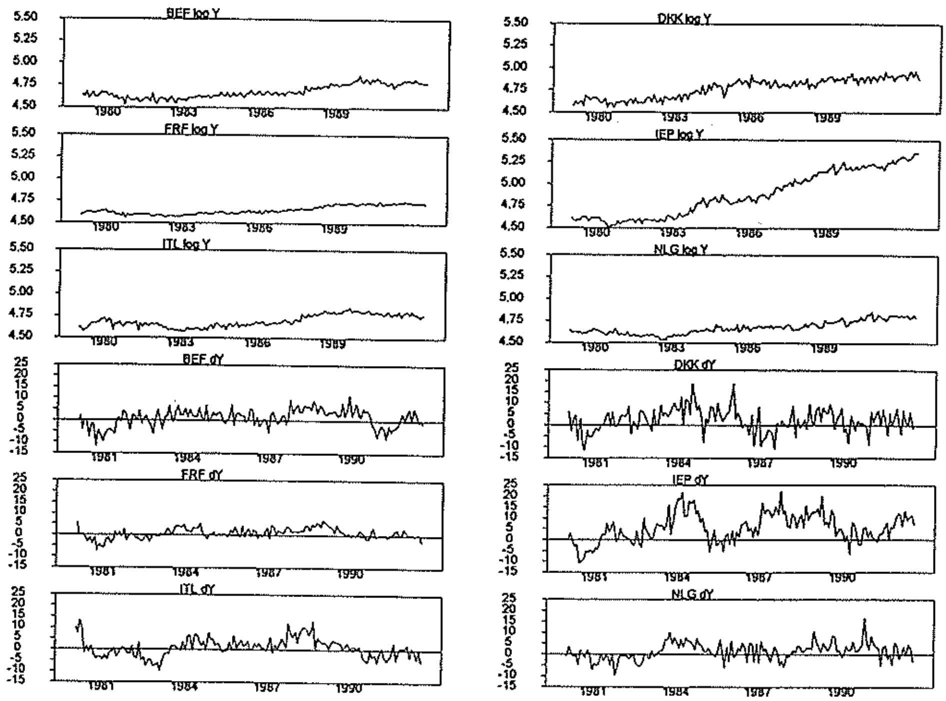
DKK log RE
FRF log RE
IEP log RE
ITL log RE
NLG log RE
BEF dRE
DKK dRE
FRF dRE
IEP dRE
ITL dRE
NLG dRE


BEF log Y
DKK log Y
FRF log Y
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ITL log Y
NLG log Y
BEF dY
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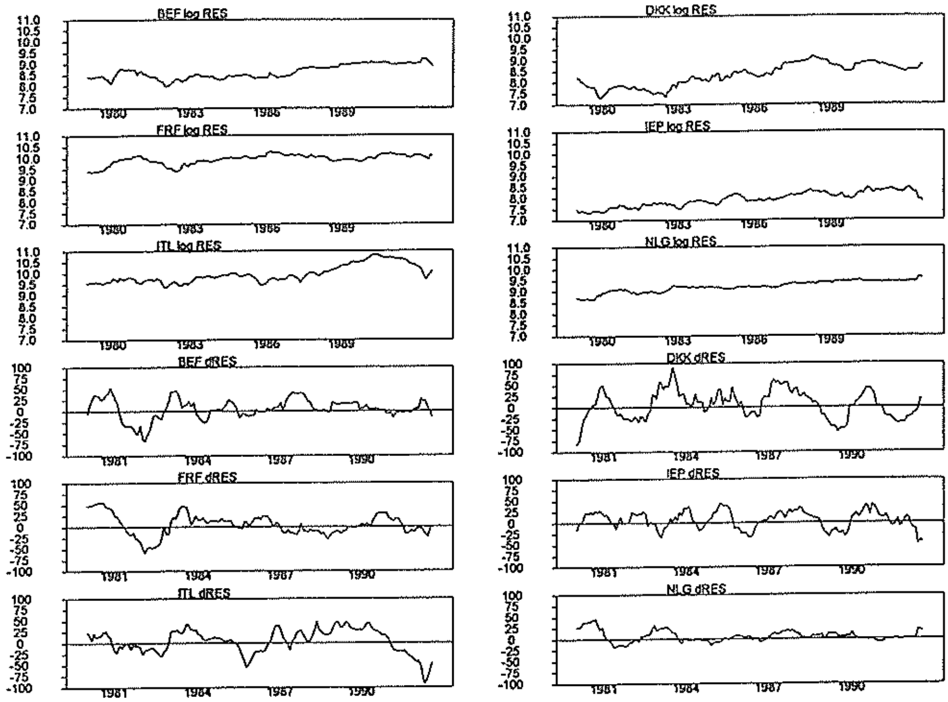
NLG dY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DKK log RES
FRF log RES
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ITL log RES
NLG log RES
BEF dRES
DKK dRES
FRF dRES
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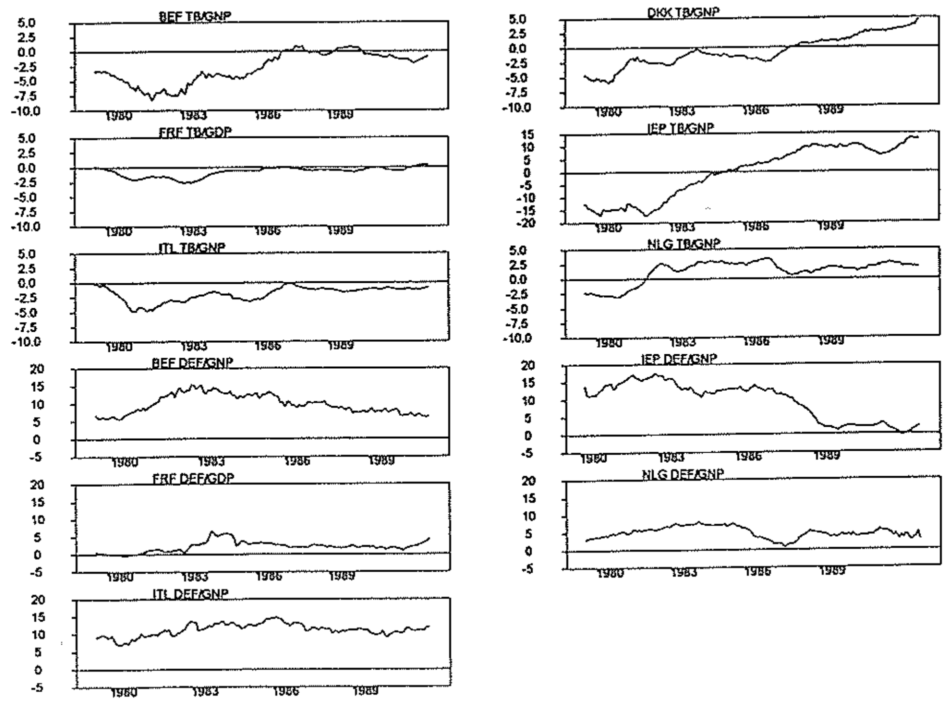
ITL dRES
NLG dRES


BEF TB/GNP
DKK TB/GNP
FRF TB/GDP
IEP TB/GNP
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NLG TB/GNP
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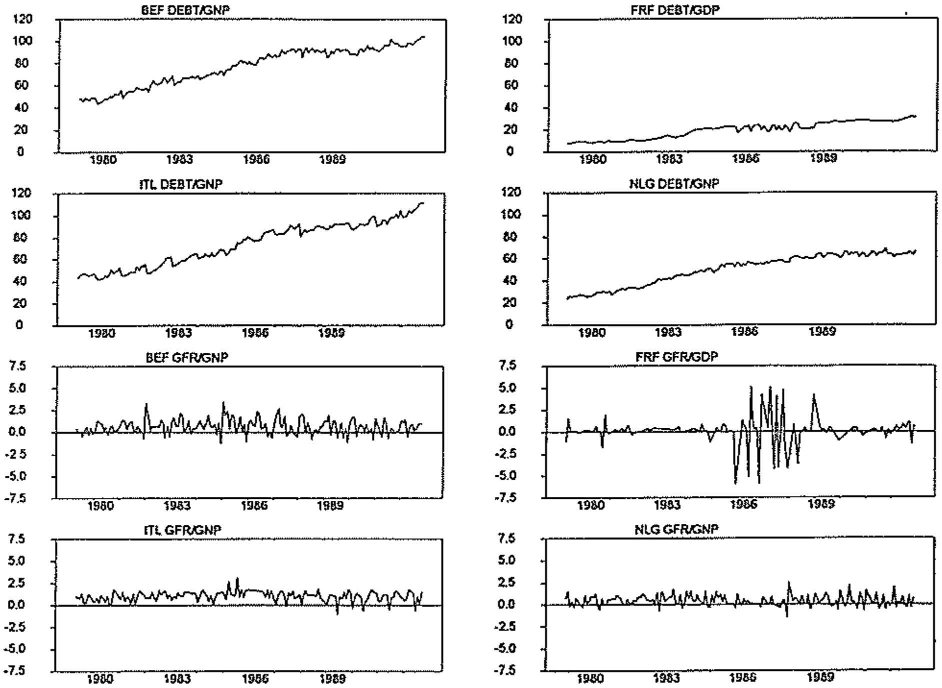
ITL DEF/GNP


BEF DEBT/GNP
FRF DEBT/GDP
ITL DEBT/GNP
NLG DEBT/GNP
BEF GFR/GNP
FRF GFR/GDP
ITL GFR/GNP
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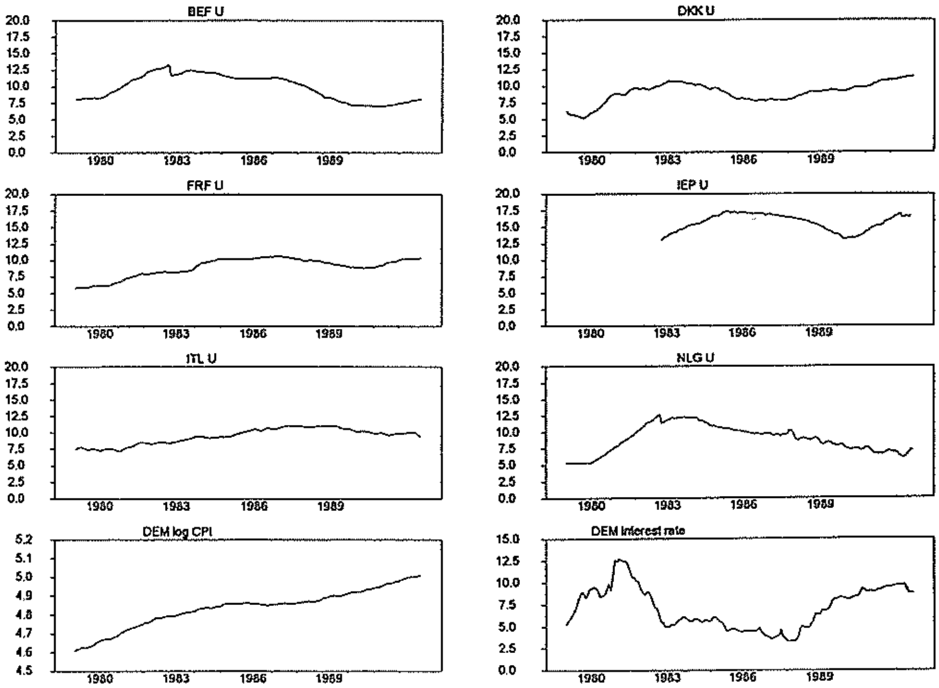
1980
1983
1986
1989


BEF U
DKK U
FRF U
IEP U
ITL U
NLG U
DEM log CPI
DEM interest rate
1980
1983
1986
1989